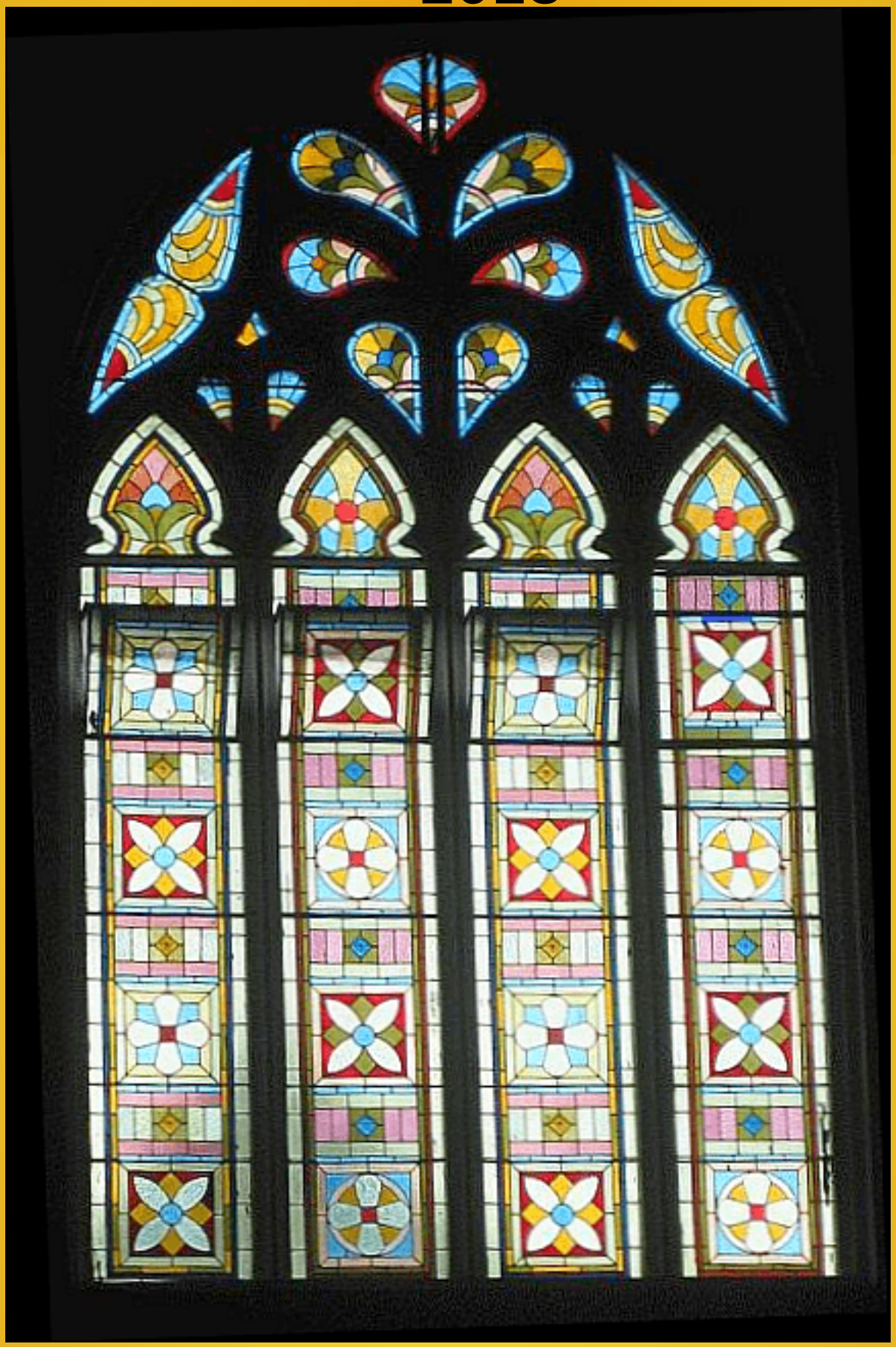
Organic Robots - LSGA December, 2018



LSGA December, 2018

Organic Robots

Ref: SCIENCE ROBOTICS – REVIEW

BIOMATERIALS : Organismal engineering: Toward a robotic taxonomic key for devices using organic materials

Victoria A. Webster-Wood, 1 * Ozan Akkus, 1,2,3 Umut A. Gurkan, 1,2,3

Hillel J. Chiel, 2,4,5 Roger D. Quinn 1 2017

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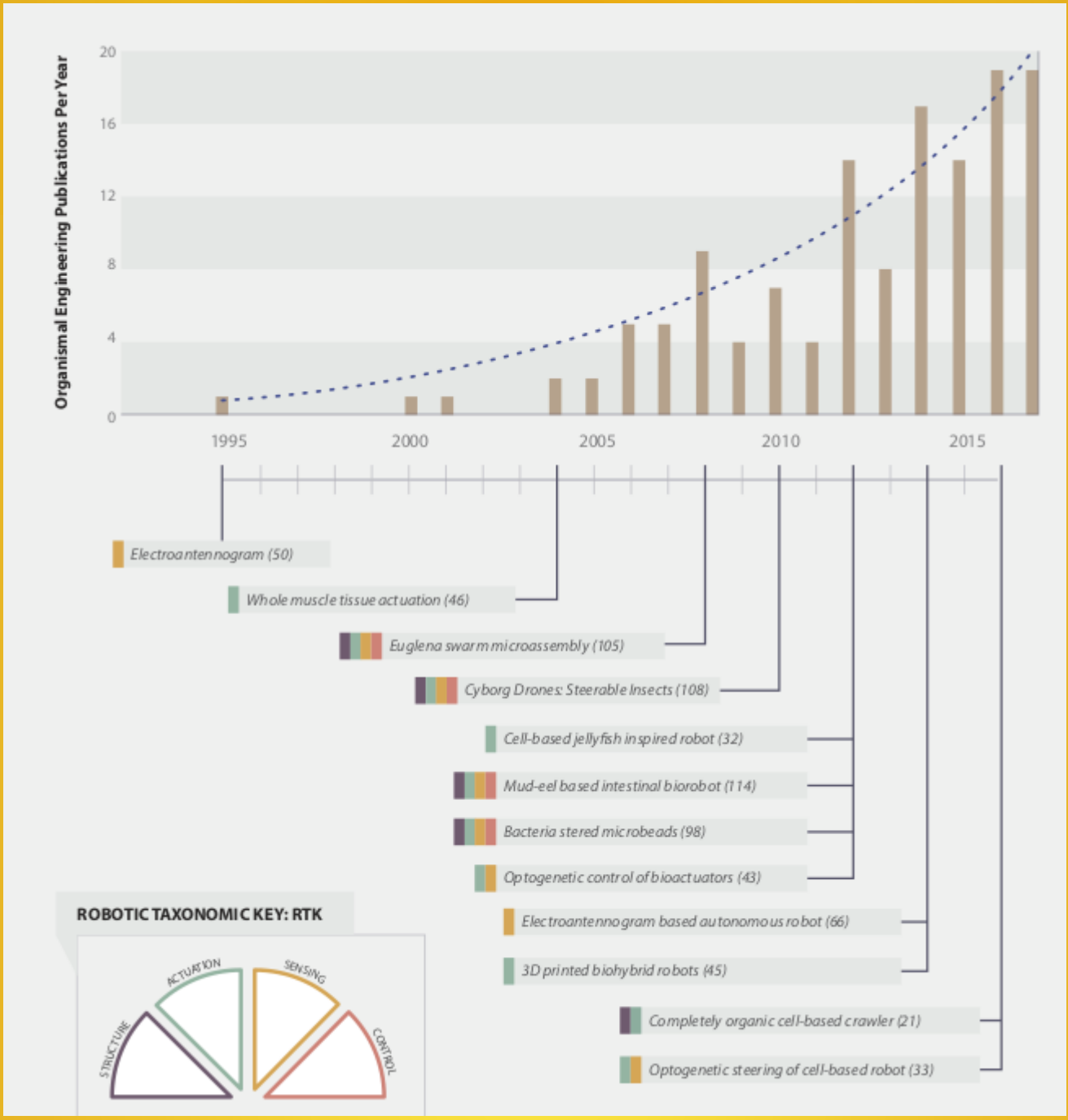
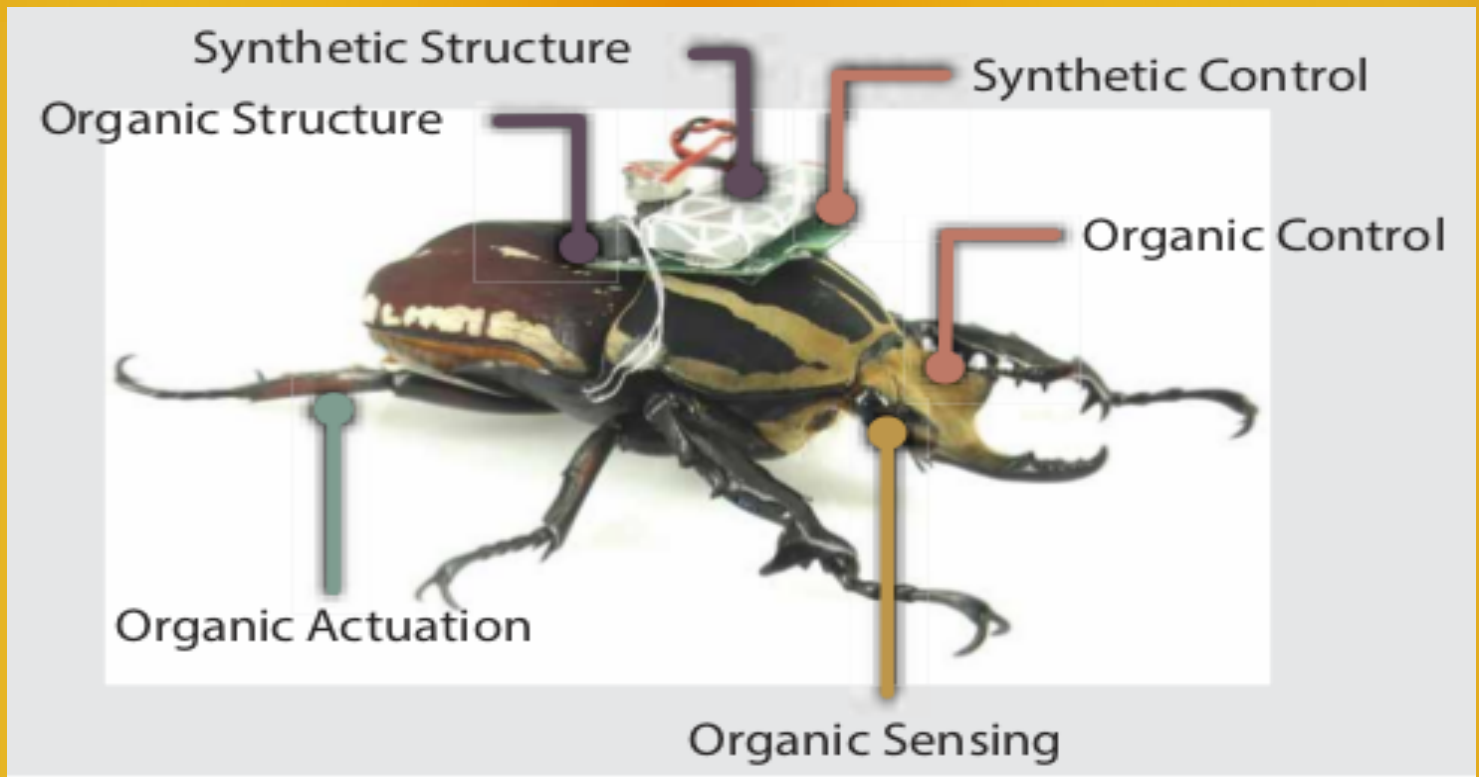


