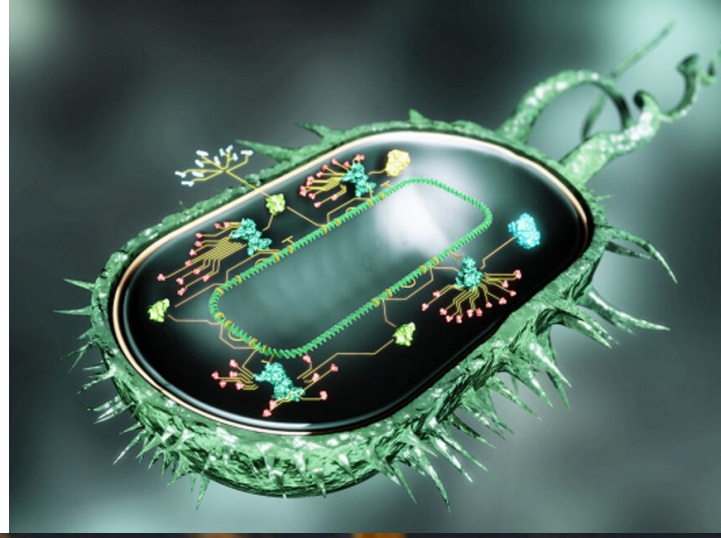
Synthetic organisms and bio-hybrid systems

By Nick Jarman and Sam Rosen

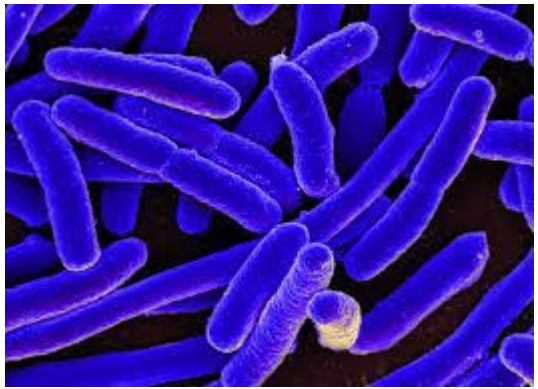
Introduction

- Synthetic organism
- Bio-hybrid systems



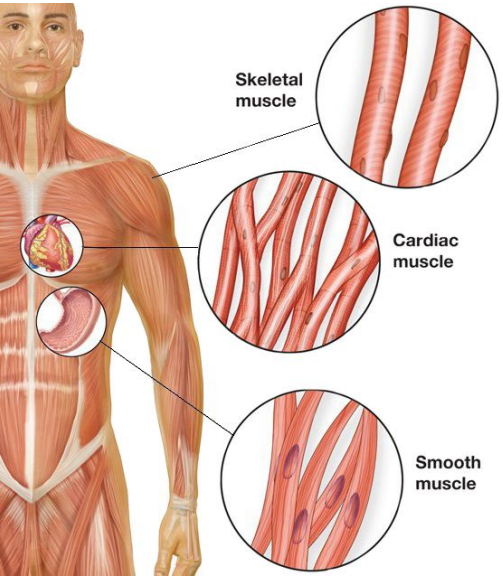
History of synthetic organisms

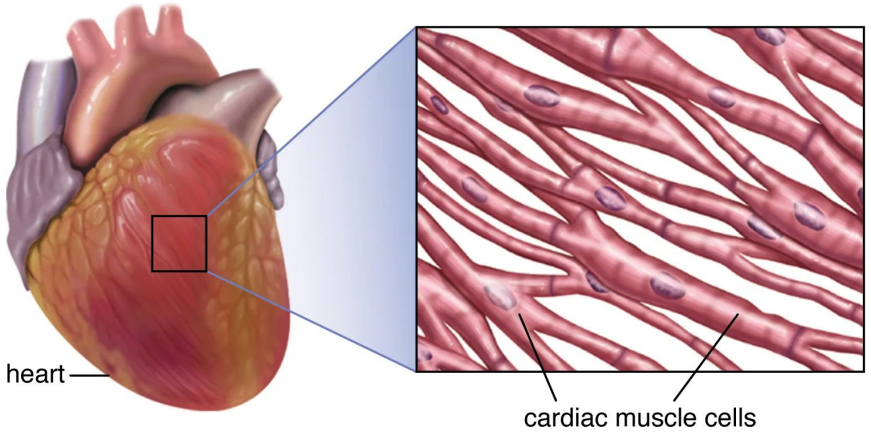
- Escherichia coli (E. coli)
  - 0157:H7
  - Infection rate
  - September 1997
  - Immune to infection



History of Bio-hybrid systems

- First use
  - Cardiac and smooth muscle
  - No random contracts or driving stimulus
  - Insects are guinea pigs





Organic Mixed Ionic-Electronic Conductors

- Creating Bio-Hybrid Systems is as much an engineering problem as a Computer Science one
- Must be durable, flexible, and low voltage, requiring both p and n type semiconductors.
- Required to make logic gates within Bio-Hybrid System circuits.
- Trying to incorporate these into Hardware based Neural Networks.
    - Rapidly classify different bio-signals without outside computing.
    - Feeds these signals into a Neuromorphic classification array.
    - Application in electromyography(EMGs) and electrocardiograms(EKGs).

