



For FUNH5000 (L01) - Introduction to Function Hub for Sustainable Future

Biodesign for Climate Solutions

Monitoring nature: capturing ecological signals

Ecologists have long monitored the effects of climate change on natural ecosystems to help understand and predict its future impacts on wildlife, ecosystems, and human health. These studies not only provide a scientific basis for ecosystem conservation but also provide important guidance for managing natural carbon sinks and responding to ecological damage.

Coral reefs, known as the “rainforests of the ocean,” are among the most biodiverse ecosystems on Earth. Although they cover less than 1% of the world's oceans, coral reefs provide habitat for more than 25% of marine life and play a key role in maintaining the ecological balance of the oceans, fisheries resources and coastal protection. However, in recent years, coral reef ecosystems are facing unprecedented threats from increased global climate change, rising ocean temperatures and increasing acidification, which have led to mass coral bleaching, disease transmission and coral mortality. In response to this crisis, ecologists and research institutions around the world are actively exploring innovative technologies to accelerate coral recovery and improve their resilience to climate change. Scientists at the Institute of Marine Biology of the University of Hawaii have developed a simple yet highly effective coral restoration method that utilizes marine epoxy putty to form a barrier around the edges of damaged coral lesions, effectively preventing the spread of disease while providing a stable restorative environment for corals to accelerate their regeneration process^[1]. This technology provides a viable solution for global coral reef restoration and brings new hope to marine ecosystems on the brink of crisis.

Biological evolution: from natural exploration to synthetic innovation

Global food production accounts for a quarter of all global greenhouse gas emissions, and biologists are helping farmers to breed more productive and environmentally friendly crops and livestock to reduce the impact of agriculture on climate change. At the same time, as climate change threatens the global food supply, biologists are also working to increase food security, improve human nutritional profiles, and reduce food loss and waste.

In recent years, the use of gene-editing technology to rapidly domesticate wild species has become a research direction for an increasing number of scientists. For example, scientists have used CRISPR gene editing to improve rice and wheat to maintain efficient growth despite drought, high salinity, or extreme temperatures. Gansha's team successfully utilized the CRISPR-Cas9 genome editing tool to create a variety of rice that is resistant to disease while maintaining high yields^[2], while Shuangqin's research on rice broke through the contradiction between the dominant varieties in terms of contradiction between resistance and yield, and realized the simultaneous improvement of alkali and heat resistance and high yield^[3].

In addition to traditional bio-breeding techniques, synthetic biology, as an emerging science, is providing innovative solutions to the challenges of agriculture and climate change by redesigning and reconstructing biological systems. By modularizing living systems, synthetic biology can build new functions at the cellular level, such as designing plants with efficient carbon sequestration or creating microbes capable of producing alternative proteins. These novel biological systems could not only help reduce greenhouse gas emissions from agriculture but also play an important role in a few fields. Perfect Day has introduced DNA sequences encoding whey protein into food-grade microorganisms to produce whey protein in large quantities using a fermentation process. The protein has the same nutritional and functional properties as traditional whey protein, but the production process has a much lower environmental impact.

As synthetic biology continues to advance, it promises to provide a more efficient and sustainable solution to the global food system, increasing crop yields while reducing environmental burdens, thus laying a solid scientific foundation for future agriculture and climate governance.

Green Transformation: Toward Bioenergy and Biomaterials

As the global focus on sustainability and carbon neutrality goals deepens, scientists are working to develop more environmentally friendly and efficient bioenergy and biomaterials to reduce dependence on fossil fuels and lower the environmental impact of industrial production. In recent years, advances in biotechnology have enabled humans to utilize microorganisms, plants, and biological processes to create renewable alternative energy sources and new materials, providing innovative pathways for the development of a green economy.

Researchers have successfully utilized mycelium to cultivate building materials by growing fungal

hyphae to form strong and biodegradable structures that replace traditional concrete and wood, thereby reducing the carbon footprint of the construction industry while providing sustainable building materials. Meanwhile, breakthroughs have been made in the development of microalgae biofuels, where scientists have optimized the metabolic pathways of algae to efficiently convert light energy and carbon dioxide to produce petroleum-like biofuels, which can provide low-carbon alternatives for energy-intensive industries such as aviation and transportation^[4].

The application of these emerging technologies not only promotes the industrialization of bioenergy and biomaterials but also lays the foundation for the green transformation of the global industrial system. With the continuous progress of biomanufacturing technology, these renewable resources will be applied in more fields, helping the world to move towards a more sustainable direction.

References

- [1] G. Aeby et al., "Changing Stony Coral Tissue Loss Disease Dynamics Through Time in *Montastraea cavernosa*," *Frontiers in Marine Science*, vol. 8, 09/16 2021, doi: 10.3389/fmars.2021.699075.
- [2] G. Sha et al., "Genome editing of a rice CDP-DAG synthase confers multipathogen resistance," *Nature*, vol. 618, no. 7967, pp. 1017-1023, 2023/06/01 2023, doi: 10.1038/s41586-023-06205-2.
- [3] S.-Q. Guo et al., "Fine-tuning gibberellin improves rice alkali–thermal tolerance and yield," *Nature*, vol. 639, no. 8053, pp. 162-171, 2025/03/01 2025, doi: 10.1038/s41586-024-08486-7.
- [4] W. You, L. Wei, Y. Gong, M. E. Hajjami, J. Xu, and A. Poetsch, "Integration of proteome and transcriptome refines key molecular processes underlying oil production in *Nannochloropsis oceanica*," *Biotechnology for Biofuels*, vol. 13, no. 1, p. 109, 2020/06/18 2020, doi: 10.1186/s13068-020-01748-2.