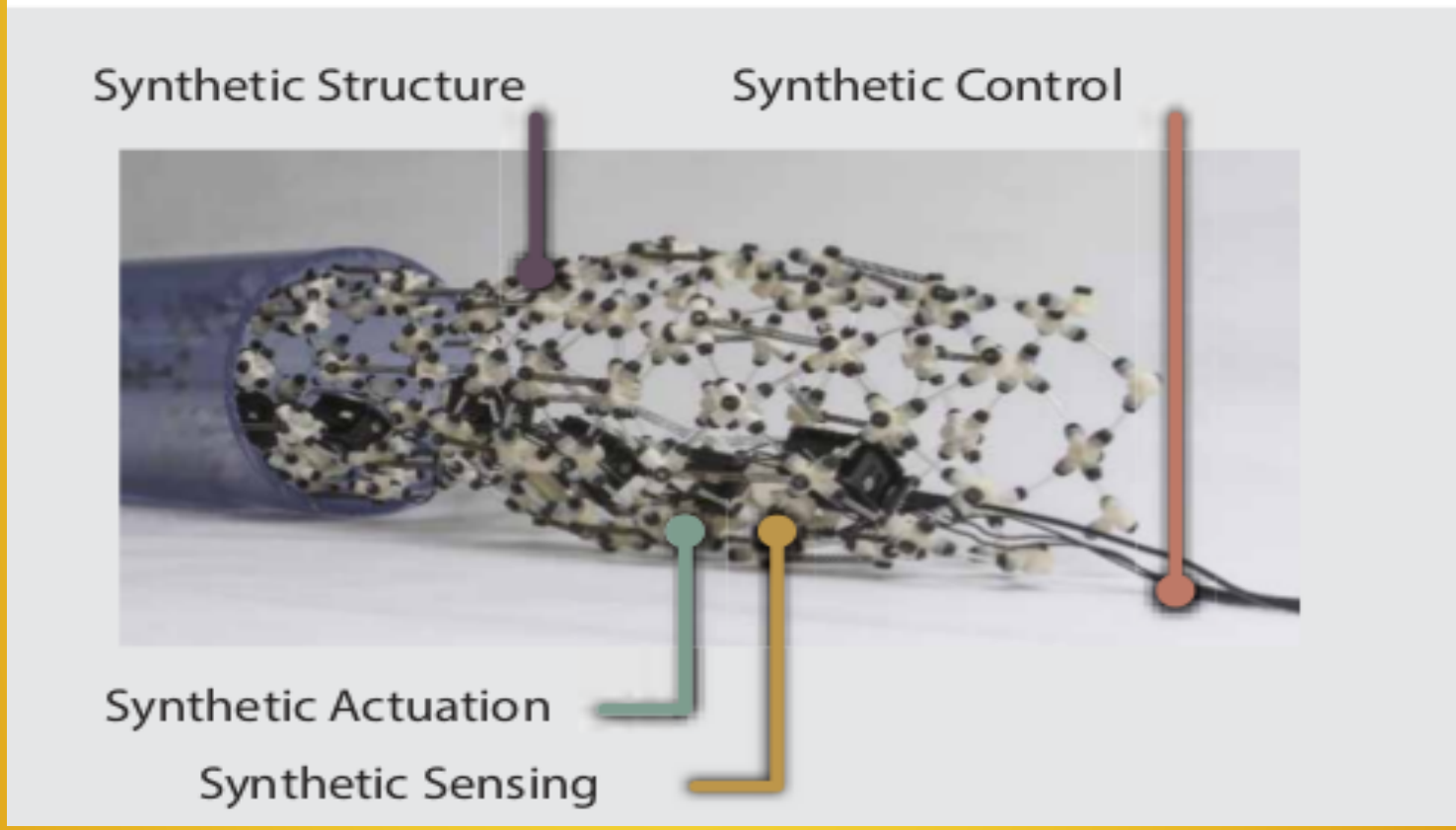
Expansion of organic robotics;

- 1995 electro-antennagram
- 2004 whole muscle tissue actuation
- 2010 cyborg drone insects – cf TED talk
- 2012 jellyfish, bio-robot eel, bacteria-steered microbeads
- 2014 Electro-antennagram bio-bot, 3-D printed biohybrid robots
- 2016 Organic cell-based crawler, steering cell-based robot

Organic Vs Synthetic

Organism based robot versus non-organic component structure. The beetle has synthetic control with orgainc structure, whereas the squid is fully synthetic. Can be used as the basis for taxonomy of robots.