Current Limitations

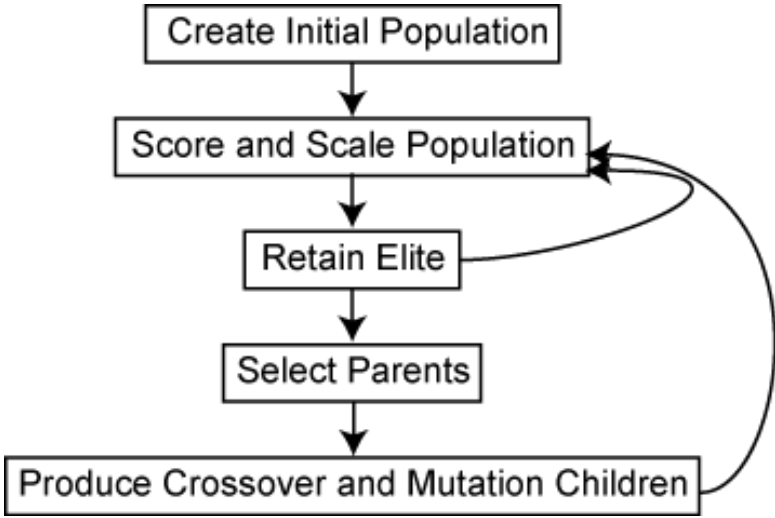
- Hardware
  - Very few materials that are suitable for use as an n-type semiconductor in Bio-hybrid applications
    - Possible solution is to make an ambipolar material that can act as both an n and p type semiconductor
  - Many of the Bio signals need to be amplified in order to work effectively.
- On site computing still has not been realized, so these devices still only act as sensors that relay information.

Synthetic Fish

- Synthetic Organisms take inspiration from biological organisms to perform tasks.
- A bit like how the Neural Network takes inspiration from the brain
- One study conducted looked into creating an adaptive swimming machine.
  - Used batoid fish (like the Manta-Ray) as a model for the propulsion of a swimming machine.
    - Quickness, agility, and endurance
    - Locomote very simply
  - Different species of batoid fish are adapted to different niches.
  - They use this variation to strive toward an adaptive machine.
  - They made a model of the machine and used the WeBots simulation environment with a genetic algorithm to optimize the design of the machine.

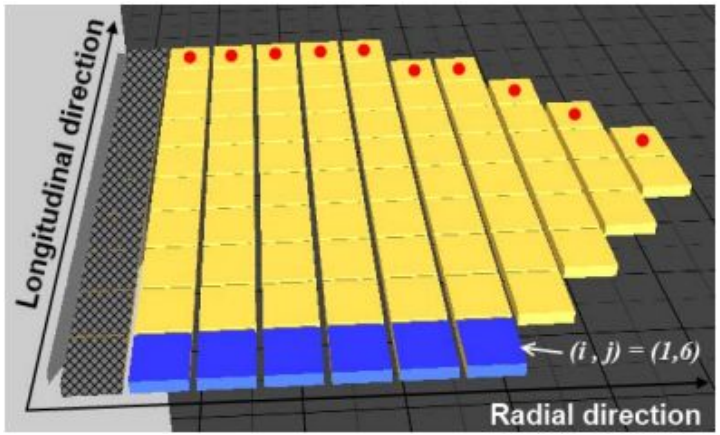
Genetic Algorithms

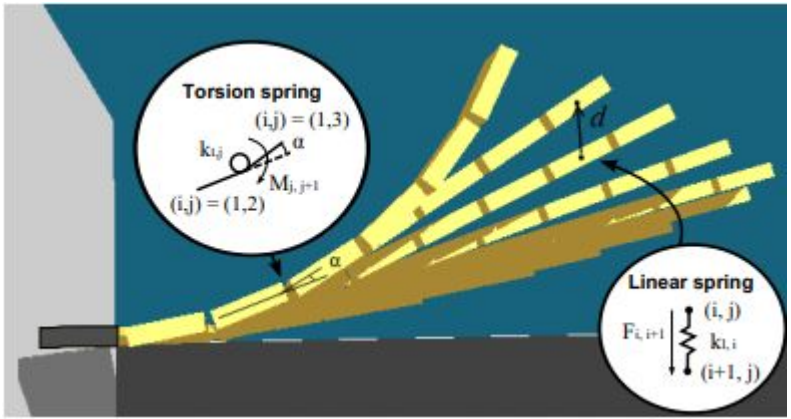
- “Genetic Algorithms are general purpose search algorithms which use principles inspired by natural genetic populations to evolve solutions to problems.”
- There is a population of different solutions to an unchanging problem that evolve over time through competition with each other over which one solves the problem the best.
    - The most “fit” solutions are chose to create new solutions through “selection”.
    - These new solutions have a mix of traits from other solutions and some brand new features(mutations).
    - This draws upon the natural phenomenon of Natural selection which is one of the main drivers of the evolution of organisms to be more successful in their environment.
- Generations of this competition and new creation leads to information accumulation and optimization of solutions.



Synthetic Fish

- Used their model and Genetic Algorithm to try to create an optimized swimming machine design.
  - Performed this multiple times in different simulated water conditions.
  - Genetic Algorithm used was offered by the MATLAB 2011b Global Optimization Toolbox.
- Running this simulation multiple times with different water conditions produced data on optimal designs for those conditions.
- This data lead to synthesizing designs into a generalist swimming machine design.





Conclusion

- E coli
- Bio-hybrid’s first use
- Current use
- Successful test

Sources

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