# The dream of Human Photosynthesis


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Biocompatibility Class

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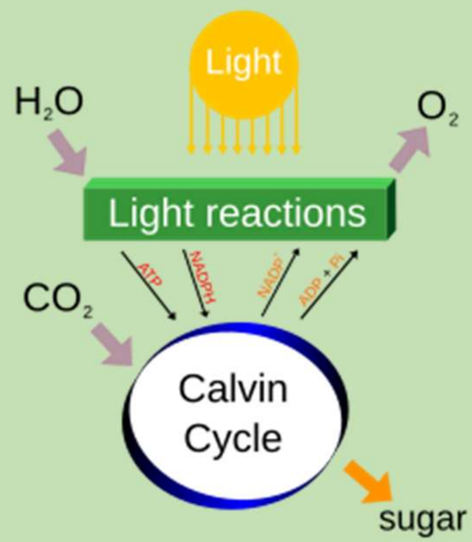
# The Current State of Global Food Insecurity and Hunger

As of 2024, approximately 733 million people around the world are suffering from hunger, according to the latest report from the UN’s Food and Agriculture Organization (FAO). Additionally, around 2.33 billion people face some level of food insecurity, meaning they do not have consistent access to enough nutritious food.

# Photosynthesis

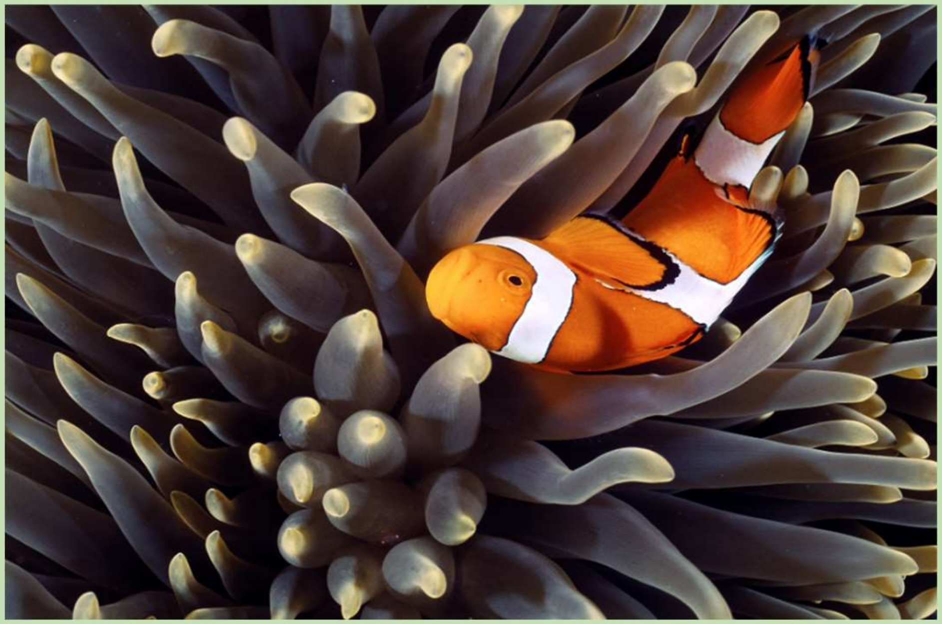
Photosynthesis is a system of biological processes by which photosynthetic organisms, such as most plants, algae, and cyanobacteria, convert light energy, typically from sunlight, into the chemical energy necessary to fuel their metabolism.

$CO_2 + H_2O + \text{photons} \rightarrow [CH_2O] + O_2$



# Symbiosis

- Symbiosis is any type of a close and long-term biological interaction, between two organisms of different species.
- The symbiotic relationship between an anemone (Heteractis magnifica) and a clownfish (Amphiron ocellaris) is a classic example of two organisms benefiting the other; the anemone provides the clownfish with protection and shelter, while the clownfish provides the anemone nutrients in the form of waste while also scaring off potential predator fish.



