Lecture: Introduction

Ref book: Biology for Engineers - Arthur T. Johnson [2nd edition]
Biology for Engineers – G. K. Suraishkumar

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United International **University**

Web ref provided on slides
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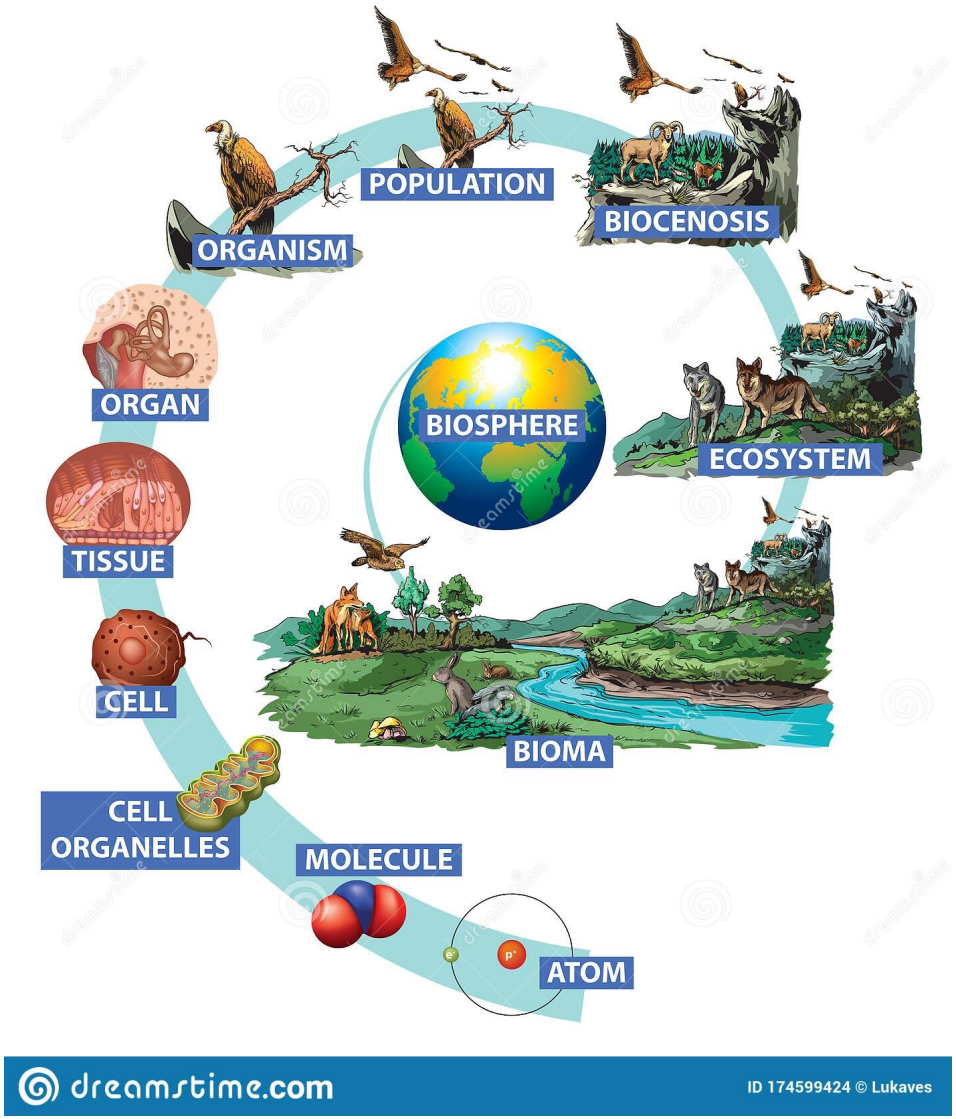
Introduction: Why Biology in Engineering

- We all are biological entities
- Know yourself, know how you function
- Understand your surroundings
- Use environment for technology
- Do yourself a favor, save the world
- Research and Upcoming Biotechnology

Ref: wikipedia

Introduction: Why Biology in Engineering

- **Exploring the Living World**
- It All Starts with a Cell: The absolute smallest unit of life is a single cell



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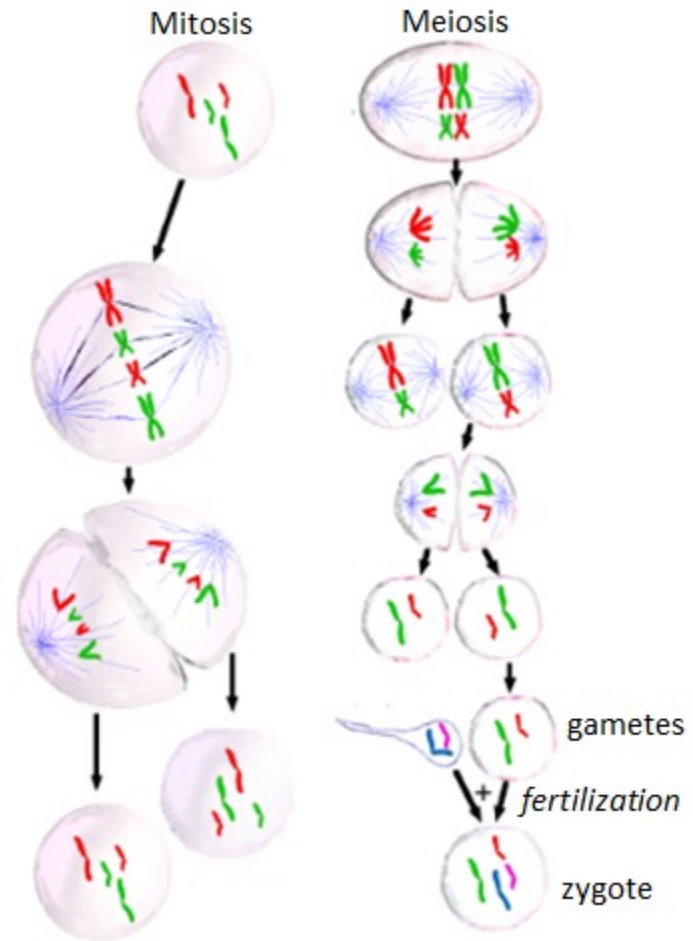
Introduction: Why Biology in Engineering

- Life Begets Life: Reproduction and Genetics
- You began life as a single cell
- Your genes are found in your DNA, which is in turn found in your chromosomes



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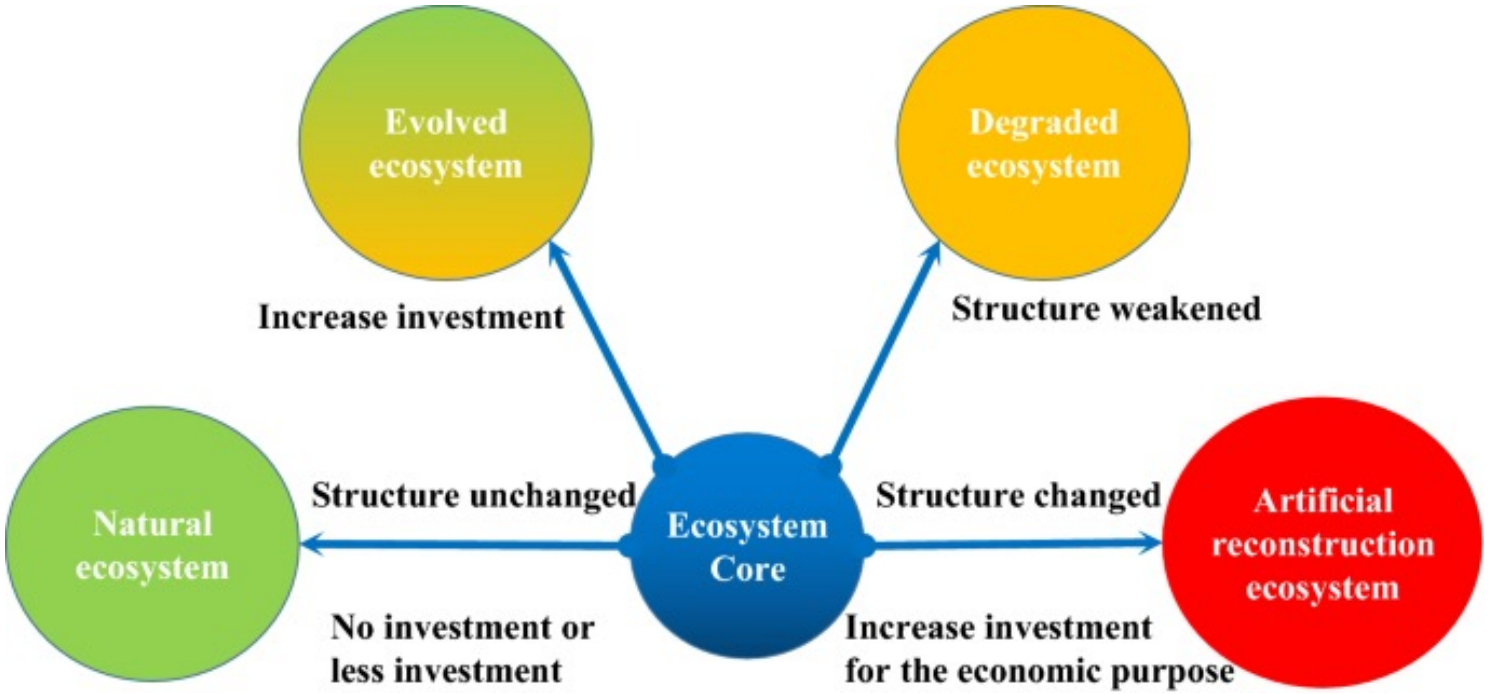
- Making the Connection between Ecosystems and Evolution



