Synthetic Carbon Fixation Pathways For Superior Biomass Generation

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Overview

Modern agriculture faces limited arable land and climate changes. Carbon fixation under these conditions will become a significant growth-limiting factor. Synthetic carbon fixation pathways can allow plants to produce more biomass using the same amount of energy from sunlight. Novel alternative synthetic carbon fixation cycles discovered by Prof. Ron Milo and his team hold the potential to greatly increase the capacity of organisms to convert atmospheric carbon into sugars. The proposed solution provides the ability to enhance crop yields using the same expanse of land. The novel technology presents alternative synthetic carbon fixation pathways that were discovered by harnessing a systems biology approach. These pathways are predicted to harbor a significant kinetic advantage over their natural counterparts, making them promising candidates for synthetic biology implementation.

Background and Unmet Need

Carbon fixation is a process in which CO2 is incorporated into organic compounds. It is primarily done by plants, using photosynthesis. Modern agriculture, which relies on carbon fixation, consumes vast amounts of fresh water and cultivatable land resources. Under human cultivation, the usage of fertilizers and irrigation makes carbon fixation a potential growth-limiting factor. Hence, it is important to increase the fixation rate to achieve sustainability in food and energy production. However, previous attempts to improve key enzymes in the process had limited success.

The Solution

Prof. Ron Milo and his team computationally identified alternative carbon fixation pathways that combine existing metabolic building blocks from various organisms.[1]

Technology Essence

The productivity of carbon fixation cycles is limited by the slow rate and lack of substrate specificity of the carboxylating enzyme, RuBisCo. Prof. Ron Milo and his team address the inefficiency of the carbon fixation process through an alternative cycle that is predicted to be two to three times faster than the Calvinâ€“Benson cycle, employing the most effective carboxylating enzyme, phosphoenolpyruvate carboxylase, using the core of the naturally evolved C4 cycle. A computational strategy was applied, comparing kinetics, energetic and topology of all the possible pathways that can be assembled from all ~4,000 metabolic enzymes known in nature. The results suggest a promising new family of synthetic carbon fixation pathways.

Applications and Advantages

- Potential synthetic organisms utilizing this revolutionary technology can offer higher carbon fixation rates as compared to natural alternatives allowing
- Theoretical superior rate of biomass generation, providing cost-effective feedstock for the production of biofuels
- Â Could lead to enhanced food production via increased crop yields
- Minimal thermodynamic bottlenecks and superior kinetics over natural counterparts

Development Status

Prof. Ron Milo and his team computationally identified alternative carbon fixation pathways from various organisms. They compared the natural and synthetic pathways based on physicochemical criteria, including kinetics, energetics, and topology. Their findings suggest that some of the proposed synthetic pathways have significant quantitative advantages over their natural counterparts, such as the overall kinetic rate.

References

Bar-Even A, Noor E, Lewis NE, Milo R. Design and analysis of synthetic carbon fixation pathways. *Proc Natl Acad Sci*. 2010;107(19):8889-8894. doi:10.1073/pnas.0907176107 [1]

Patent Status

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