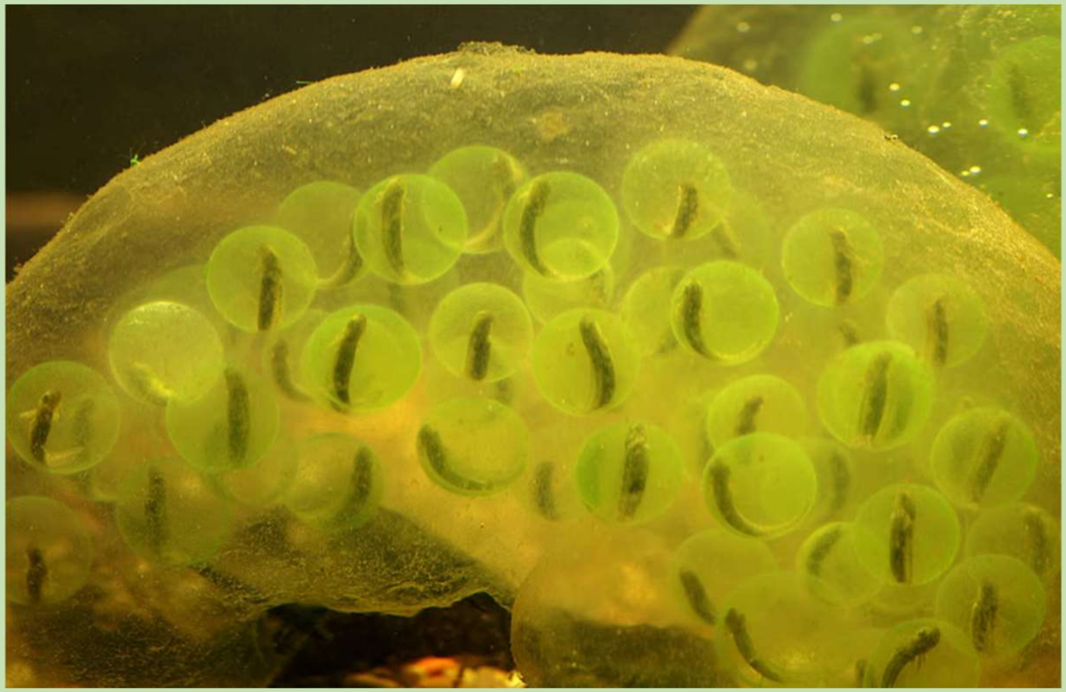
# Photosymbiosis

- Photosymbiosis is a type of symbiosis where one of the organisms is capable of photosynthesis.
- Examples of photosymbiosis are found among sponges, cnidarians, flatworms, molluscs, ascidians and even some vertebrates.

A ciliate, Paramecium bursaria, with green zoochlorellae living inside it endosymbiotically

# Symbiotic salamander/algae relationship

A unique photosymbiotic association occurs between microalgae, Oophila amblystomatis, and embryos of the spotted salamander whereby microalgae enter the cells of the salamander during early development.



# Conventional strategies for tissue oxygenation

**1. Prevascularization Strategies:**

• Uses endothelial and supporting cells to create vascular networks.

• Drawback: Limited by natural diffusion distance of oxygen (~100–200 μm), unsuitable for larger tissues.

**2. Oxygen-Releasing Biomaterials:**

• Uses materials like calcium peroxide and magnesium peroxide to release O2.

• Drawback: Short-term oxygen supply, potential toxicity (ROS, inflammation), and issues with control of O2 release speed.

**3. Perfluorocarbons (PFCs):**

• Chemically inert molecules that dissolve and release oxygen based on demand.