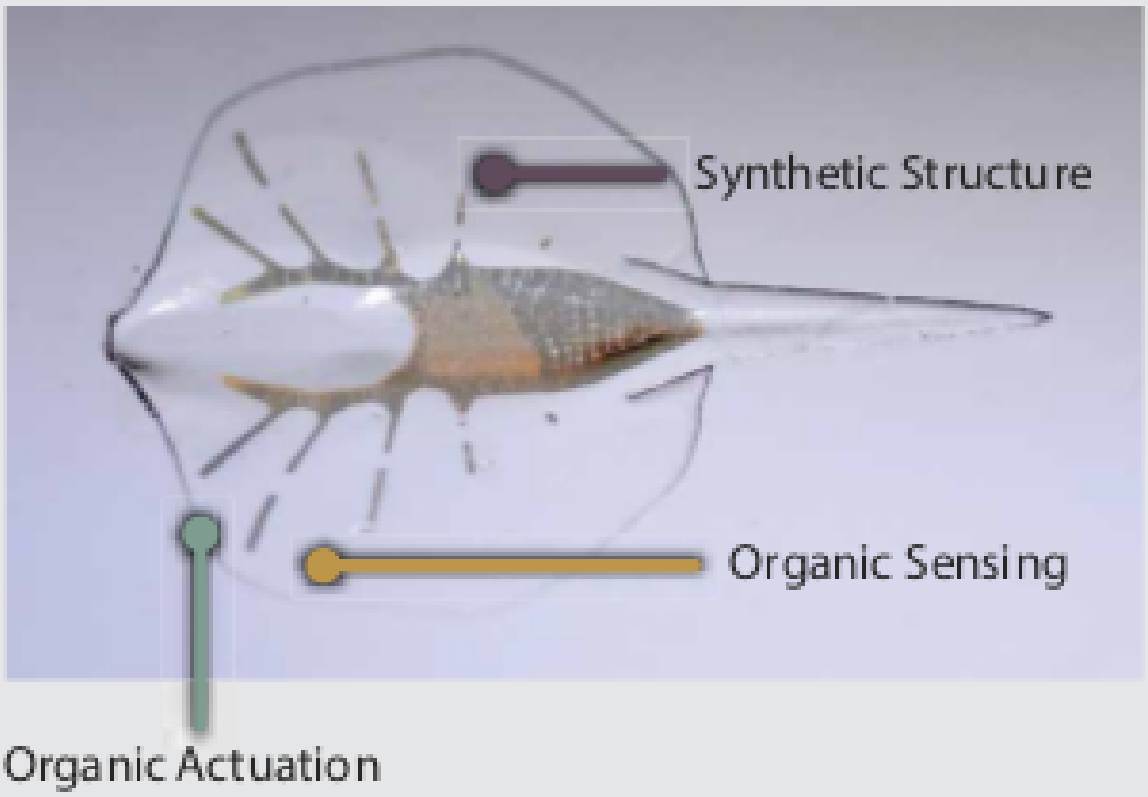




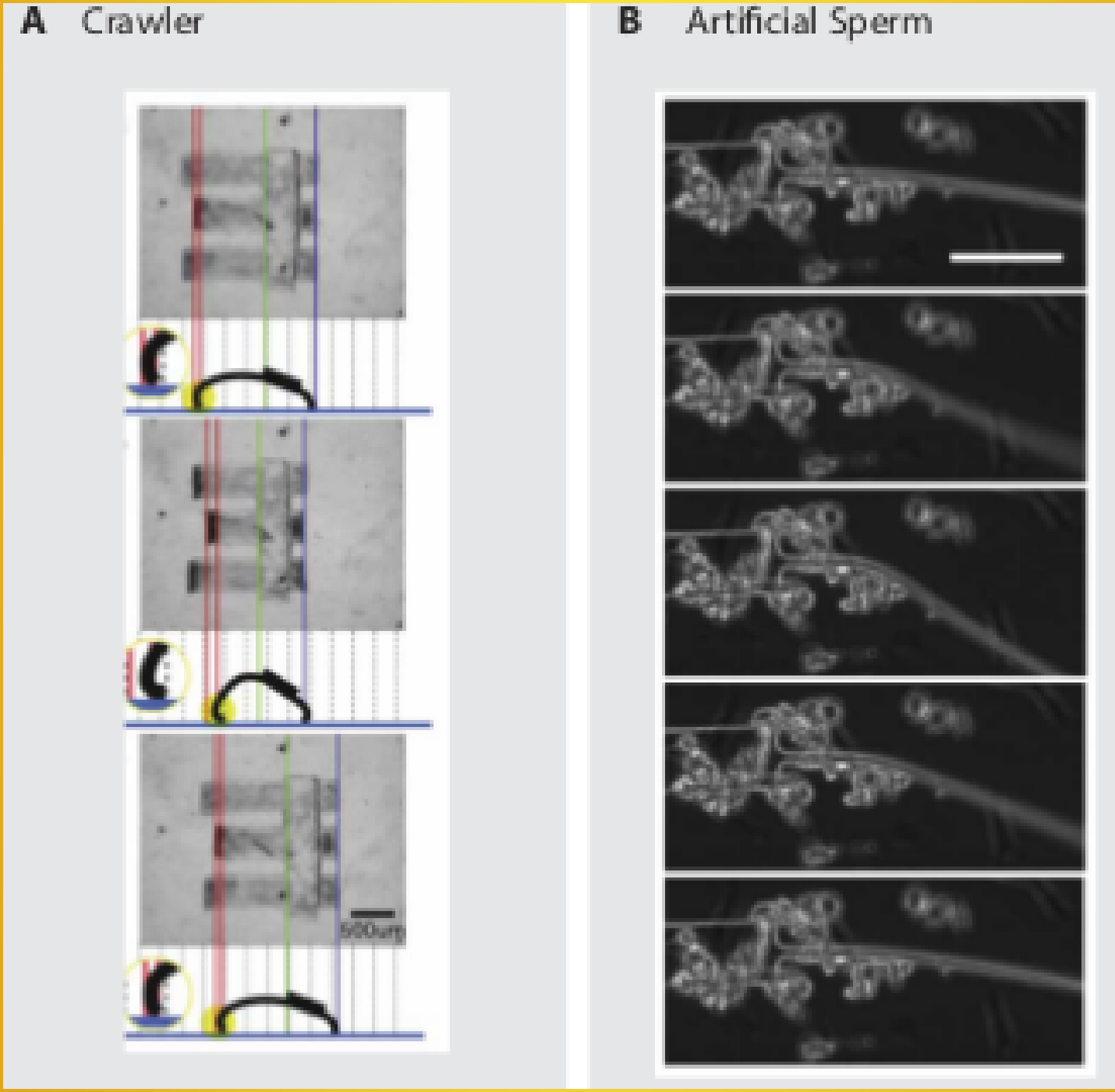
Organism as a fully synthetic robot.

Cells respond to light (sensor). Cell DNA modified to respond.

Organic biohybrid in structure.



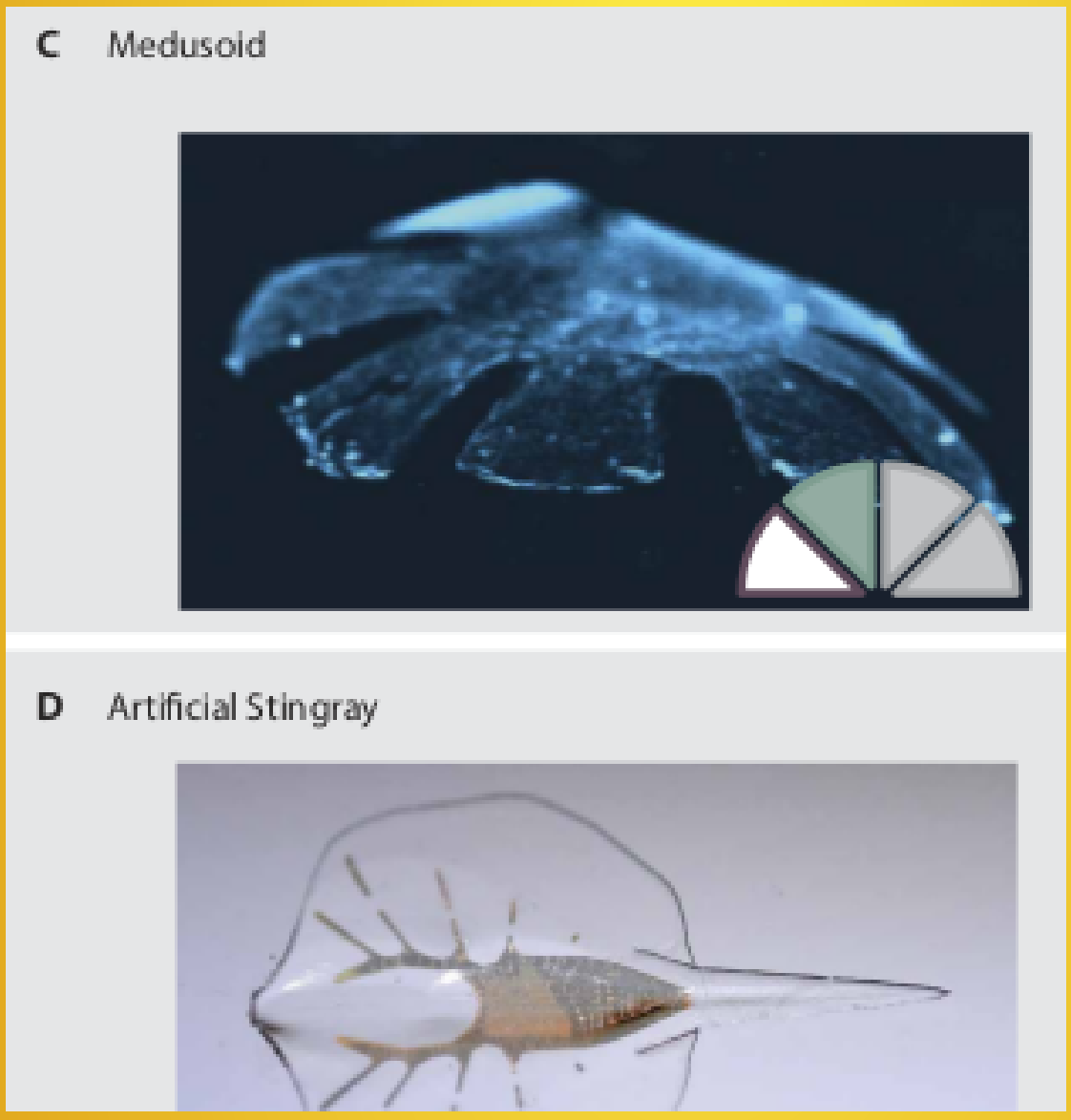
Organism based on cardiomyocyte cells. 3 legged crawler; and “sperm” where heart cells drive a long tail in fish-like motions.



Organisms based on cardiomyocyte cells.