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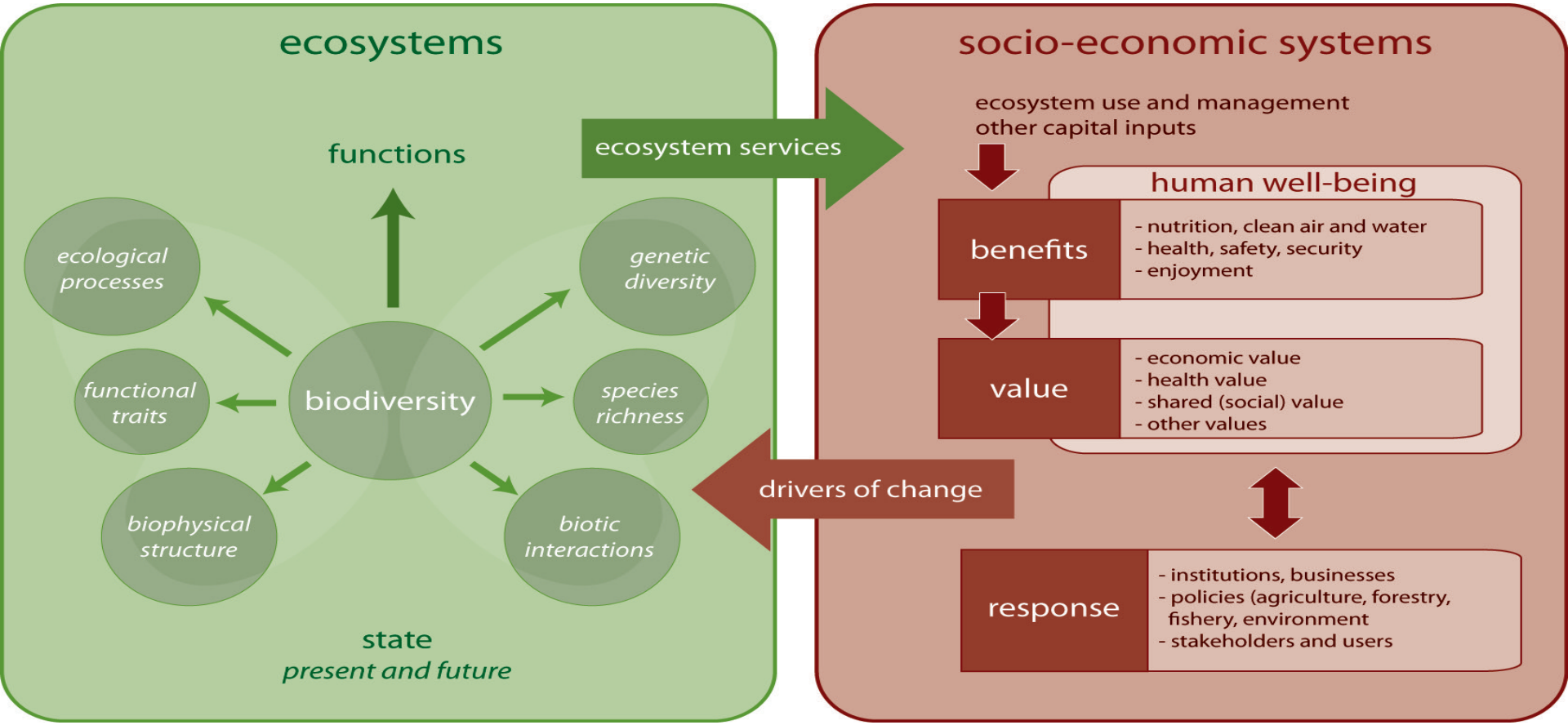

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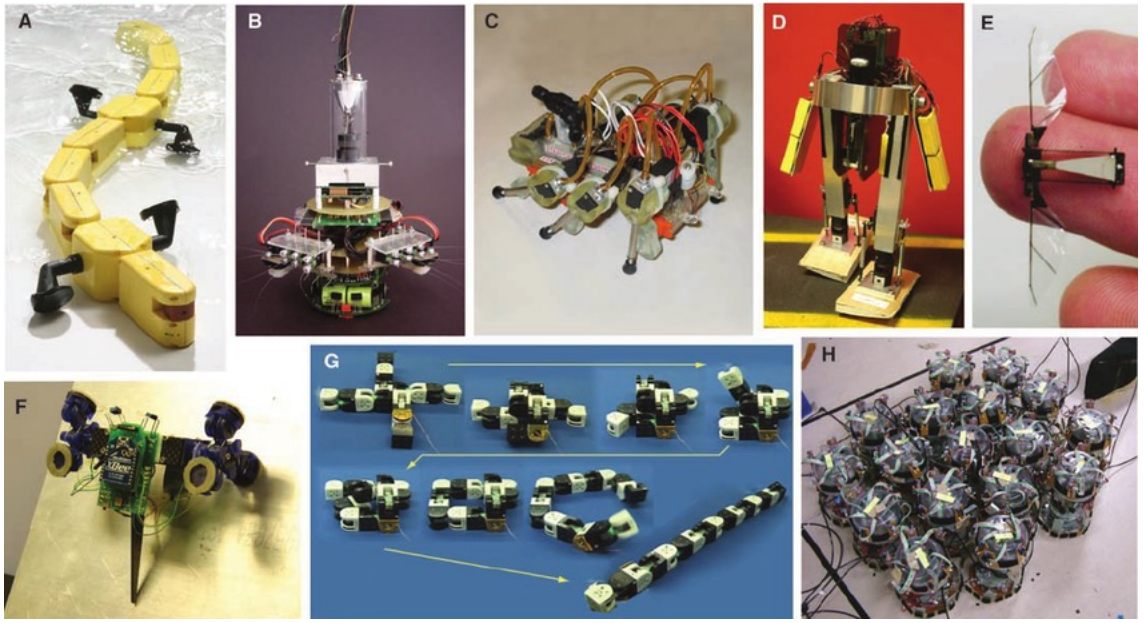
Introduction: Play with Biology



- Modern Technology based on Biological Systems

Bio-robotics It refers to robots that are inspired by biological entities or the use of biological components in robots. In reality, there have been many initiatives such as ‘artificial sensing skin’, which can detect pressure changes upon touch, robots inspired by animal movements, and softer robots that interface with the body for various prosthetics, or to provide insights into the working of natural systems.

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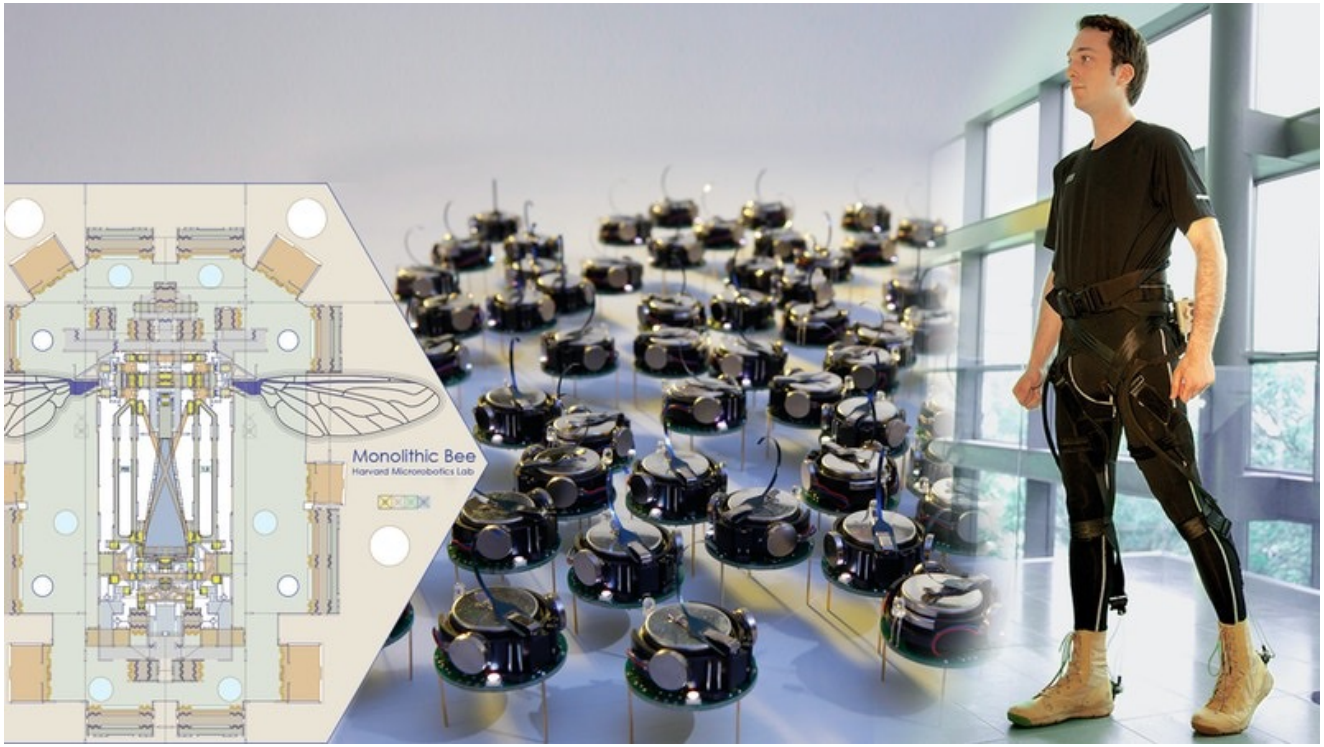

- These softer bio-robots provide distinct advantages over rigid robots that are traditionally used for various automated operations, for example, in the assembly line for cars. The bio-robots can be used to perform intricate tasks which the traditional ones cannot perform. More recently, a number of androids (human-like robots) have even passed the Turing test, a test devised by Alan Turing to differentiate between humans and robots.

