SYMBIOSIS, COEVOLUTION, COMMUNAL BENEFIT, COMMENSALISM AND PARASITISM

Biological units **cooperate** with other biological units resulting in an **interaction and relationship**. This makes an effectively functioning whole organism. The gills gather oxygen, the heart circulates blood, the muscle locomote, the mouth ingests food, the gut digests food, the excretory system eliminates wastes and the liver processes biochemicals. If you look at plants also the biological units cooperate. The root hairs absorb water and nutrients, the xylem and phloem transport materials, the leaves fixes energy from solar photons and cells at various locations emit chemicals for communication.

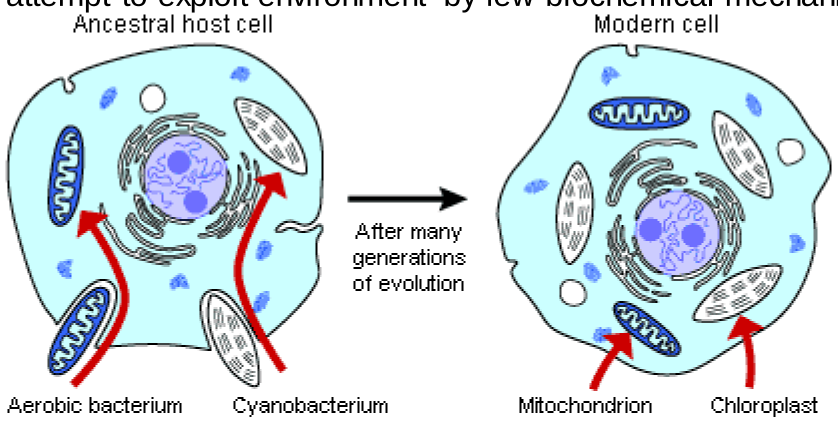
Symbiosis*:* This is a relationship between dissimilar organisms for the benefit of both the partners. Hence this is a **mutualism**. This is a +/+ interaction. We can see lot of examples from the environment

(1) The association between **hermit crab and sea anemone**. The anemone attaches to the crab's shell and obtains food scraps from the crab. In return, the crab is camouflaged by the anemone and defended by the stinging cells of anemone

(2) **Lichens**: This is a composite organism. The partners are green algae and fungus. The fungus gains oxygen and carbohydrates from the photosynthetic green alga. The alga gains water, carbon dioxide and mineral salts from the fungus. The fungus also provides protection from desiccation. Do you know that lichens are bioindicators?

Discussion: Lichens as bioindicators for pollution

(3) **Mitochondria and chloroplast**: It is believed that mitochondria and chloroplasts evolved from prokaryotes that became residents in a larger host cell in an attempt to exploit environment by few biochemical mechanisms.



Coevolution: In this type of example two or more species have developed a mutual dependence that is very profound and essential.

Many species of flowering plants coevolved with specific pollinators. A perfect example can be seen in the case of the Madagascar orchid and its pollinator moth. The orchid produces nectar at the base of a foot long spur. When Charles Darwin saw this orchid for the first time, he predicted the existence of a moth with a proboscis (tongue) long enough to reach that nectar. Later this moth was discovered.

Communal benefit:

Look at the following interaction in which when a single ant cannot bridge the gap between two leaves to be used in a nest, the worker ants arrange themselves in chains and pull together to close the gap. The entire community is benefited from this behavior.

Bacteria and their communal behavior: **Biofilims** are the complex, multilayered, multispecies consortia of microbes. These aggregations form sticky and persistent coatings on surfaces. <u>What is the advantage for the community?</u>

Biofilms are more resistant to some physical forces like a shear flow. It also well tolerates antimicrobial agents at concentrations much higher than an individual bacteria. Bacteria within biofilms may also be better adapted to withstand nutrient deprivation, pH changes, oxygen radicals, disinfectants and antibiotics than planktonic bacteria.

Biofilm formation is also a mechanism that enables bacteria to remain within a favorable environmental niche. By living together, they can specialize and divide the labor. Hence biofilms are interactive communities. They also provide an opportunity with higher rates of gene transfer. Therefore biofilm formation is a communal behavior of many bacteria

Discussion: Surgical equipments and catheters are susceptible to biofilm formation by bacteria. This is a great threat. It will be more severe if the bacteria in the biofilm is drug resistant.

Commensalism: This is an interaction of +/o type. This is an interaction between species that benefits one of the species but neither harms nor helps the other. Cowbirds and cattle egrets feed on insects flushed out the grass by a grazing cattle. The birds increases their feeding rates by following a herbivore and clearly benefit from the association. On the other hand the cattle is unaffected or not benefited from the association.

Parasitism: Parasitism is an interaction in which one organism is benefited, while the other is harmed. Therefore this is a +/- symbiotic interaction. The organism benefited is known as the parasite and the affected organism is called the host. The host is harmed in this process. Parasites can be endoparasites or ectoparasties.

BIOINSPIRATION AND BIOMIMETICS

INTRODUCTION: Bioinspiration and biomimetics – creativity and innovation

Can you tell one of the earliest inspiration we got from nature? We tried several times to mimic it, many lost their life during this experiments.

Do you know what is a Velcro? How it functions? Can you trace how it was discovered?

Design by Nature led to the invention of Velcro. This is an example of **biomimetics** —the young science of **adapting designs from nature** to solve modern problems. The terms bionics, bionik (german) and biomimetics, are of a much more recent date. Biomimetics is a study involving copying, imitating and learning from nature.