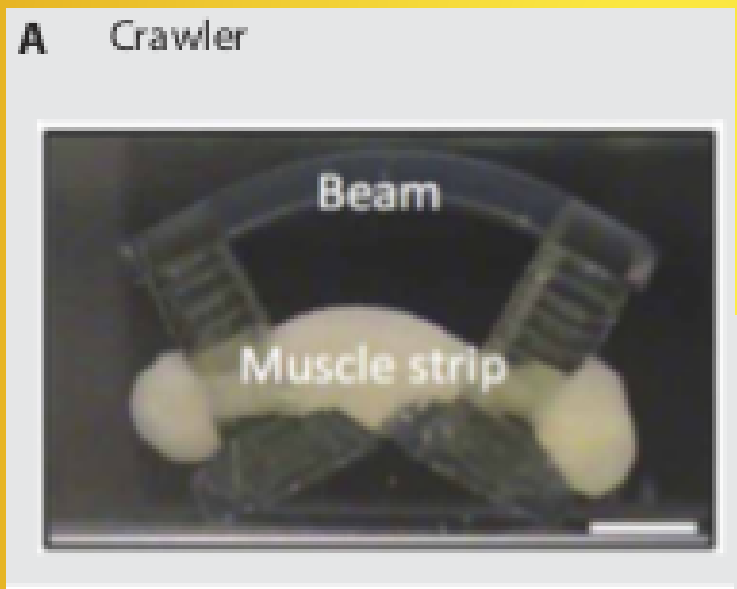
Jellyfish. Micro-patterning of cardio cells used

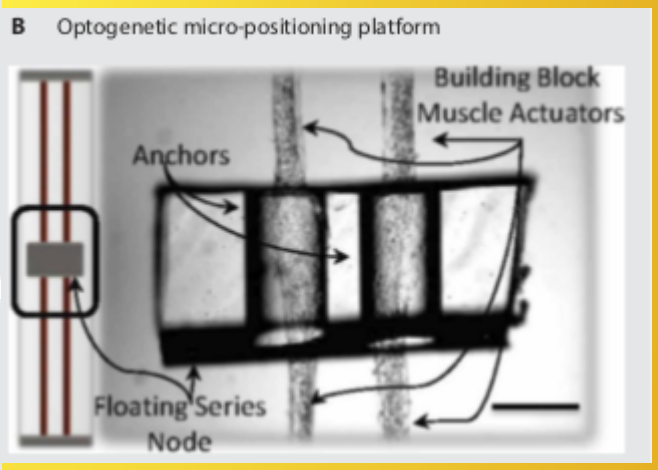
Stingray – optogenetically modified cardio cells used for steering.

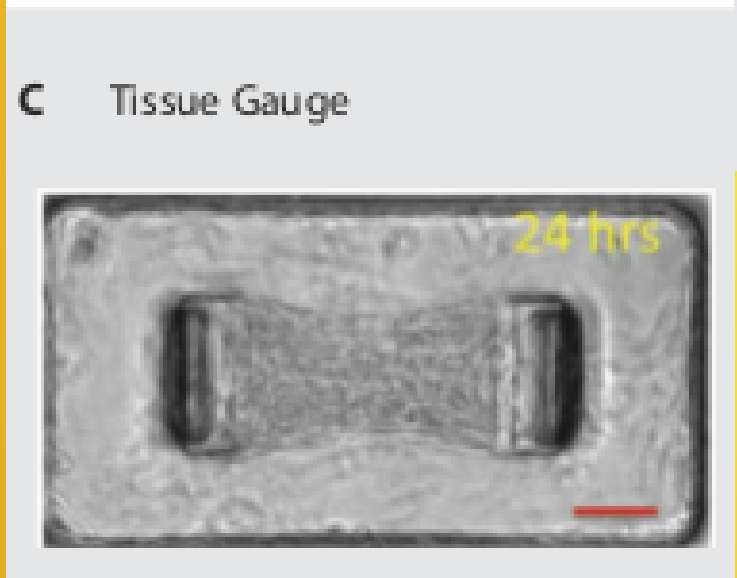


Organisms based on skeleton muscle cells.

A - 3-D printed support for a crawler
B – Light used to actuate rotation/position of a micro-positioning device. Eg Fertilisation.
C – Tissue-based strain guage.

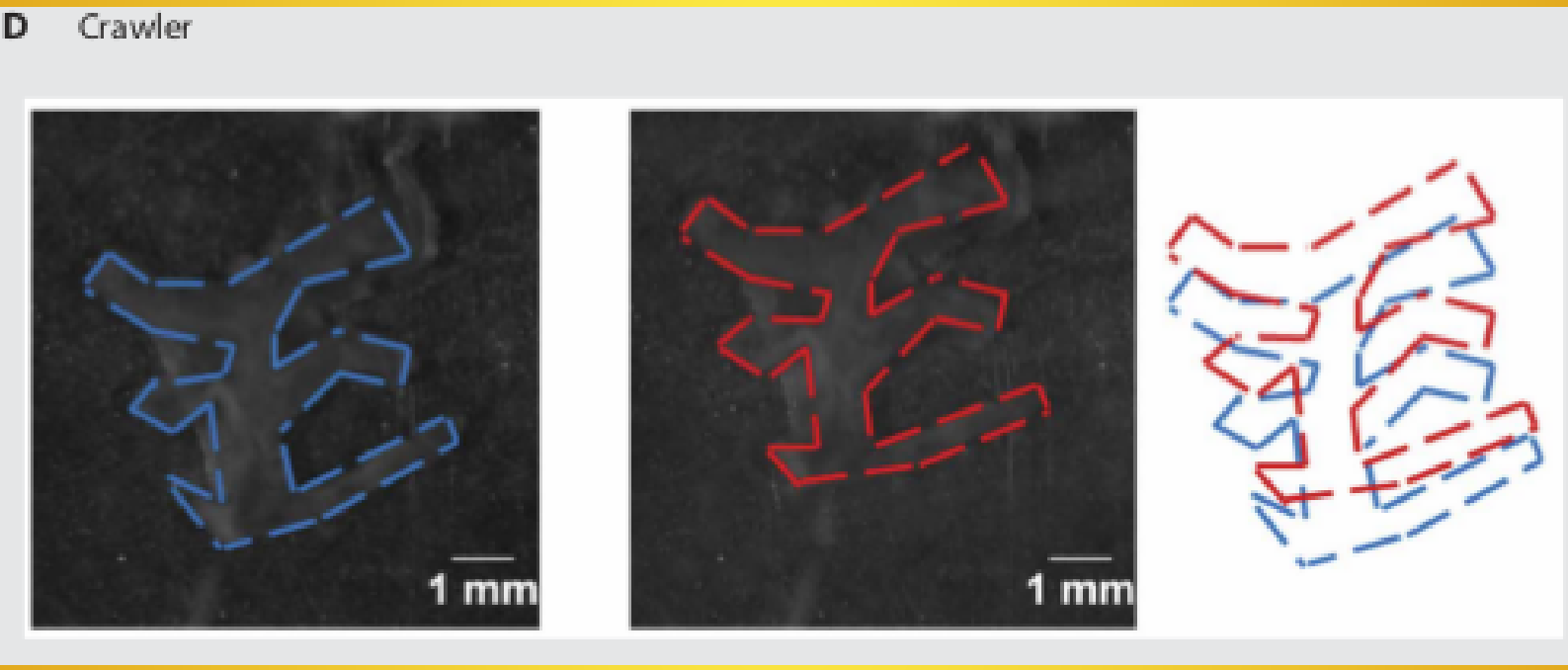






Crawler.

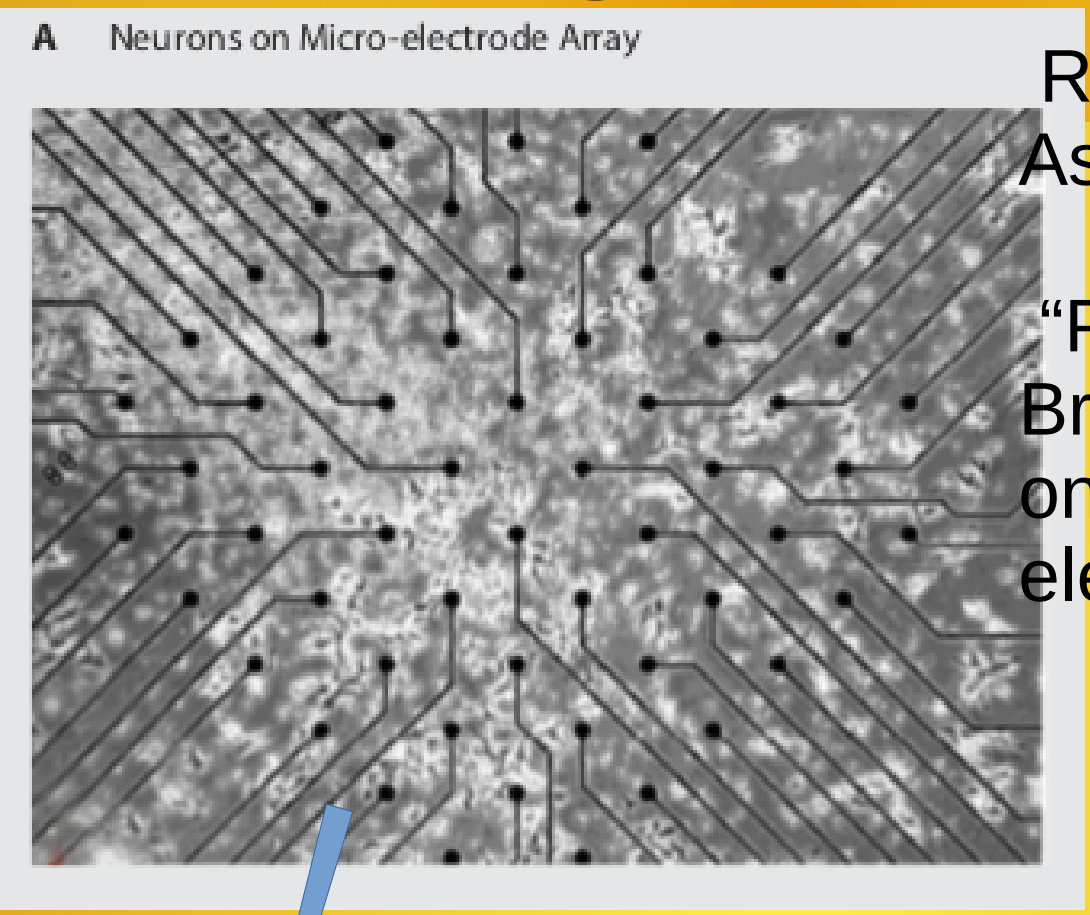
Hard to see, but it does move!