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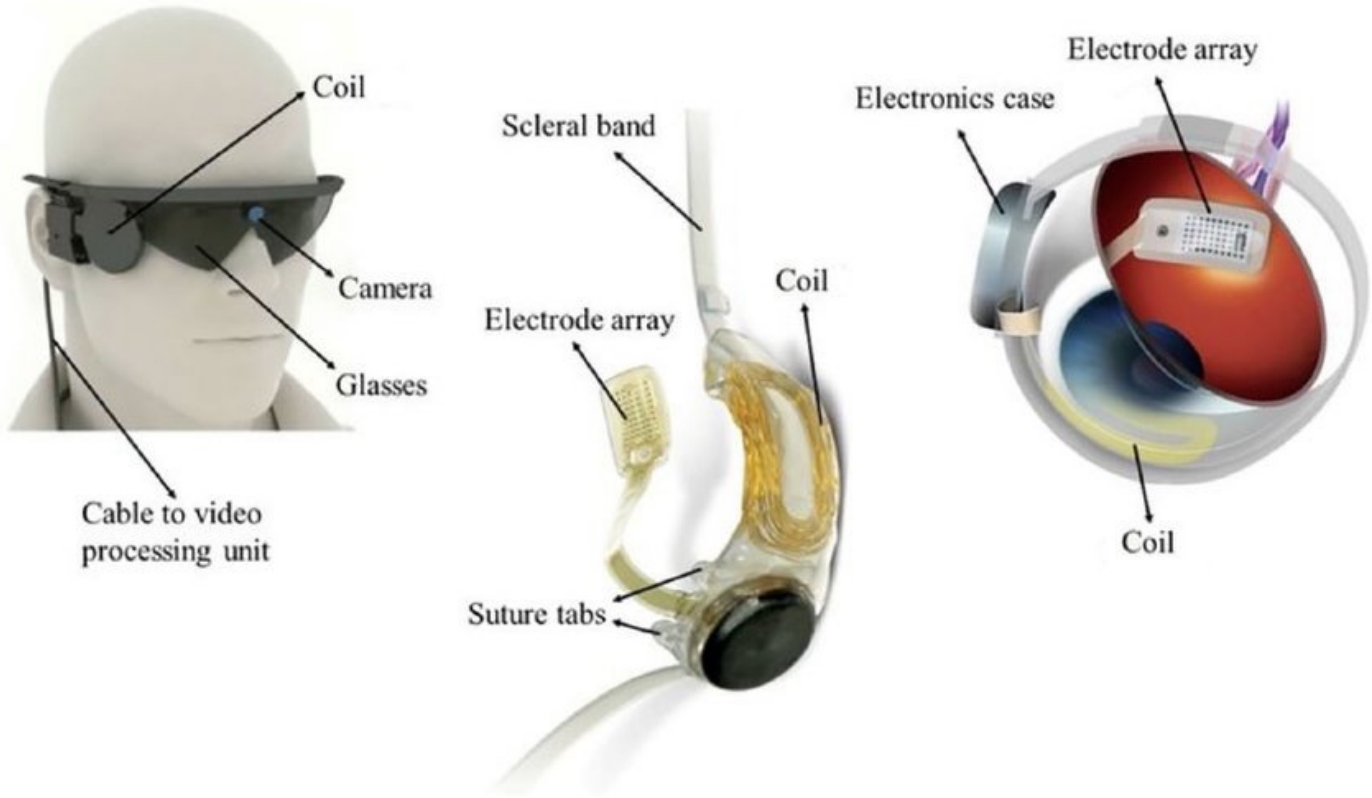

Retinal Prosthetic Let us now consider one of the many examples where the inputs from many engineering fields were effectively harnessed along with biology to provide eye-sight to people who could see due to retinal diseases such as macular degeneration.

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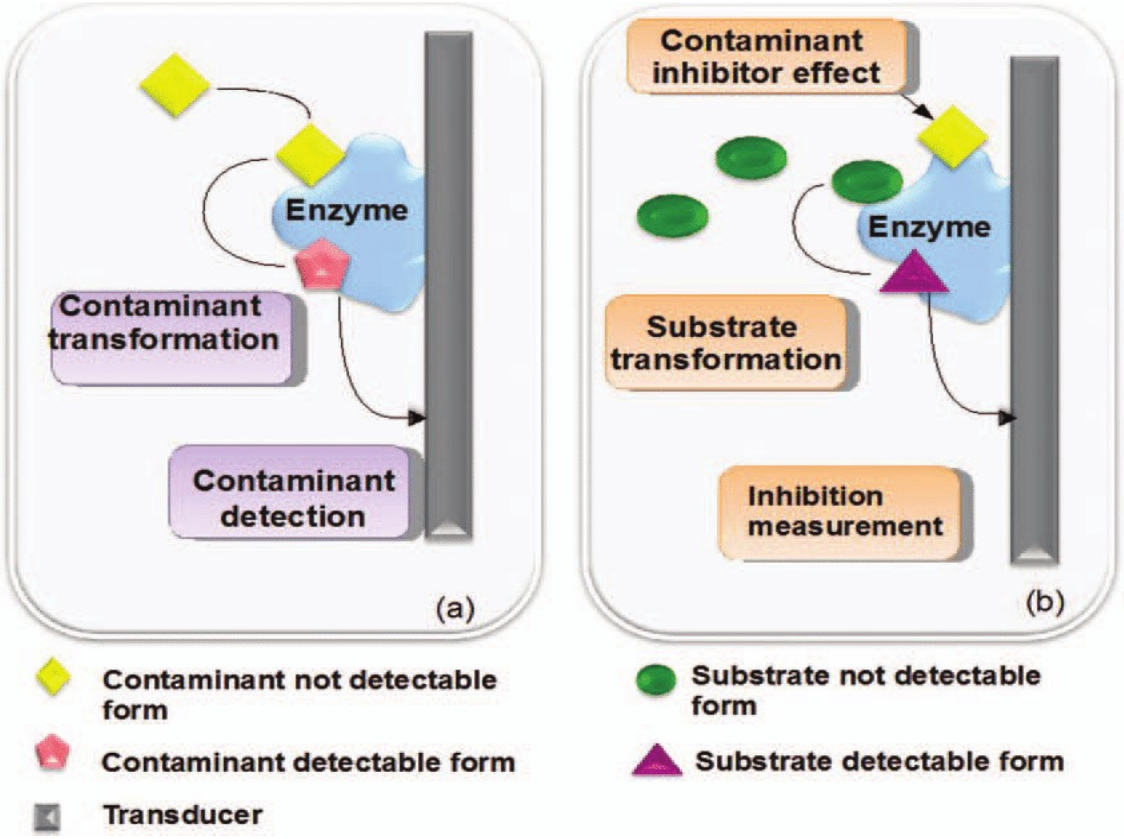

Bio-sensors These are devices that are used to measure many different parameters such as analyte concentrations. They are used for diverse purposes such as analysis, toxicology, medical diagnosis (i.e., they can even be incorporated into *digital plasters* to monitor the healing progress of wound), environmental monitoring, and others.

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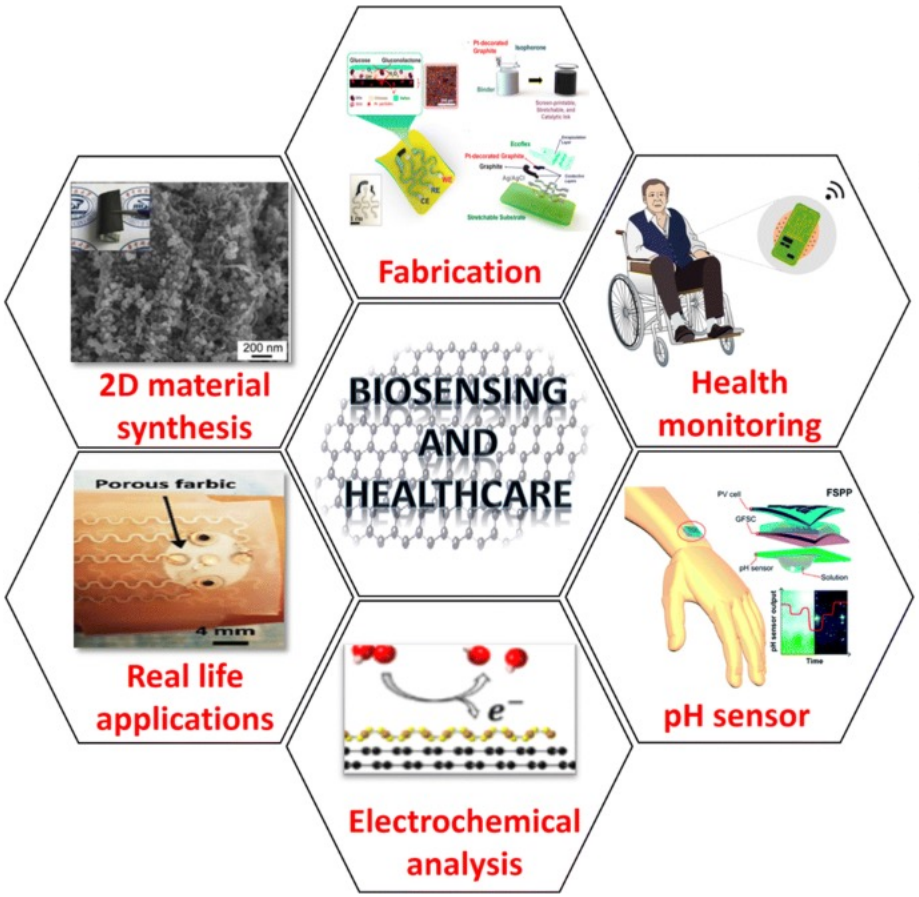