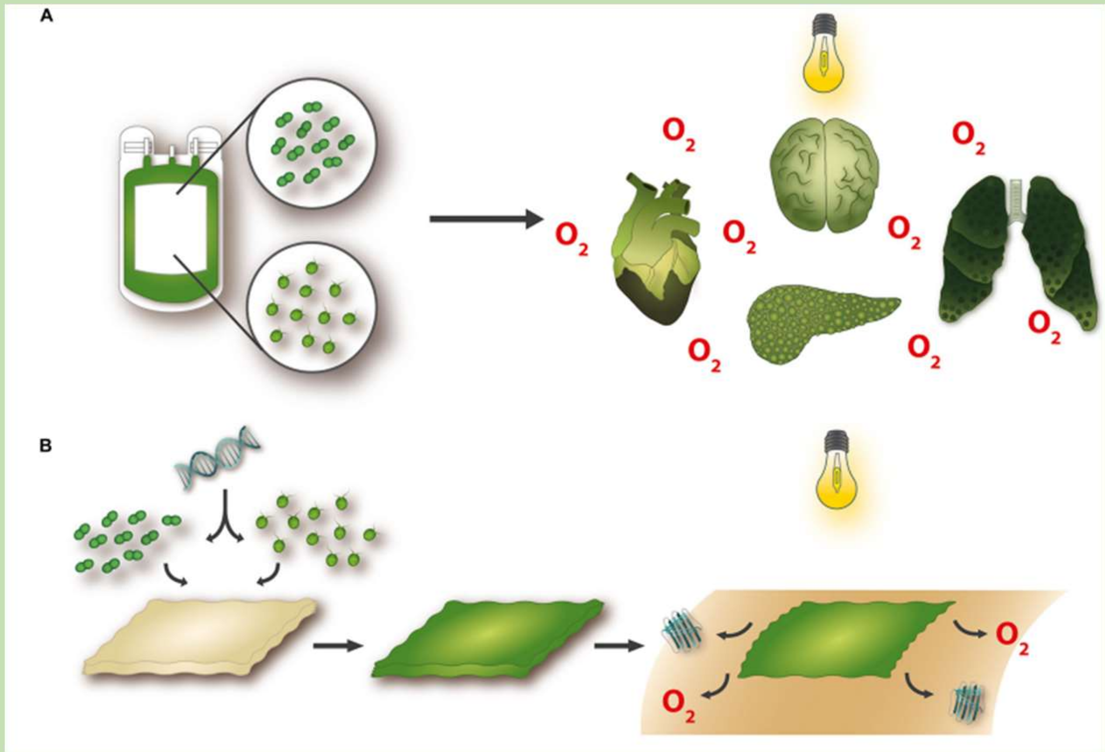
• Drawback: Passive, limited long-term tissue oxygenation.

**4. Hemoglobin-Based Oxygen Carriers (HBOCs):**

• Modified hemoglobin carriers that release O2 more efficiently than red blood cells.

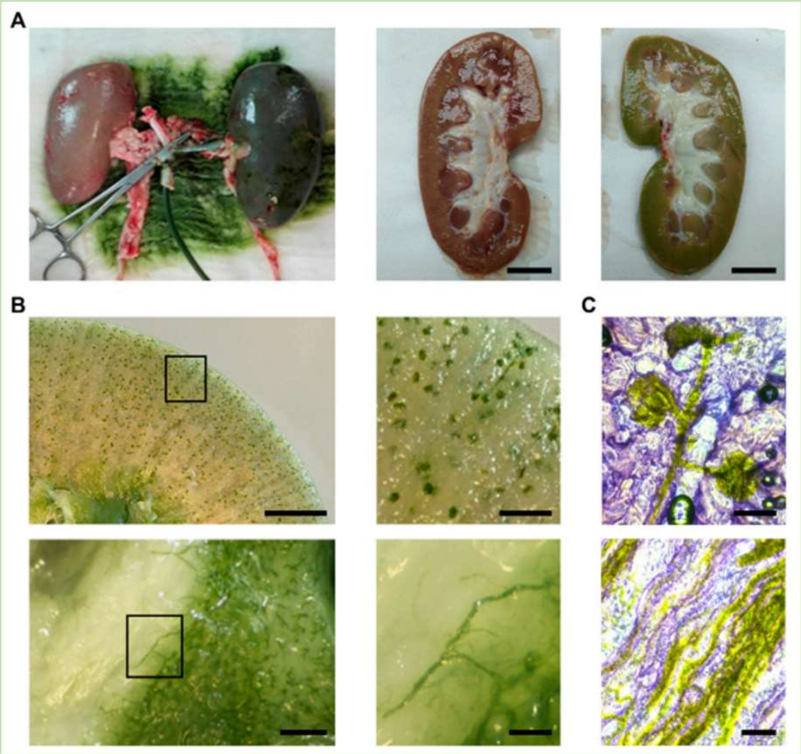
• Drawback: Short half-life, potential vasoconstriction due to nitric oxide binding, and inaccuracies in O2 saturation.

# Potential applications for photosynthetic technologies




Novel approaches to organ oxygenation have shown that microorganisms with the capacity to produce oxygen when stimulated with light can improve organ functionality and survival in the absence of blood perfusion (A). Furthermore, the availability of genetic tools makes it possible to construct transgenic photosynthetic organisms that bioactivate tissue-engineered materials and confer upon them the potential to simultaneously and steadily release oxygen and functional recombinant molecules, such as growth factors (B).