Organism moves based on pressure on a plastic cover above an alginate cell layer.

=> touch sensor potential use.

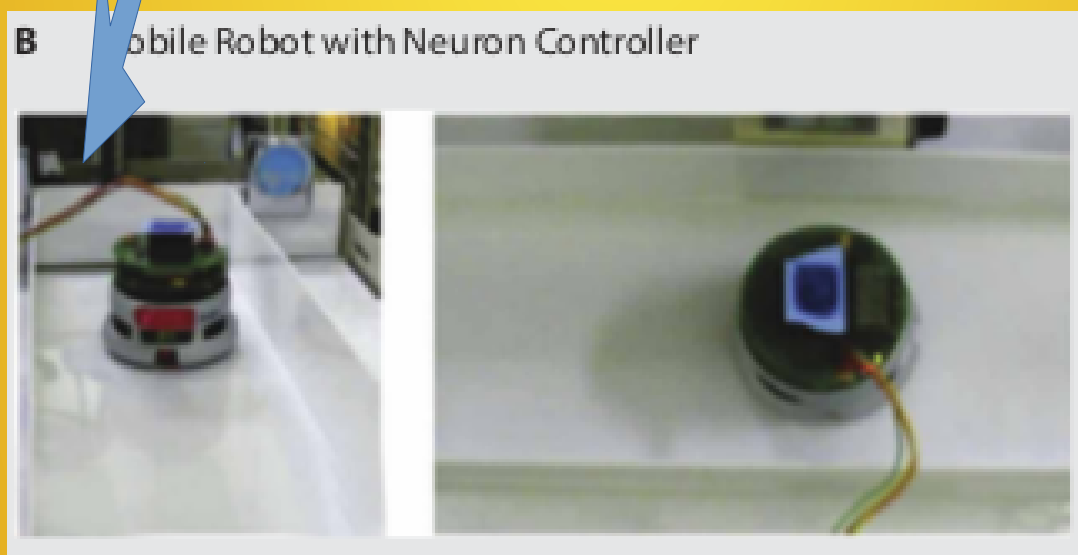
Prolog in action?



Robot based on Asimov?

"Positronic Brain" neurons on a multi-electrode array.

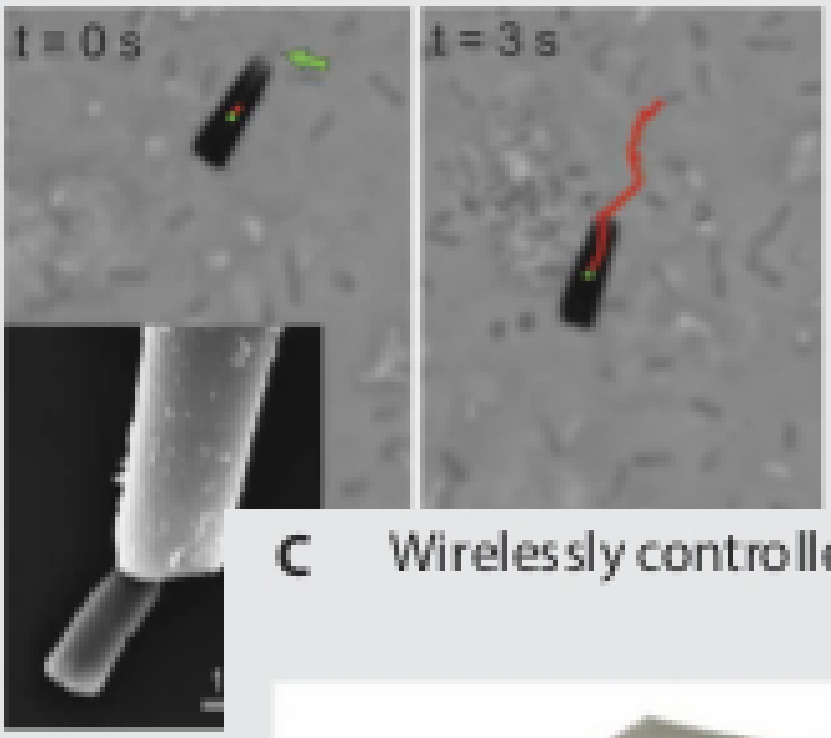
Hayashi et al., 2011 – neuron controlled mobile robot with fuzzy logic. Line-follow was 80% good



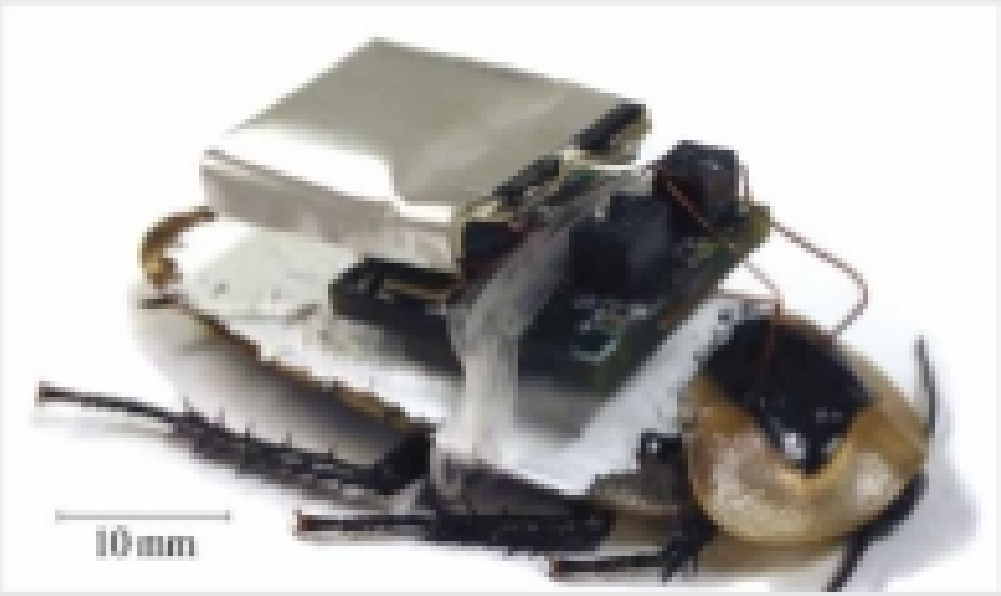
A. Could be used to deliver chemical to tumour.

C – collect food scraps at LSGA meetings? An "IoT" variantion.

A Bacteria Driven Micro-particle



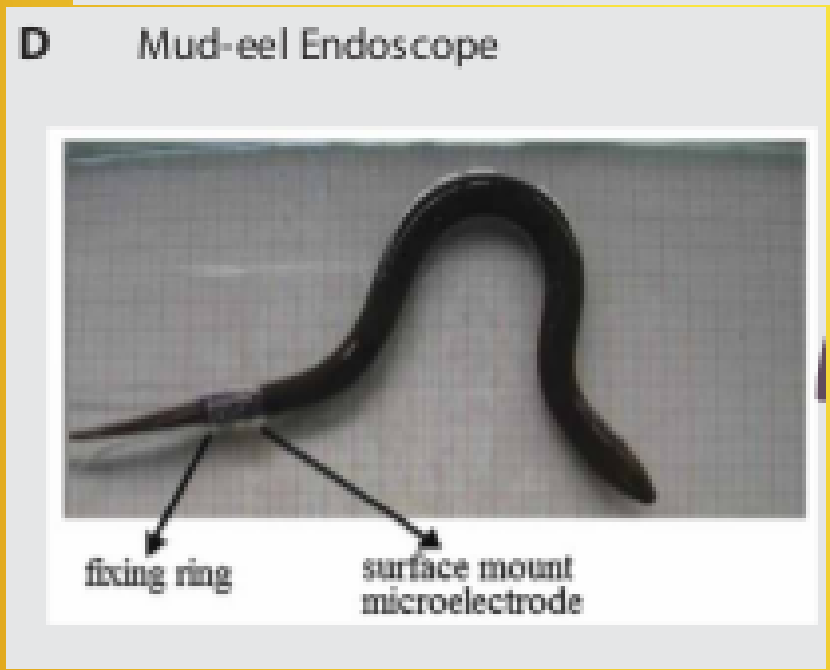
C Wirelessly controlled Cockroach



B - Organism based on *Euglena* swarm. 70NN force at 1-5 microM per second. “Zoom”!

“Cyborg Drone” type. Eg Biofuel cell in a cockcroch thorax => power for electronics.

D - Eel at 12mm/sec. Encapsulated in gut.



Cockcroaches and beetles with WiFi and video used by US Army.

Where next?