Commercial biosensors

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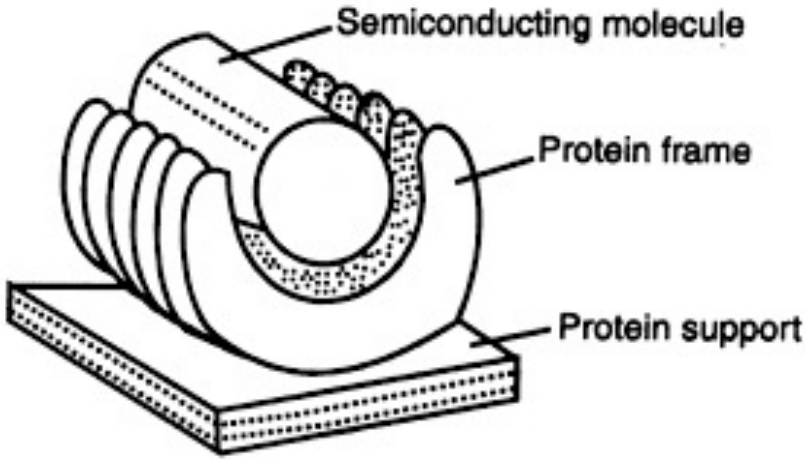

Bio-chips

Theseareminiaturisedlaboratoriesinwhichthousandsofbiochemicalreactionscan be carried out simultaneously at micron scales for useful purposes such as disease studies or safety studies.

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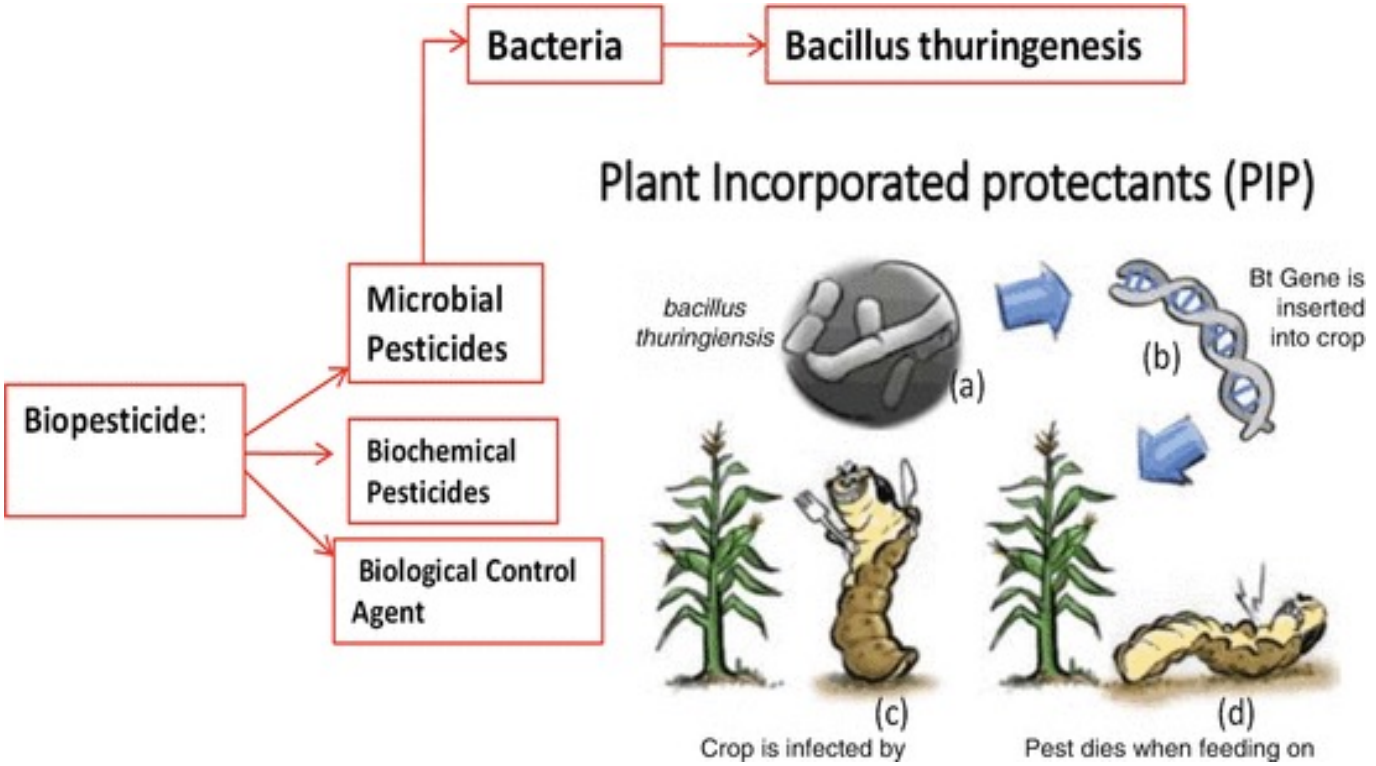

Bio-pesticides These are organisms that can be used instead of chemicals for pest control and thus they overcome the negative effects of chemical pesticides. In the same vein, *Bio-fertilizers* are fertilizers that are composed of appropriate microorganisms.

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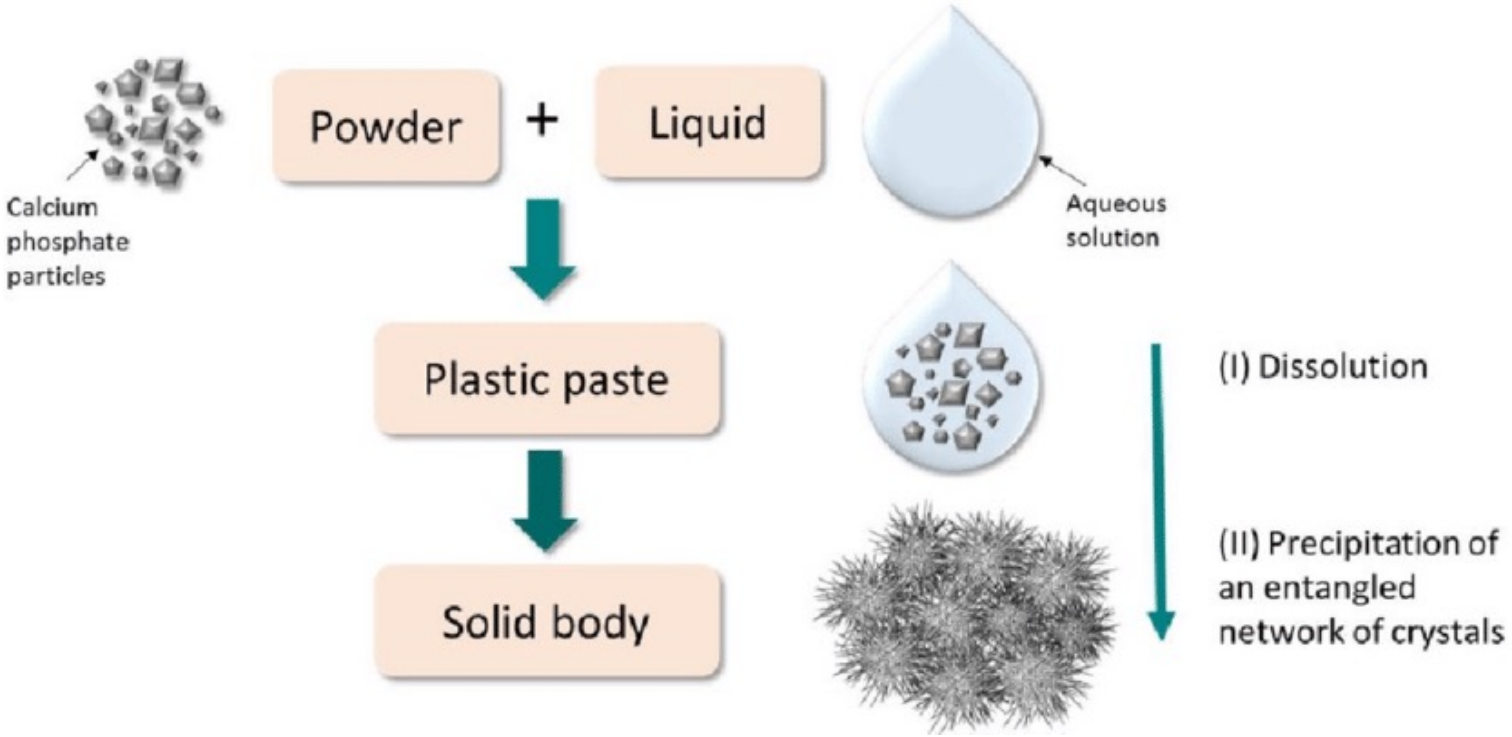

Concrete Self-heal Organisms can be used to make *concrete self-heal* its cracks due to wear- and-tear. For example, some bacteria can catalyse the formation of calcium carbonate in their surroundings under appropriate conditions.