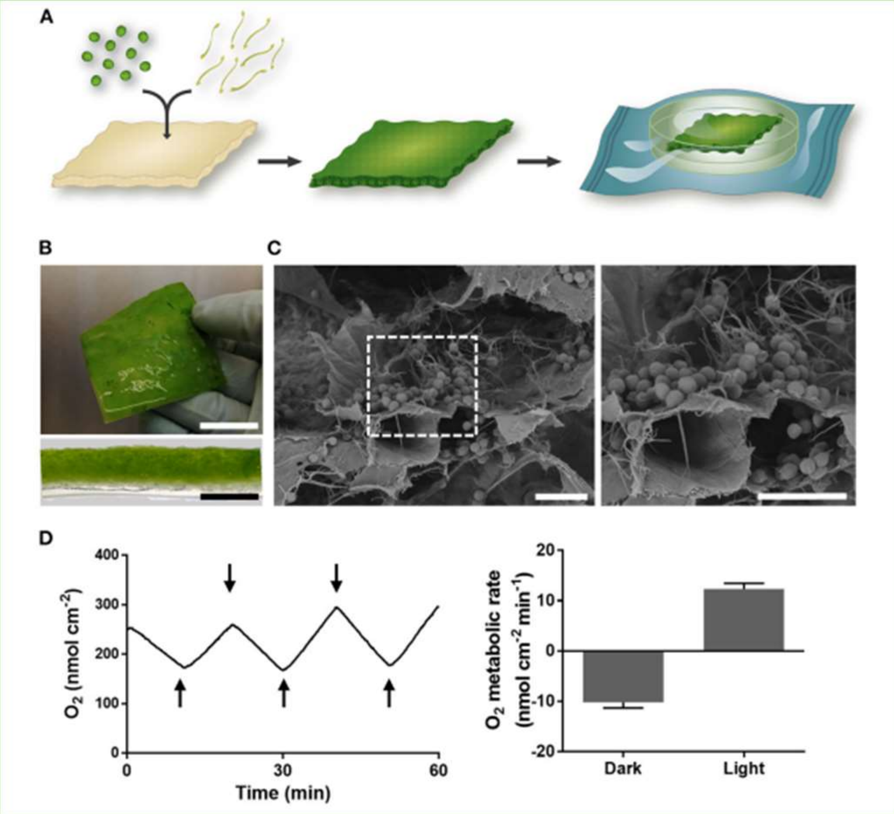
# Distribution of the photosynthetic solution in porcine kidney