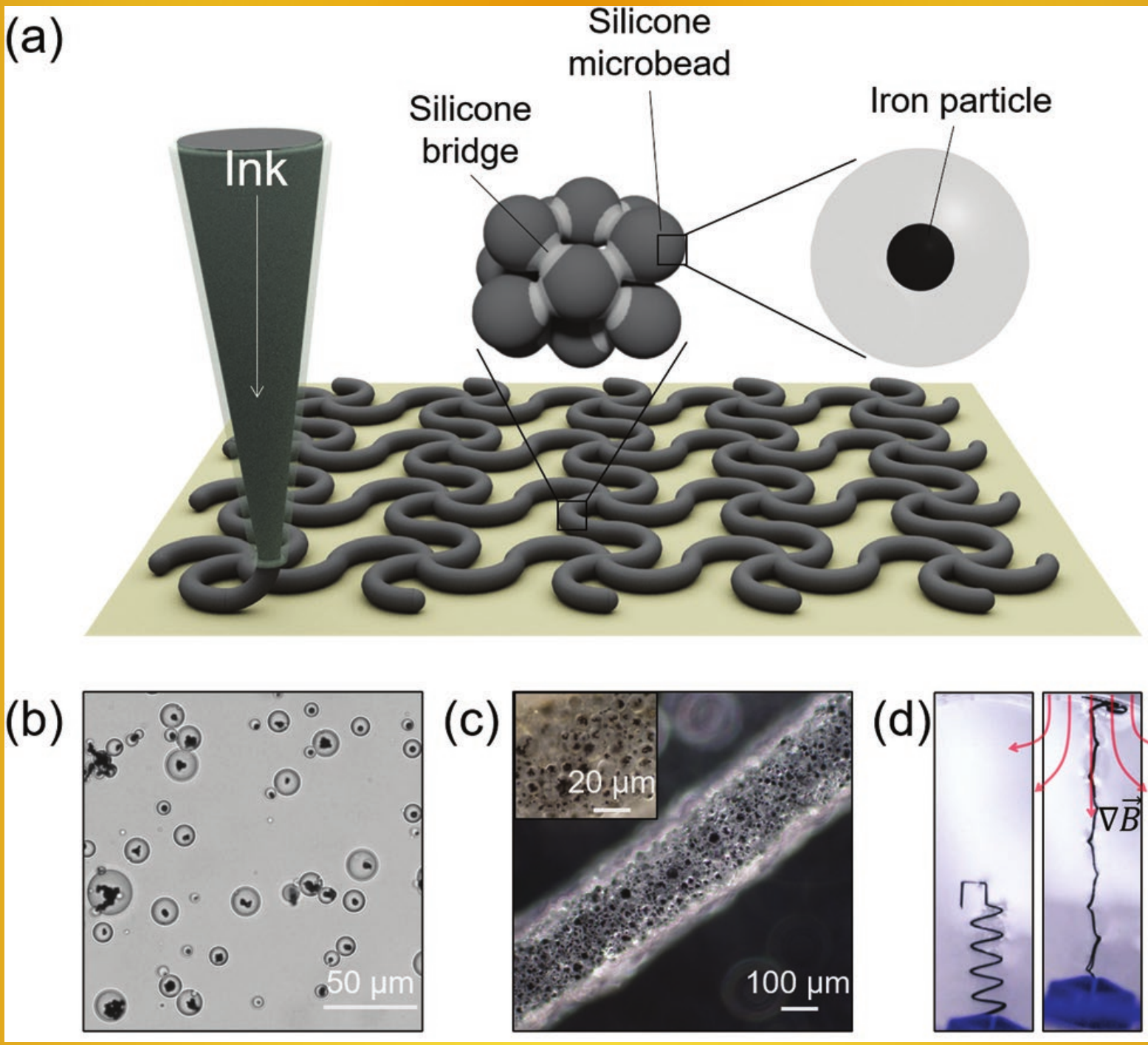
- Organic Robots - LSGA December, 2018

North Carolina University **3D-printed flexible mesh** structures that can be controlled with applied magnetic fields while floating on water. The structures can grab small objects and carry water droplets, giving them the potential to be useful as soft robots that mimic creatures living on water surfaces or that can serve as tissue scaffolds for cell cultures.

An "ink" from silicone microbeads, was bound by liquid silicone and contained in water. The "homocomposite thixotropic toothpaste" used in a 3D printer can shape the paste into mesh-like patterns. The cured pattern can be moved by the application of magnetic fields.

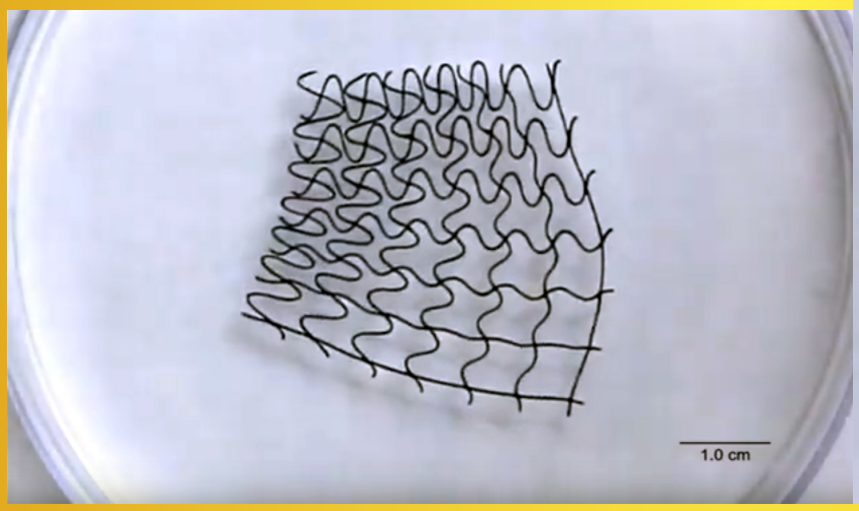
Embed with iron carbonyl particles that have a high magnetization imparts a strong response to magnetic field gradients. They float and also could be used for robot faces.

Meshes could "grab" a tiny ball of aluminum foil that can "carry" a single water droplet and then release it on demand through the mesh.


(a)
Silicone microbead
Silicone bridge
Iron particle
Ink
(b)
50 μm
(c)
20 μm
100 μm
(d)
$\nabla\vec{B}$

Organic Robots - LSGA December, 2018

3D-printed flexible mesh



Organic Robots - LSGA December, 2018

Bioinspired photocontrollable microstructured transport device

Emre Kizilkan, Jan Strueben, Anne Staubitz and Stanislav N. Gorb› *Kiel University, Am;* *Science Robotics 18 Jan 2017: Vol. 2, Issue 2, eaak94*

Developed an artificial, photocontrollable microstructured transport device. Provide for substantial adhesion and, at the same time, for quick detachment by mechanical stimulus through leg movements like Gekos.

Through tunable ultraviolet light illumination, the adhesive ability of this bioinspired transport device is reduced up to a factor of 2.7 in terms of adhesive forces and is quickly recovered when the light stimulus ceases.

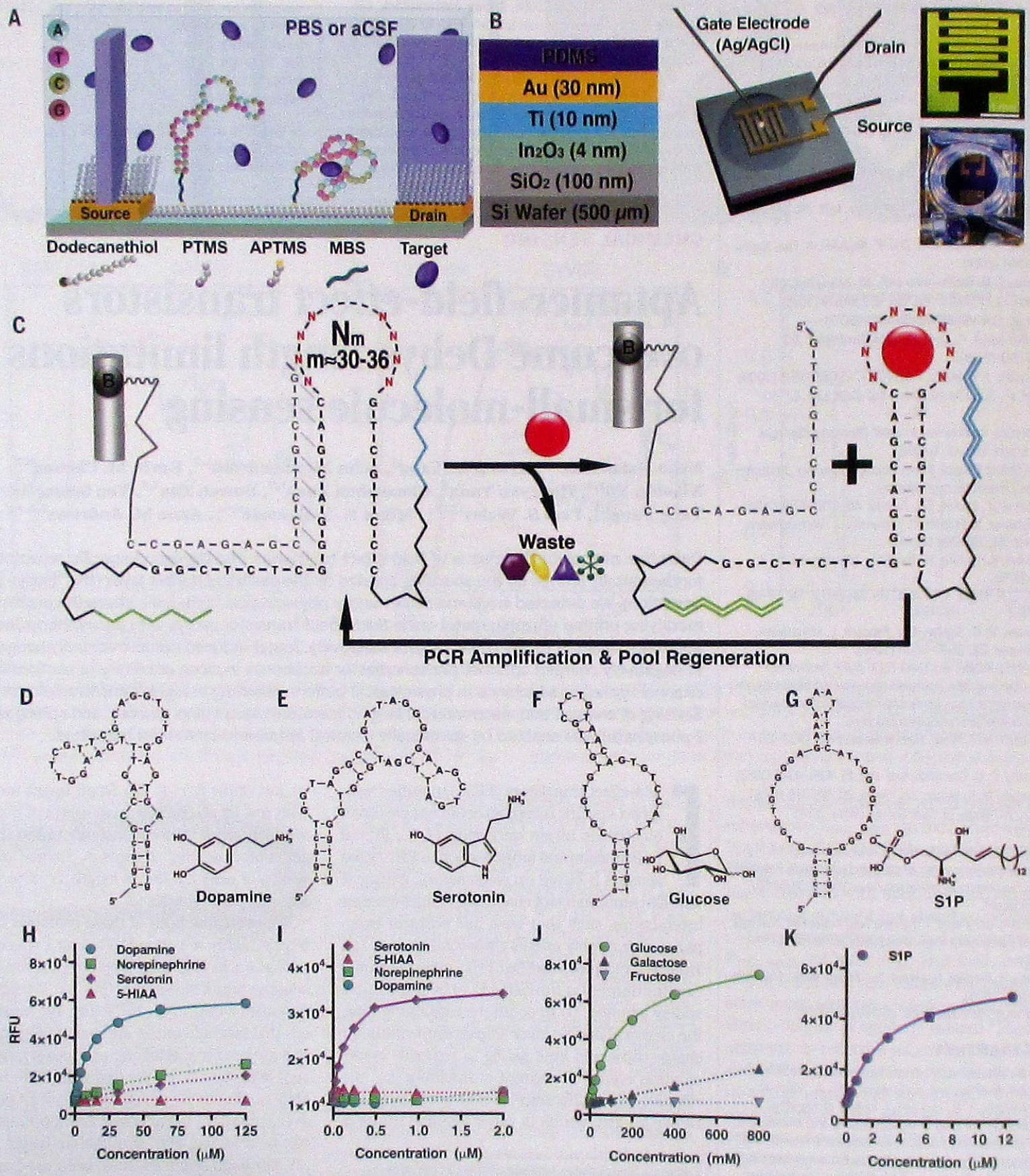
This bioinspired photocontrollable device has been used in a pick-up and drop-down system for transporting planar and three-dimensional solid objects.