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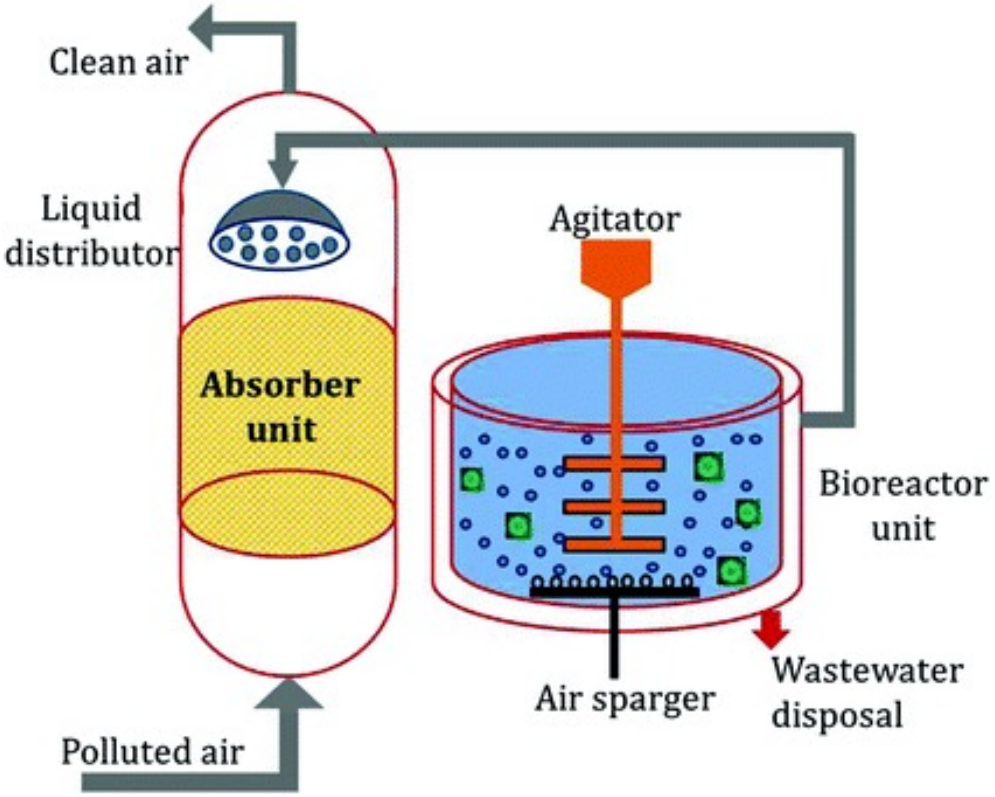

Bio-filters These are essentially sand columns containing organisms that are used in wastewater treatment. They can be used on a large scale to provide clean water to large areas such as fields and ponds. They can also be used on smaller scales to purify water for home-use in challenging regions of the world. They are accessible, sustainable, and affordable.

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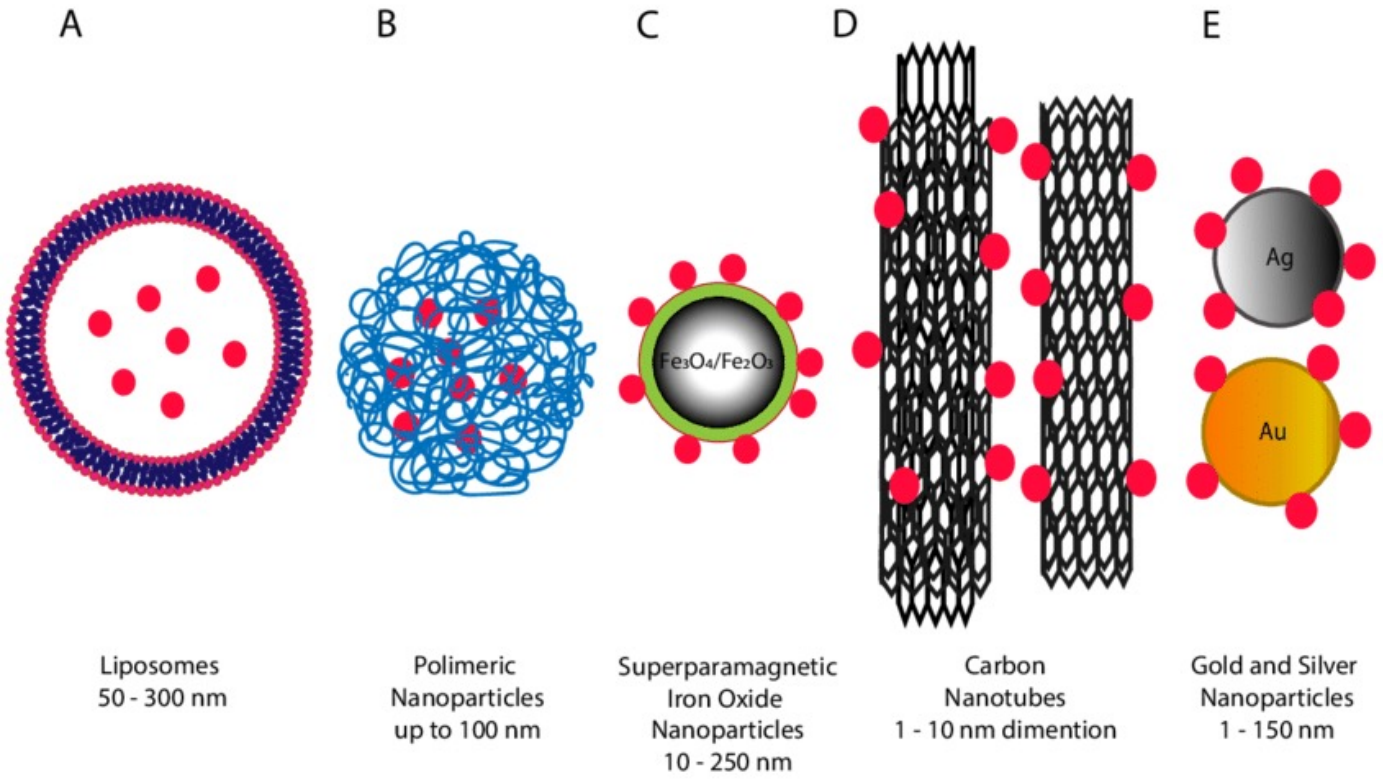

Nanoparticles These are particles of various shapes with sizes in the range of a few to a hundred nanometers. They have specialized physical and chemical properties because of their small size, which make them suitable for use for specialized needs. For example, *Nanoparticles for drug delivery* have been developed, which are effective in delivering anti-cancer drugs to cancer cells, without affecting normal cells.

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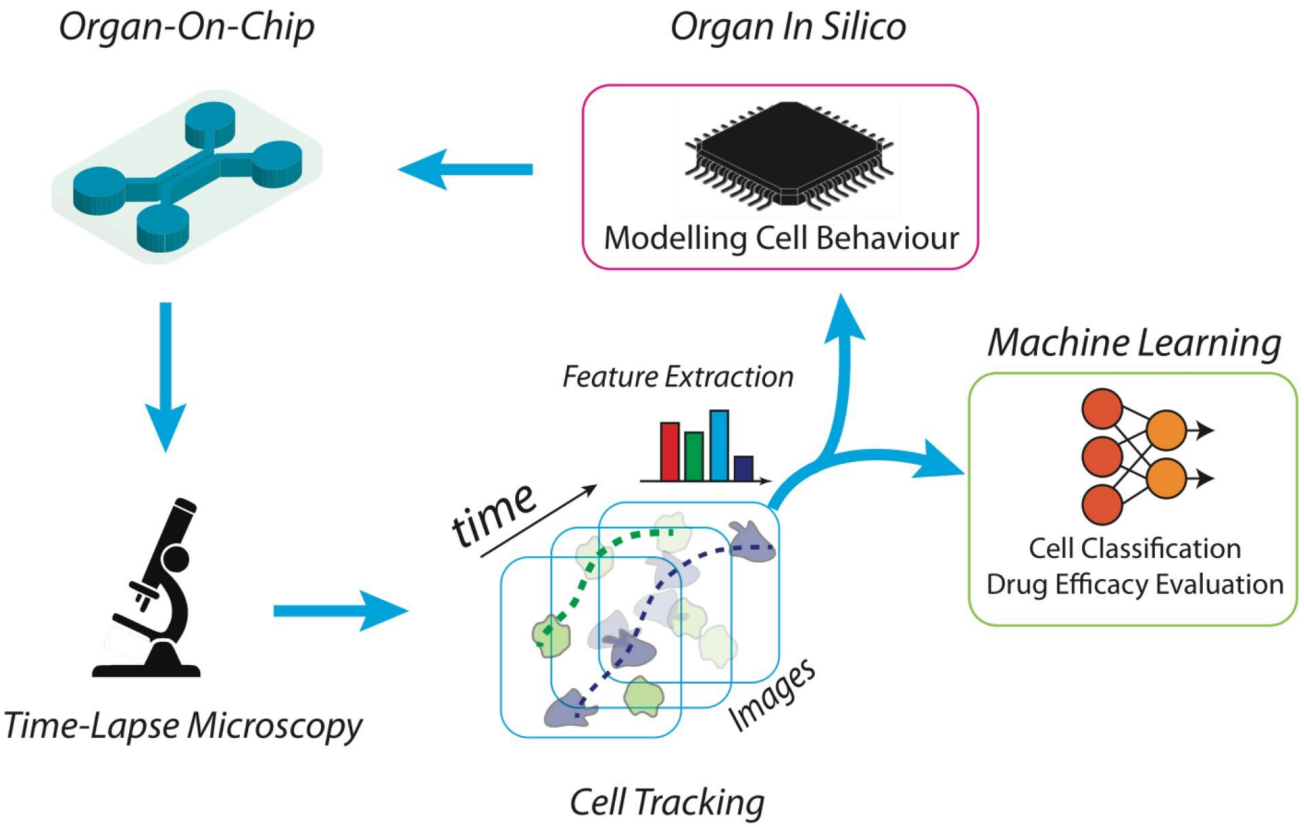