AI Statement

I read through the websites and articles, extracted some of the headings and had ideas for subheading the segments, and let chat-gpt embellish them for me:

Here is two reasonable topic: Biological engineering for nature-based climate solutions/ bioscience is helping fight climate change. Can you learn this two and provide some topic.

Based on the topics **"Biological Engineering for Nature-Based Climate Solutions"** and **"Bioscience is Helping Fight Climate Change,"** here are several additional topics that follow a similar theme:

1. **Synthetic Biology for Climate Resilience: Engineering Nature to Combat Global Warming**
2. **Harnessing Microbial Power: How Engineered Bacteria and Fungi Can Mitigate Climate Change**
3. **From Carbon Capture to Climate-Resilient Crops: The Role of Bioscience in a Warming World**
4. **Next-Gen Bioenergy: Using Algae, Microbes, and Plant Biotechnology for Sustainable Fuels**
5. **Genetic Innovations for Climate Adaptation: Enhancing Plants, Soils, and Ecosystems**
6. **Rewilding with Biotech: How Genetic Engineering Can Restore Lost Ecosystems**
7. **Nature Meets Engineering: Biomimicry and Synthetic Biology for Climate Solutions**
8. **Bio-Based Materials: From Fungal Bricks to Algae Plastics in the Green Economy**
9. **The Future of Carbon Sequestration: Leveraging Biology for Negative Emissions**
10. **Biodesign for a Sustainable Planet: How Bioscience is Reshaping Industry and Conservation**

These topics cover various aspects of how biological science and engineering are being applied to tackle climate change, from carbon sequestration and biofuels to climate-resilient agriculture and ecosystem restoration. Let me know if you'd like me to refine any of them further!



From to 监测自然
from natural biology to synthetic biology
from to BIOENERGY AND BIOMATERIALS 请帮我补全标题，显示
变化

已推理，持续 19 秒

下面提供几个可供参考的标题版本，每个版本都展示了从自然监测与自然生物学向合成生物学，再到生物能源与生物材料的演变过程：

选项一：

“探索之路：从生态监测到自然生物学，从自然生物学到合成生物学，最终迈向生物能源与生物材料”

选项二：

“从监测自然到生物能源：自然生物学与合成生物学的渐进转变”

选项三：

“生态观察到工程革新：从监测自然到自然生物学，再由合成生物学引领生物能源与生物材料”

各个标题均力图展现以下变化：

1. **起点—监测自然/生态监测：**强调对自然现象和生态数据的观察与监控；
2. **中间阶段—自然生物学到合成生物学：**从对自然系统的理解出发，逐步引入利用工程手段进行优化与创新；
3. **终点—生物能源与生物材料：**指向通过生物工程实现的实际应用和转化成果。

你可以根据文章侧重点和风格选择合适的标题。

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变化是指在标题这个领域里的变化，而不是标题之间的变化，现在写的太牵强了

已推理，持续 22 秒

下面给出几个标题建议，这些标题侧重于展示领域内的演进与转型，而非仅仅是标题之间的排列：

1. **从监测自然到合成创新：自然生物学演进至生物能源与生物材料的新纪元**
(突显从基础的自然监测，经过对自然生物学的深入理解，再通过合成生物学实现创新，最终引领生物能源与生物材料的发展。)
2. **生态观测与合成设计：自然生物学向生物能源和生物材料的跨界演变**
(体现从生态观测出发，到利用合成设计实现突破，推动自然生物学在新领域的转型与跨界融合。)
3. **从自然监测到合成革新：驱动生物能源与生物材料领域的进化之路**
(强调由自然监测起步，通过合成革新，持续推动整个领域向生物能源和生物材料方向的进化。)

Let the AI help me find some examples of usage to support my argument:

For decades ecologists have been monitoring the impact of a changing climate on the natural world to help understand and predict future effects on wildlife, ecosystems, and human health. This research underpins efforts to protect the ecosystems that support us, and informs the best ways to manage natural carbon sinks.关于这一段能否找到支撑的例子

多年来，生态学家一直在监测气候变化对自然界的影响，以理解和预测其对野生动植物、生态系统和人类健康的未来影响。这些研究为保护支持人类生存的生态系统以及管理自然碳汇的最佳方法提供了基础。以下是相关的支持性例子：

1. **气候变化对生态系统的影响：**研究显示，气候变化已对94个核心生态过程中的82%产生了影响，这些过程涵盖从遗传多样性到生态系统功能等多个层面。 [Open Knowledge FAO](#)
2. **气候变化对人类健康的影响：**世界卫生组织指出，气候变化通过日益频繁的极端天气事件（如热浪、风暴和洪水）、对粮食系统的干扰以及食源性、水源性和病媒传播疾病的增加等多种方式影响人类健康。 [World Health Organization \(W...](#) +1

这些研究强调了持续监测和研究气候变化对自然界和人类健康影响的重要性，为制定保护生态系统和合理管理自然碳汇的策略提供了科学依据。