Extra Stuff

1. FETs used for small molecule sensing.

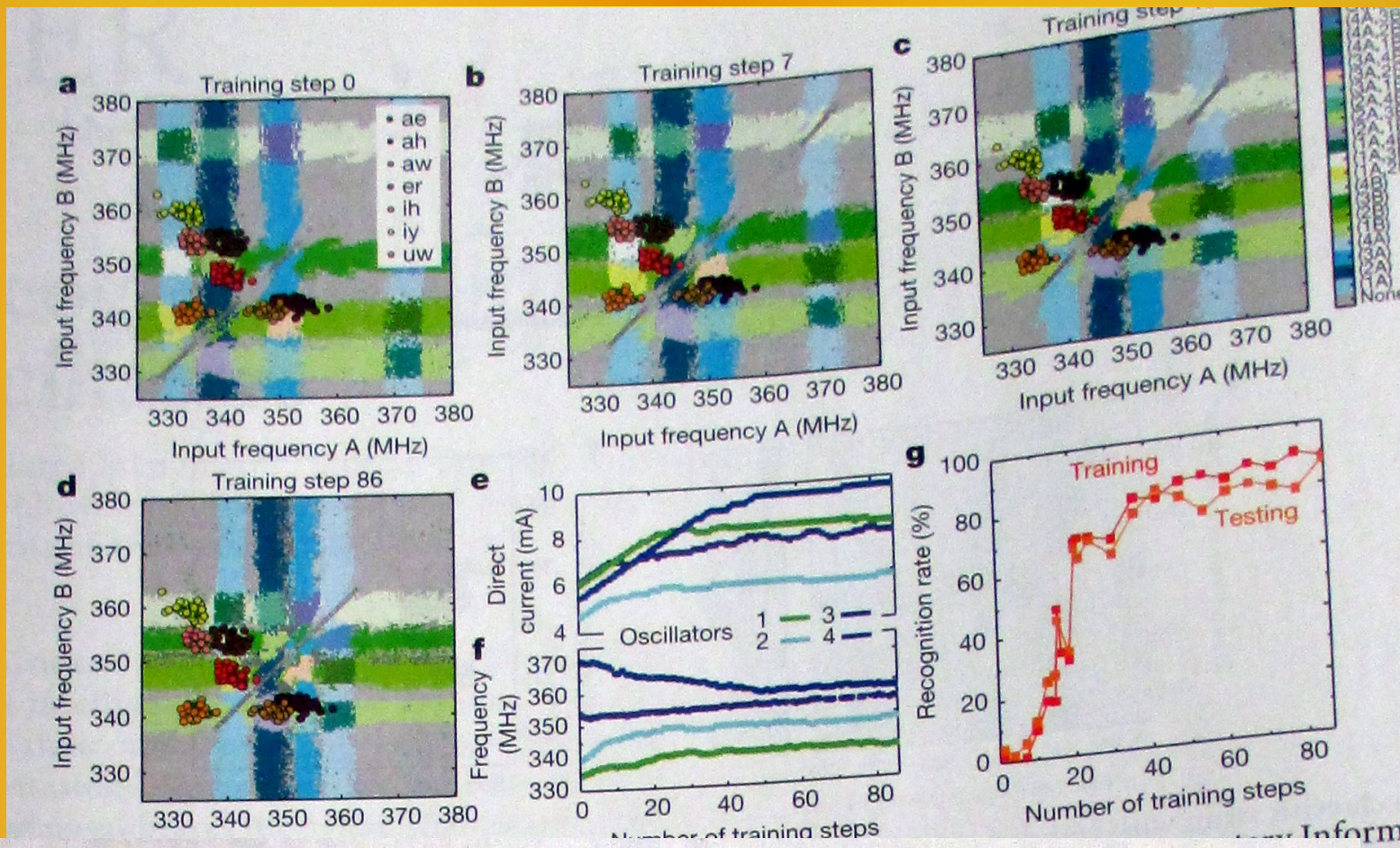
Debye length (double layer electonic interference) limits organic sensing normally, BUT!, can use Deoxyribonucleotides as “links” to overcome prximity problem. Target-induced conformational changes cause change in field (effect) and thus sensing of organics. e.g. dopamine, serotonin, glucose, etc.
e.g. use - Parkinson’s Disease control.

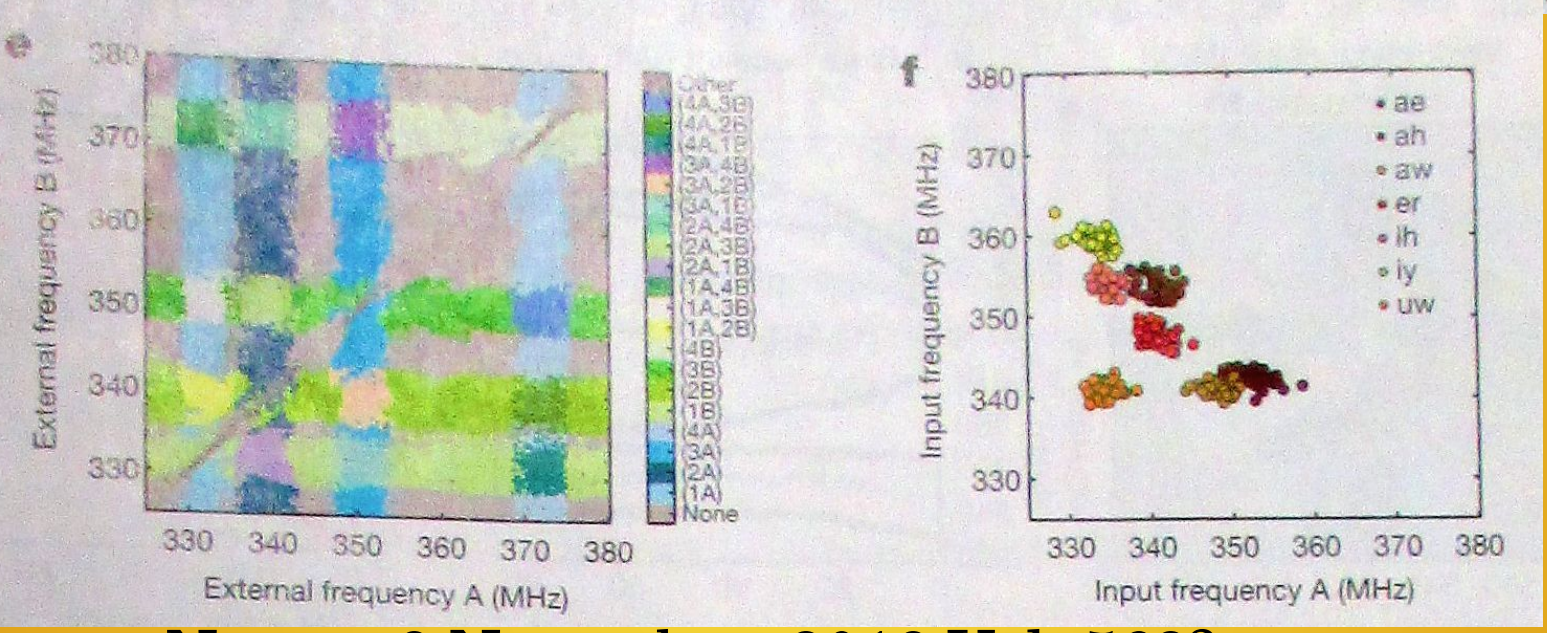
1. FETs used for small molecule sensing.



3. Voice Recognition using nano-scillators

Pattern classification with coupled spin-torque nano-oscillators provide input to Neural Net analysis of speech.





Nature 8 November, 2018 Vol. 563?

4. Heart Printing

Jennifer Lewis uses 3-D printing of heart muscle tissue but the problem is that they do not have blood vessels. She uses removable strands of "fugitive ink" to form a skeleton. Uses self-healing polymers to print a network of channels which later dissolve leaving vessel tubes. Fugitive ink is a gel at room temperature but liquefies at 4 deg C.