Organ-on-a-chip It is a micro set-up to test the effect of say, new drugs or toxins on representative animal tissues without actual animal studies. Microfluidic devices with small membranes and other support structures that can hold specialized organ cells are used to create the organs- on-a-chip. Body fluid-like materials that can flow on either side of the membrane, provide a functional representation of the real organ.

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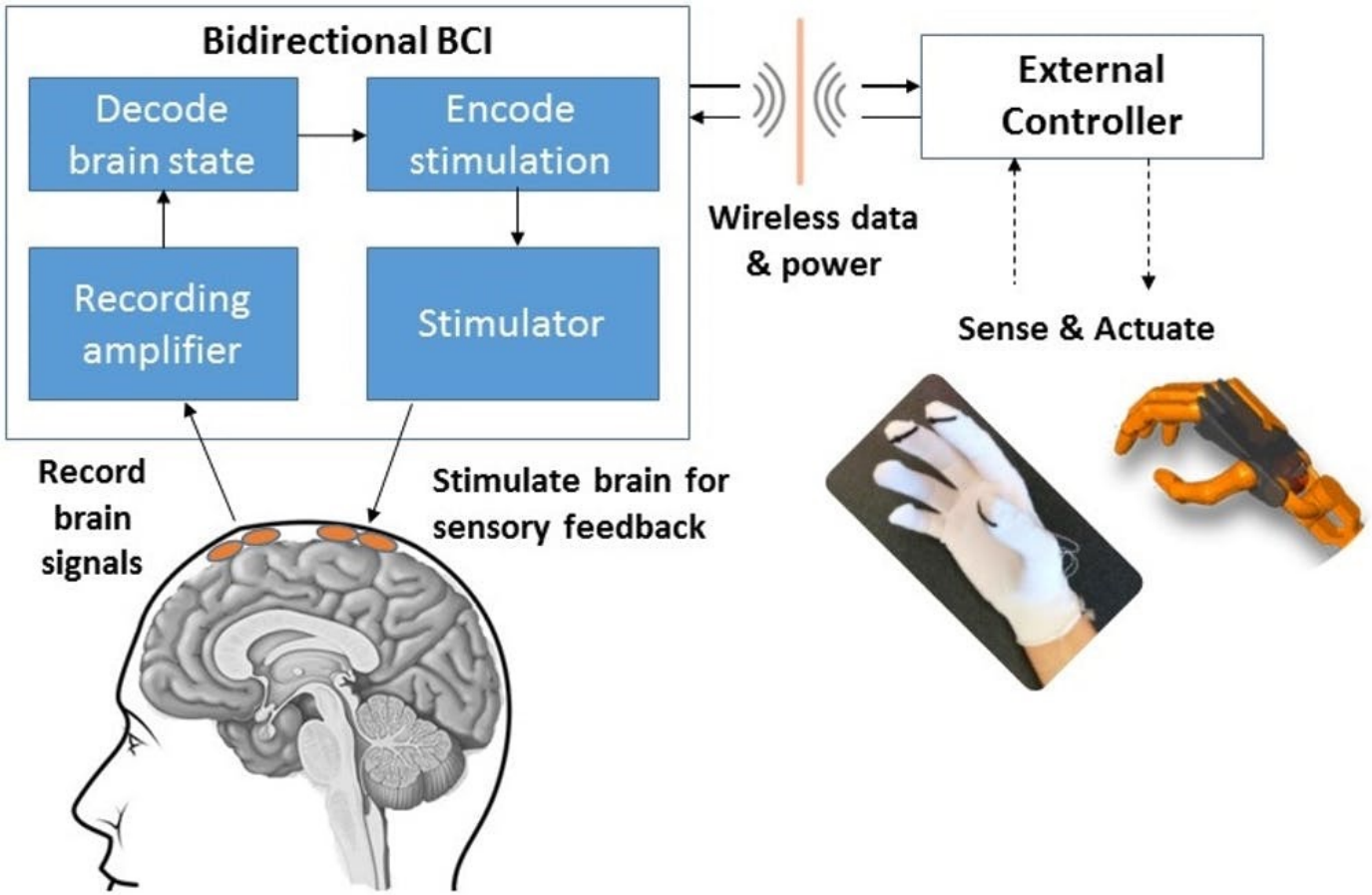
Introduction: Scope for Engineers

Brain and Neuroscience



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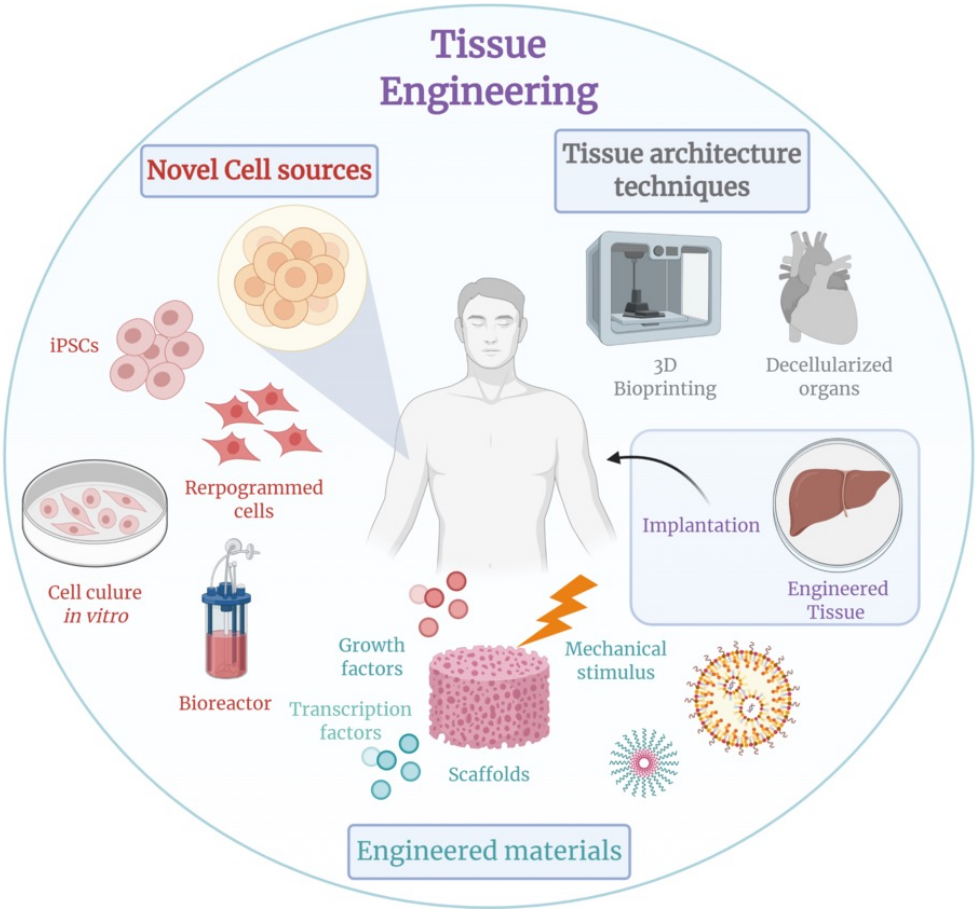
Tissue Engineering