Examining burs plucked from his pants and dog's coat, Swiss engineer George de Mestral found their spines were tipped with tiny hooks—sparking his invention of Velcro. He was disappointed that fashion designers didn't rush to adopt his product [may be because of that ripping sound!] But Velcro found loftier applications "in the first artificial heart surgery and on trips into space." We will be surprised to know the fact that NASA was the one of the first user of Velcro tape sending Velcro to the moon on space boots and suits.

Functionality in many of the tools and **artefacts** that we use in our daily life can be traced back to origins in nature.

First we will look into few examples.

(1) Mercedes-Benz's bionic concept car

Behind the squared-off contours of the boxfish lies a lesson in sleek design. Low drag helps the fish swim up to six body lengths per second, stabilized by the keel-like edges of its carapace. The boxfish's surprisingly streamlined form inspired Mercedes-Benz's bionic concept car. Flowing vapors during wind-tunnel tests in a Stuttgart facility show off the car's aerodynamics, which helps boost its gas mileage to as high as 70 miles per gallon.

2. Australian Devil Lizard

Sipping through a foot, the thorny devil lizard of the arid Australian desert demonstrates its ability to wick water to its mouth via channels between its scales. Scientists hope to mimic the mechanism to develop water-capture technologies for dry regions.

(3) The Lotus effect

In 1982 botanist Wilhelm Barthlott of the University of Bonn in Germany discovered in the lotus leaf a naturally self-cleaning, water-repellent surface. The secret lies in waxy microstructures and nanostructures that, by their contact angle with water, cause it to bead and roll away like mercury, gathering dirt as it goes. Barthlott patented his discovery, calling it the Lotus Effect. Barthlott patented his discovery, calling it the Lotus Effect. It has found commercial application in products like the biomimetic paint Lotusan (on blocks above). Infused with microbumps, the paint is reputed to repel water and resist stains for decades.

(4) Translating whale power into wind power

The whale's flipper's scalloped edge helps it generate force in tightly banked turns. The whale-inspired blades are being tested at the Wind Energy Institute of Canada to see if they can make more power at slower speeds than conventional blades, and with less noise.

The significance of Bioinspiration/Biomemetics

The production of bioinspired and biomimetic constructs has fostered much collaboration between biologists and engineers. Biologists, engineers, and industrial designers differs in what will be the exact definition of this branch and how far we can copy a biological design/ This has resulted in a confusion regarding the level of integration and replication of biological principles. Innovative researchers with both biological and engineering backgrounds have found ways to use bioinspired models to explore the biomechanics of organisms from all kingdoms to answer a variety of different questions. Bringing together these biologists and engineers will hopefully result in an open discourse of techniques and fruitful collaborations for experimental and industrial endeavors.

Biomimetic vs. Bioinspired: Is There a Difference?

The terms **biomimetic** and **bioinspired** are often used almost interchangeably, because they do describe very similar concepts. In both cases, the idea is to replicate some property or function of a biological system.

The biomimetic approach most commonly strives to achieve this goal by reproducing some aspects of the biological system. An example we can found in early plane designs. Such early designs involved flapping wings, a biomimetics of birds.

In contrast, **bioinspired approach** aims to **discover and capture an essential idea** that underpins a biological system with an ultimate goal to use the same idea at the technological implementation level.

The two approaches are not mutually exclusive, i.e., in many cases a biomimetic solution can provide the best technological implementation of a bioinspired design, but a biomimetic solution is not always optimal from an engineering prospective. The modern technology of powered flight, for example, is dominated by designs that are bioinspired (by the idea of using a wing for flight), but distinctly *not* biomimetic. Fixed-wing aircraft turns out to be a more efficient solution for carrying cargo than are designs that replicate flapping wings of birds.

Application of Bioinspiration/Biomemtics

1. Biological Materials & Nanostructures : Starting from well-known biological structures, such as the complex structures with high toughness (biominerals like diatom and sponge silica, seashells and bone) and the structures with hierarchical organization and high mechanical strength (of organic fibers like spider silk), scientists and engineers develop the principles for design of novel nanomaterials with superior properties, using biomimetic nanotechnology.

2. Robotics: Animals exploit soft structures to move effectively in complex natural environments. These capabilities have inspired robotic engineers to incorporate soft technologies into their designs. The goal is to endow robots with new, bioinspired capabilities that permit adaptive, flexible interactions with unpredictable environments. Human-made manufacturing robots are mostly designed to be stiff. By contrast, in the animal world soft materials prevail. The vast majority of animals are soft bodied, and even animals with stiff exoskeletons such as insects have long-lived life stages wherein they are almost entirely soft (maggots, grubs, and caterpillars). Studying how animals use soft materials to move in complex, unpredictable environments can provide invaluable insights for emerging robotic applications in medicine, search and rescue, disaster response, and human assistance.

3. Sensing the Environment : Biosensors- Just recall that we discussed Lichens as bioindicators for pollution. In fact they are sensing the pollution and avoids polluted areas such as road sides, town and near-vicinity of a factory. How they sense the pollution? If we understand can be develop a machine that can sense the pollution levels?

   Nature has developed, by many years' evolution processes, sensing organs and strategies. These natural sensors are being really difficult to achieve artifically by sensor technologists in versatility, performance, tolerance to saturation or sensitivity. The objectives of the system is to mimic animal senses to perform olfaction or tasting in hazard conditions, or in non-stop manner. This objective is followed by artificial olfaction or artificial taste researchers. But the same principle of using sets of sensors is being adapted to many other objectives for example a skin of pressure sensors to detect structural stress in vehicles or buildings.

4. Decision Making: Bioinspired algorithms and applications. The mystique of biologically inspired (or bioinspired) paradigms is their ability to describe and solve complex relationships from intrinsically very simple initial conditions and with little or no knowledge of the search space.
5. Bioinspiration in Architecture (Already discussed examples)