Removable strands of "fugitive ink" are crucial to 3D printing tissues for organs such as kidneys

J. Lewis – Bioprinting New Scientist, 17 Nov 2018

Sensors:

Corkscrew eye microbots?

Robots that swim when propelled by a magnetic field may be used to deliver drugs to the retina.

Max Plank Institute, used glass electrodes with iron plus a coating to go through the collagen mesh of the cornea.
2 micrometre long.
Prevents drug diffusion if just injected.
Ref: Sci Advances 4, eaat4388 (2018)

Sensors:

NEUROSCIENCE

PIEZOs mediate neuronal sensing of blood pressure and the baroreceptor reflex

Wei-Zheng Zeng[1], Kara L. Marshall[1], Soohong Min[2], Ihab Daou[1], Mark W. Chapleau[3,4], Francois M. Abboud[3], Stephen D. Liberles[2], Ardem Patapoutian[1]*

Activation of stretch-sensitive baroreceptor neurons exerts acute control over heart rate and blood pressure. Although this homeostatic baroreflex has been described for more than 80 years, the molecular identity of baroreceptor mechanosensitivity remains unknown. We discovered that mechanically activated ion channels PIEZO1 and PIEZO2 are together required for baroreception. Genetic ablation of both *Piezo1* and *Piezo2* in the nodose and petrosal sensory ganglia of mice abolished drug-induced baroreflex and aortic depressor nerve activity. Awake, behaving animals that lack *Piezos* had labile hypertension and increased blood pressure variability, consistent with phenotypes in baroreceptor-denervated animals and humans with baroreflex failure. Optogenetic activation of *Piezo2*-positive sensory afferents was sufficient to initiate baroreflex in mice. These findings suggest that PIEZO1 and PIEZO2 are the long-sought baroreceptor mechanosensors critical for acute blood pressure control.

Zombie baby minders attack!!

Use Mirai virus on people who insist on using IoT with “admin / admin” for name and login.

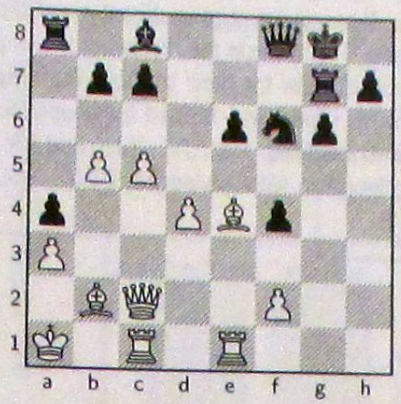
algorithm

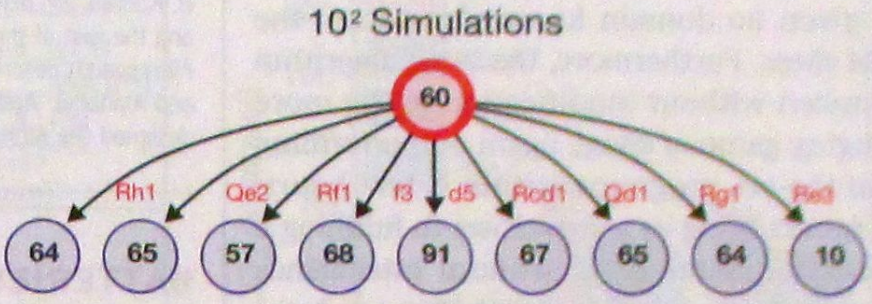
AlphaGo Zero algorithm is replaced by one that is self-adaptive. Generalised the AlphaGo Zero to allow reinforcement learning from self-play (Vs 'observing' a set of plays, for exmple by experts.) Don't think they used deep convolutional neural network approach.

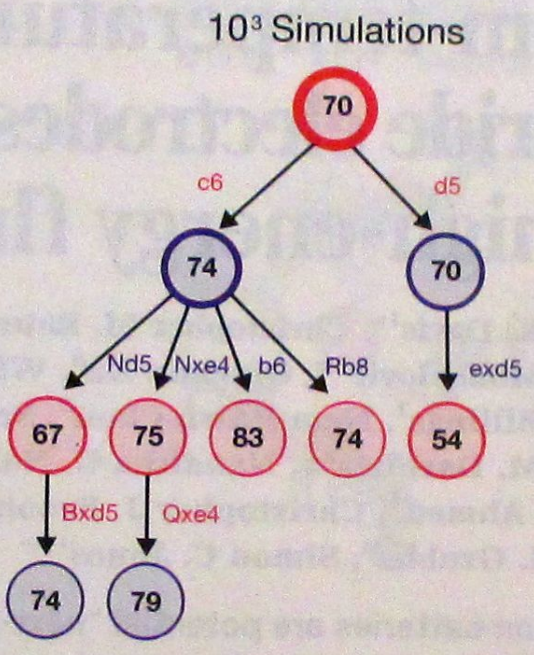
AlphaZero uses a Monte Carlo tree search algorith instead of alpha-beta searching with domain-specific enhancement.

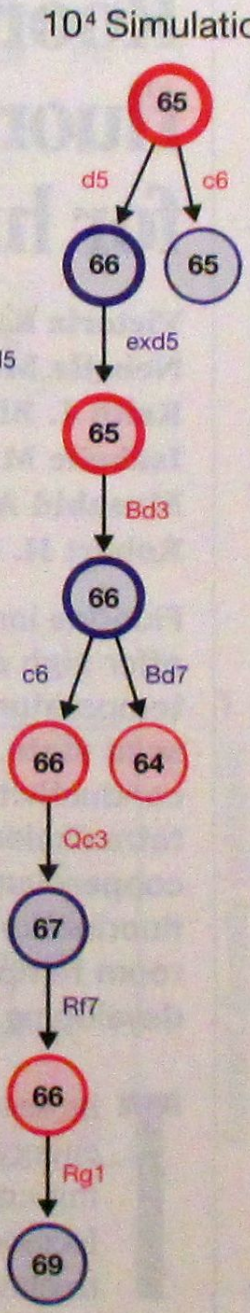
This reader did not understand the paper!
But you might?

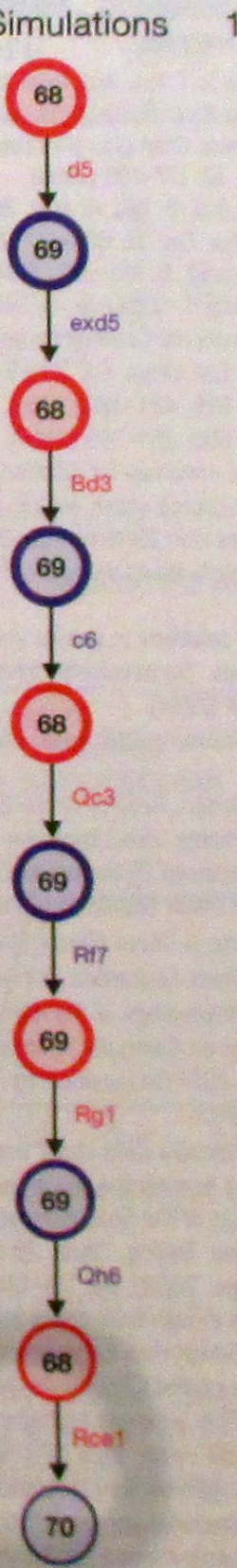
Science, 7 Dec., 2018

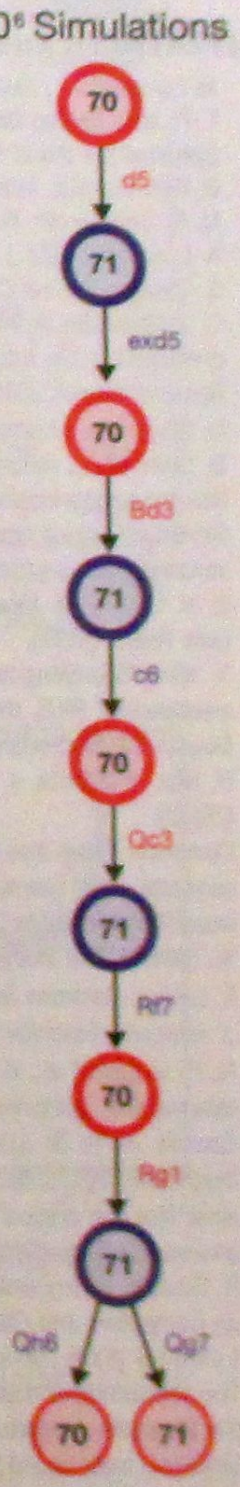



10^2 Simulations
60
Rh1
Qe2
Rf1
f3
d5
Rcd1
Qd1
Rg1
Re3
64
65
57
68
91
67
65
64
10


10^3 Simulations
70
c6
d5
74
70
Nd5
Nxe4
b6
Rb8
exd5
67
75
83
74
54
Bxd5
Qxe4
74
79


10^4 Simulations
65
d5
c6
66
65
exd5
65
Bd3
66
c6
Bd7
66
64
Qc3
67
Rf7
66
Rg1
69


10^5 Simulations
68
d5
69
exd5
68
Bd3
69
c6
68
Qc3
69
Rf7
69
Rg1
69
Qh6
68
Rce1
70


10^6 Simulations
70
d5
71
exd5
70
Bd3
71
c6
70
Qc3
71
Rf7
70
Rg1
71
Qh6
Qg7
70
71