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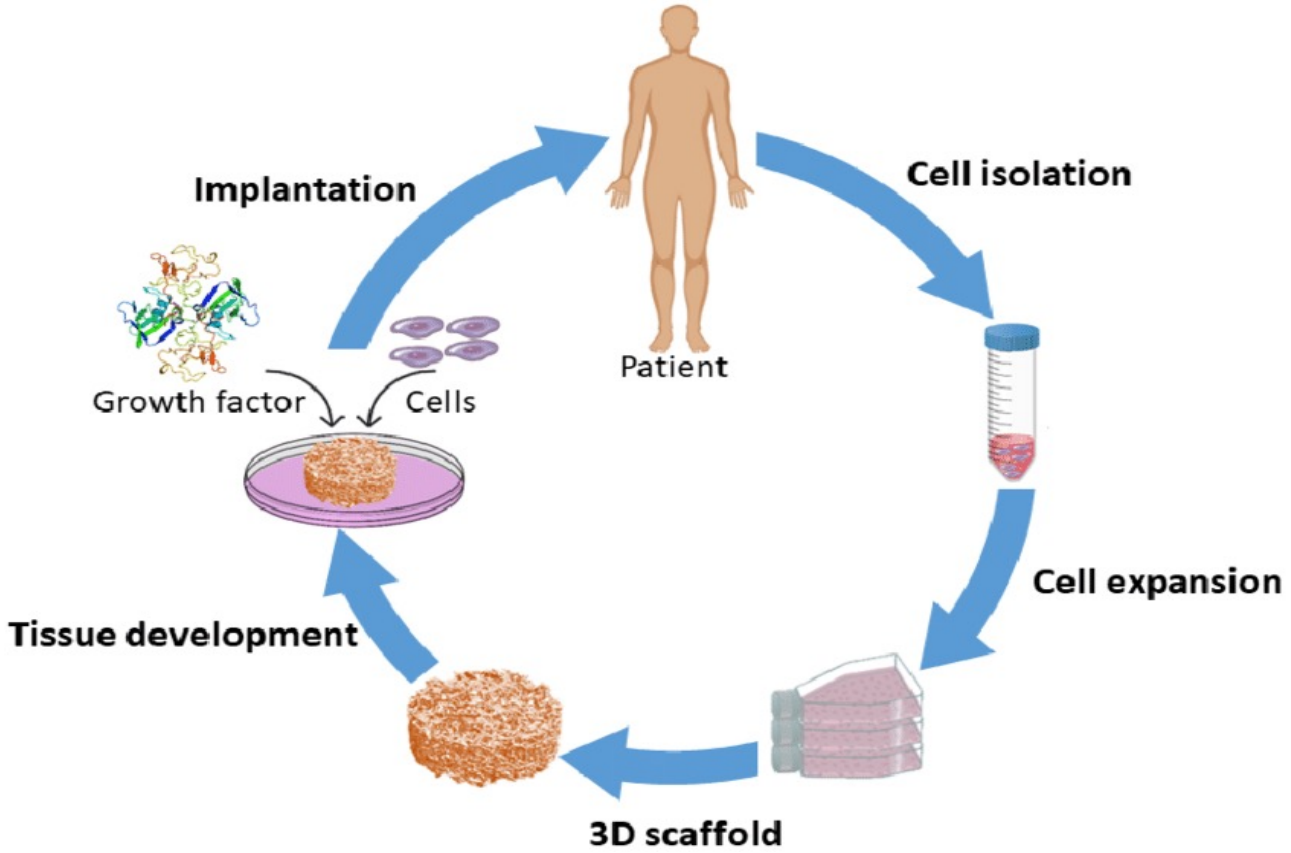

Muscular Bio-polymers These refer to specialized biopolymer nano-composites that can be used for artificial muscles, and so on. These specialized materials aim to have properties that are close to biological muscles such as excitability, contractility, elasticity, and extensibility. This example is only one advantage of engineers knowing biology, that is, inspiration or help with solutions to challenging problems.

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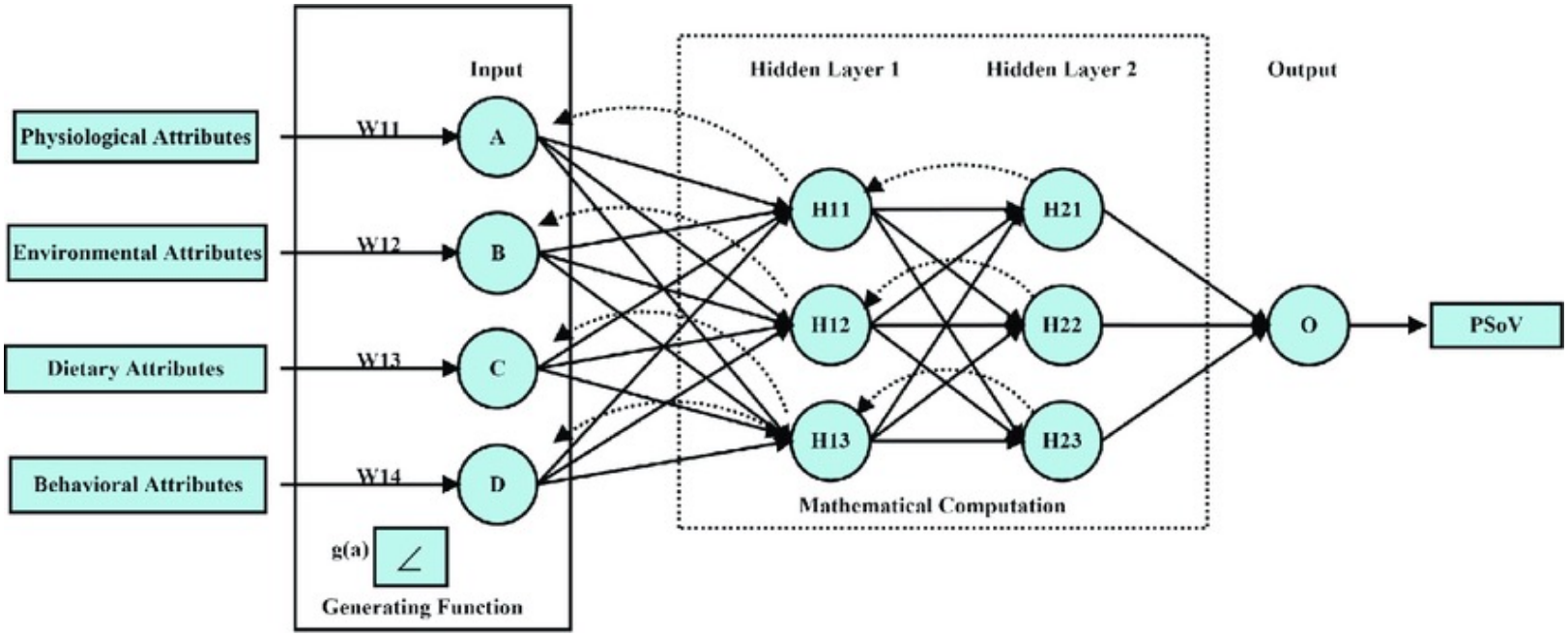

Artificial Neural Network The artificial neural network (ANN), a processing set-up, is supposedly inspired by the working of animal brains—they learn by example. ANNs are made up of a large number of interconnected elements, each of which work similar to a biological nerve cell. ANNs can be used to derive useful information from imprecise data. For example, they can be used to detect patterns or trends in complicated data that are difficult to detect by manual inspection.

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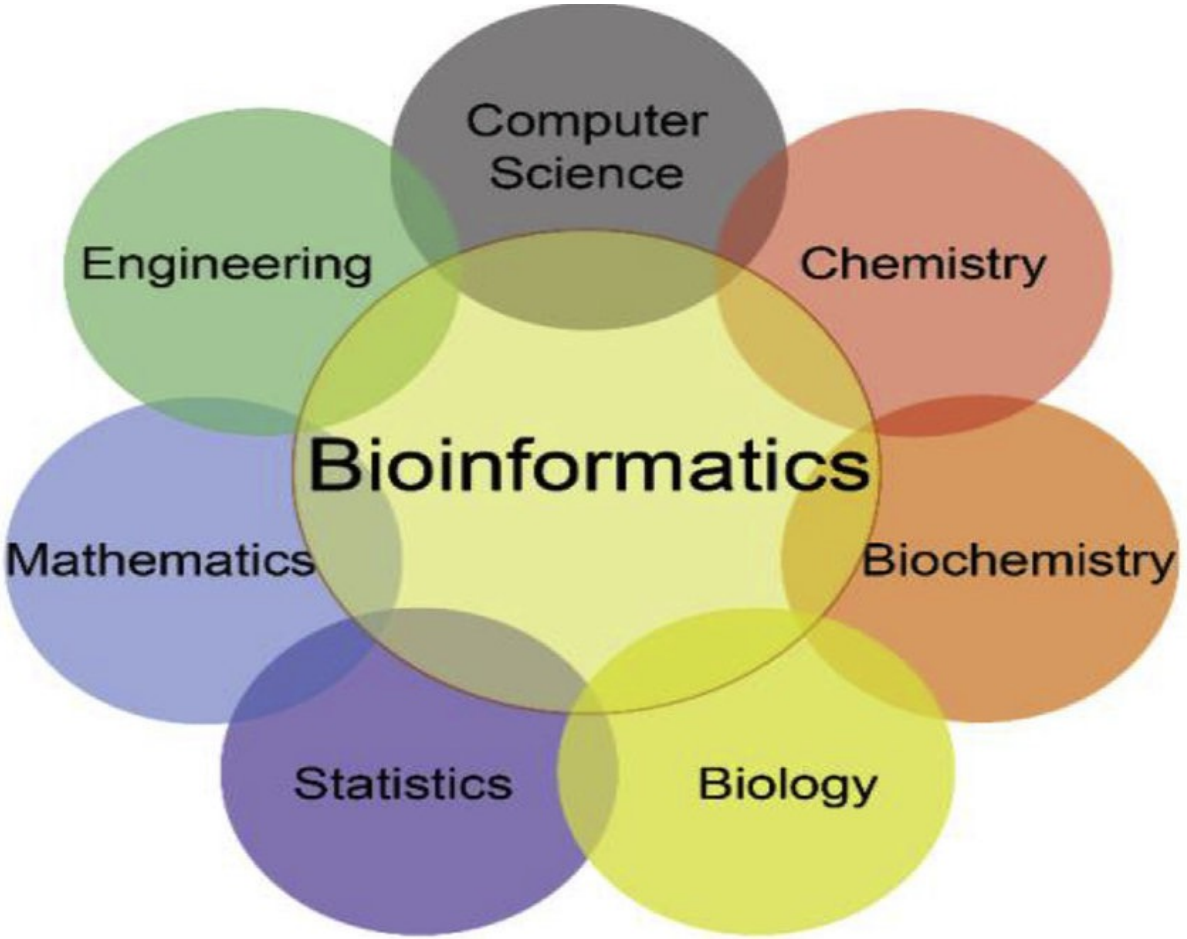
Bioinformatics, Systems Biology, and Computational Biology

These are currently popular fields of study which are highly multi-disciplinary, and engineers can significantly contribute to those fields. Those fields of study computationally analyse very large data sets to draw insights into the working of the fundamental functional unit of life—the cell. To make sense of such large data sets, people with backgrounds as diverse as computer science, biology, biochemistry, biological engineering, electronics engineering, and many others, need to come together.