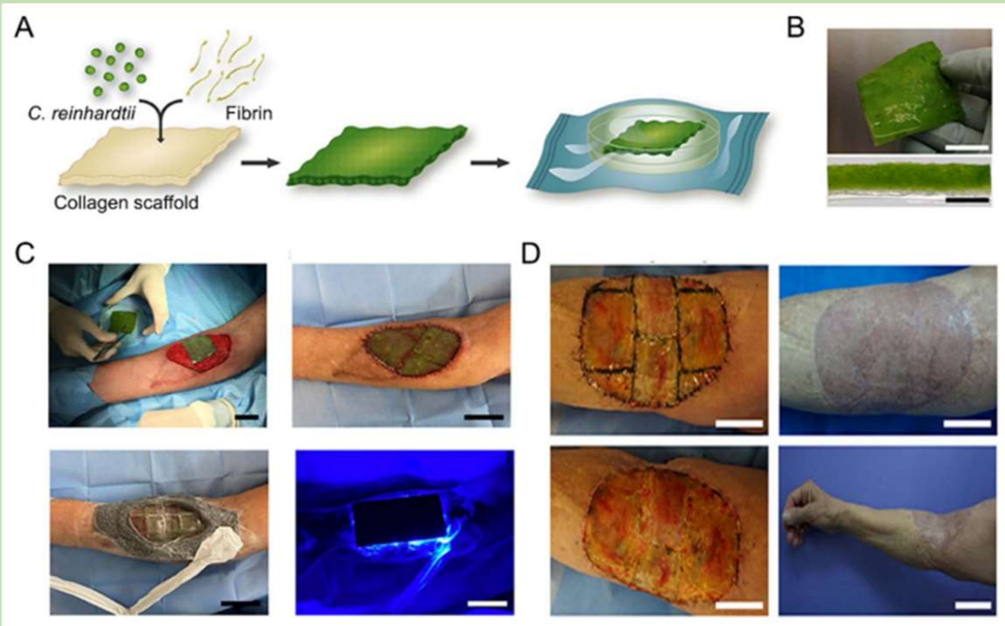

Photosymbiotic strategy for kidney preservation. (A) Porcine kidneys before and after perfusion of C. reinhardtii suspension, followed by photographs of fresh slices of kidneys with and without C. reinhardtii in the renal cortex. Scale bars: 2 cm. (B) Microscopic images of cryosectioned kidney showing the distribution of C. reinhardtii in the renal cortex (top) and medulla (bottom). Scale bars: 5 mm (top left), 1 mm (top right and bottom left), and 250 µm (bottom right). (C) Microscopic images of cryosectioned kidney showing the distribution of C. reinhardtii in the glomeruli and afferent arteriole (top) and the medullar blood vessels and capillaries (bottom). Scale bars: 100 µm

# Photosynthetic scaffold fabrication and characterization

(A) Microalgae and fibrin were seeded in a commercially available collagen scaffold and allowed to grow during 4 days. Once sterility of the material was confirmed, scaffolds were packaged and delivered to the operating room. (B) Macroscopic image (top) and cross section (bottom) of photosynthetic scaffold. (C) SEM imaging showing microalgae embedded in the fibrin matrix inside the scaffold. (D) Representative evolution of oxygen concentration upon dark/light cycles of 10 min, represented by upper and lower arrows respectively (left), and scaffold metabolic rates (right). Scale bars represent 2 cm (B, top), 2 mm (B, bottom) and 20µm (C). Data in (D) is representative of at least five independent experiments and is expressed as mean value ± SEM (right).



# Photosymbiotic strategy for skin regeneration




(A) Schematics of biofabrication of a photosynthetic scaffold showing the seeding of C. reinhardtii and fibrin on a commercially available collagen scaffold. (B) Top and cross-sectional views of the photosynthetic scaffold. Scale bars: 2 cm (top), 2 mm (bottom). (C) Photosynthetic scaffold implantation on a wound bed.

The photosynthetic scaffold was sutured to the wound edges and covered with a transparent silicone membrane followed by illumination. Scale bars: 5 cm. (D) Functional recovery and clinical outcome of the wound at day 90 post-implantation. Scale bars: 5 cm except for the lower right image (10 cm).

# Challenges on photosymbiotic tissue engineering

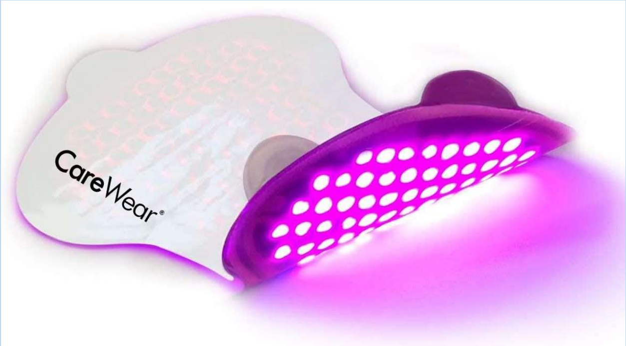
1. **Environmental Dependency: Light conditions :** High light intensity can cause photoinhibition, while low light intensity can limit growth and biological processes.
2. **Host-Symbiont Interaction:** Managing the relationship between the host and photosymbiont, including nutrient depletion and accumulation of metabolic waste.
3. **Immune Response:** Photoautotrophic microorganisms may trigger the host's immune system as foreign bodies
4. **Lack of Clinical Establishment:** A deeper understanding of cellular and molecular mechanisms is needed for clinical translation.

# My Ideas :

## 1-tanning bed

Using a device similar to a tanning bed that delivers visible light to the body, while simultaneously injecting a photosynthetic agent in solution into the tissues. This approach could temporarily support oxygen supply and boost metabolism in the target tissue. The visible light, acting as a photosynthesis activator, together with the appropriate agent, could play a significant role in providing energy and maintaining cellular function in tissues

# 2-Using wearables similar to phototherapy wearables




# 3-Optical fibers

Using thin, flexible optical fibers to directly deliver visible light to deep tissues. (such as in endoscopy)

# Refrences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