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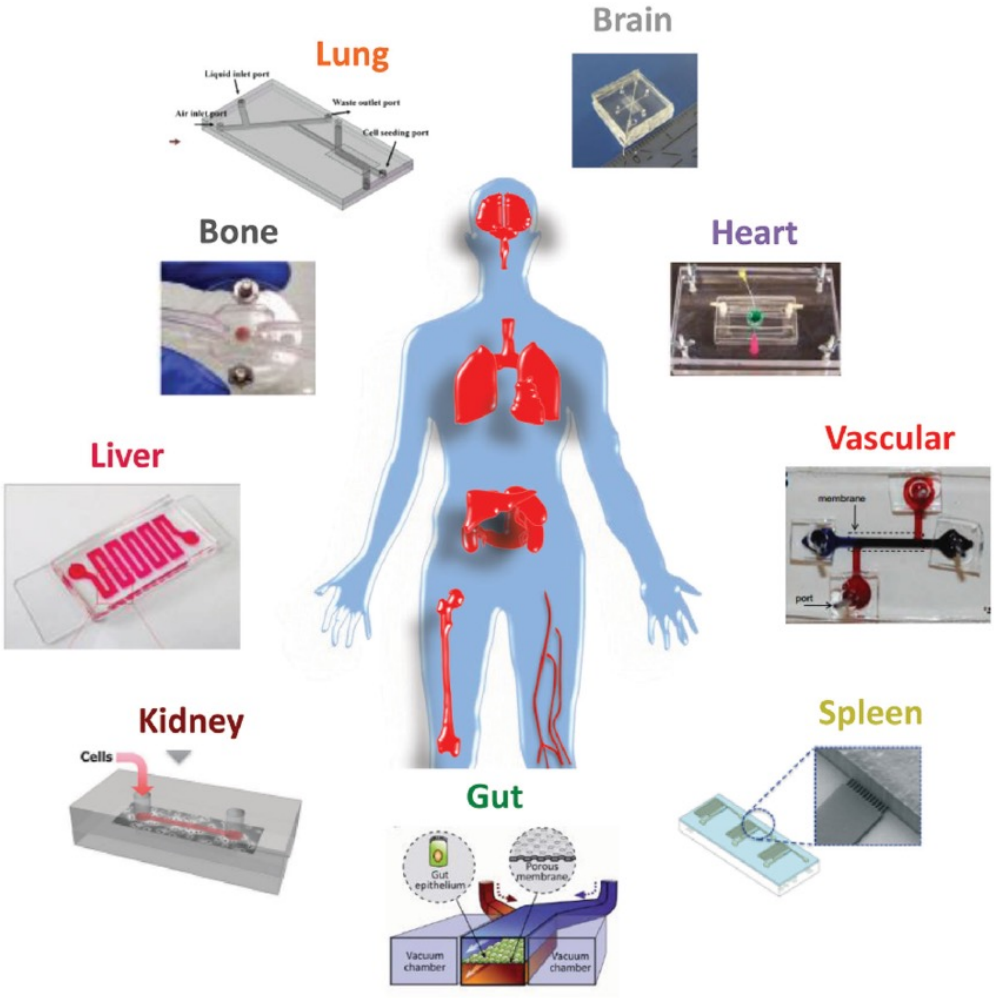
Organ-on-a-chip Body fluid-like materials that can flow on either side of the membrane, provide a functional representation of the real organ. Drugs to be tested are dissolved in those body fluid-like materials that are contacted with the tissue to test their effects on the organ tissues. The claim is that these organs-on-a-chip are closer to the human situation than the animals are, and thus the predictions could be much better. Further, whole *organs* can potentially be *3-D bio-printed* for various study purposes. However, 3-D bio-printing is a challenge because the biological cells need to be kept alive and vibrant during processing and printing. Cells need suitable nutrition and environment to be active, and techniques are being developed to maintain cells under desirable conditions.



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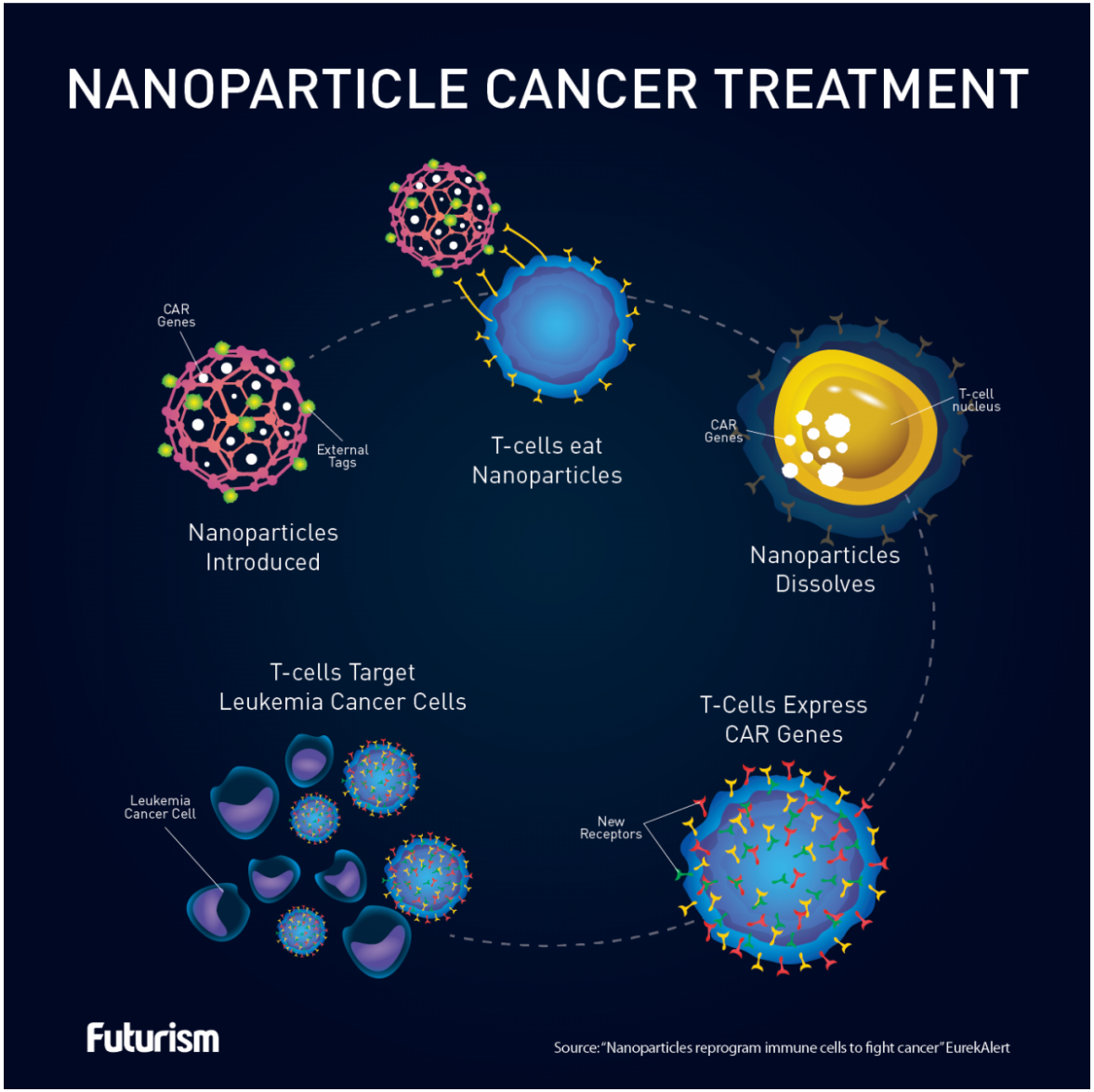
Nanoparticles

Nanoparticles made of a suitable, bio-compatible material can be coated with agents that recognise cancer cells. Another coating on the same material is the drug that can kill cancer cells. Thus, we have 'bullets' that can home in preferentially to cancer cells, attach to them or go into them, and destroy them using the attached anticancer drug.



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