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實驗室：代謝工程與合成生物學實驗室
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研究興趣

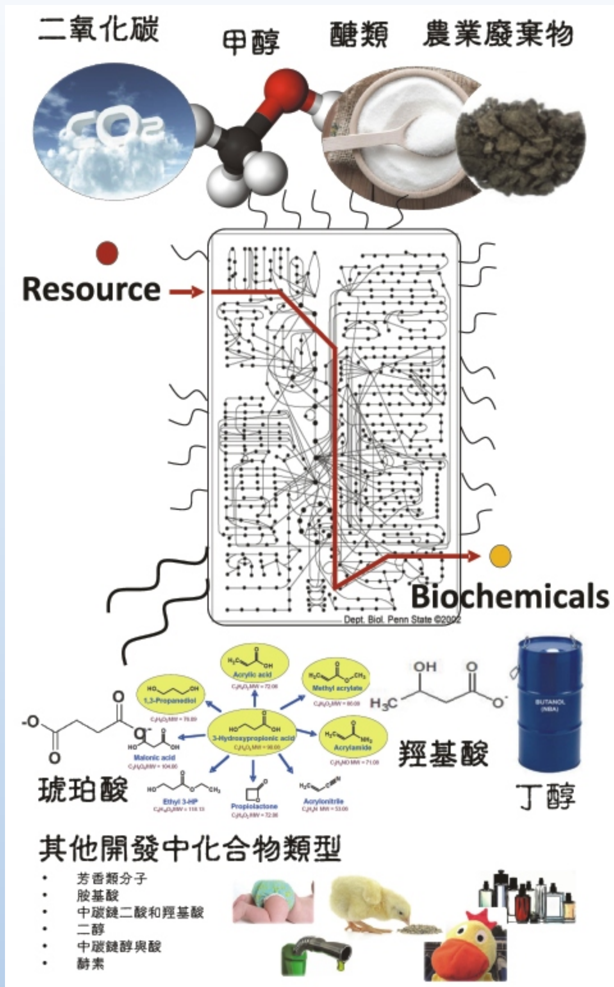
代謝工程與合成生物學實驗室的研究目的主要為開發新穎功能微生物，進而達成次世代資源再利用的循環經濟目標，我們同時也利用代謝途徑的編輯生產非天然化合物，其中包括藥物，塑膠單體，芬香與香料等生質化合物。下面一些是我們實驗室近期所發表的研究主題：

以二氧化碳合成生質能源與化學品，國際能源總署全球二氧化碳排放量之比較數據顯示，台灣占全球總排放量的0.77%並且位居全球第21位，每人平均的二氧化碳排放量居全球前20名，在全球暖化威脅下，將二氧化碳轉換為化學品與燃料可達到碳中和的永續發展。目前碳捕捉技術雖逐漸成熟，但無實質經濟誘因，為此我們團隊極力開發新穎藍綠菌，將二氧化碳透過光合作用合成多種工業用化合物，其中包括：

- 丁醇 - 目前來於石化工業，年產量達 3 百萬噸，約 6 0 億美元市場，主要用於各產業製程所需之溶劑，同時作為理想的生質汽油。 Lan E.I. et al. 2013, Energy & Environmental Science 6, 2672-2681; Lai M.J. & Lan E.I. 2018, Biotechnology and Bioengineering, 116:893903.
- 琥珀酸 - 年產量約5萬噸，主要用於食品、化妝品、與藥物添加物。可轉換成 1,4丁二醇，作為化學原料，台灣傳產化工年產量約60萬噸，和其他工業用化合物。Lan E.I. & Wei C.T. 2016, Metabolic Engineering 38, 483-493.
- 羥基酸 - 3-羥基丙酸用於合成生物可分解高分子材料(Poly-3HP)，同時作為丙烯酸（壓克力酸）和相關丙烯酸酯前驅物，用於生產各式塑料、塗層、粘合劑、彈性體、地板擦光劑及塗料。3-羥基丁酸做為掌性（分R&S），使用於不對稱有機合成，同時作為生質生物可分解塑膠（Poly-hydroxyalkanoate)單體。Ku J.T. & Lan E.I. 2018 Metabolic Engineering, 46, 35-42

除了利用代謝工程將藍綠菌開發成新穎的光合生物工廠外，下面是我們實驗室目前涵蓋的方向：

- **建構合成二氧化碳固碳途徑：**利用高速率的羧化酶，開發合成二氧化碳固碳途徑以彌補天然卡爾文循環的不足



- **建立生物甲醇轉換平台：**因應未來頁岩天然氣的量產，甲醇將取代現在的石油，同時甲醇也是目前較可行的二氧化碳再利用產物之一，但甲醇價格過於低廉，因此，開發甲醇高值化技術變為重要研究方向。
- **高值化合物生產平台：**藥物、芬香與香料、等高值生質化合物的生產目前主要以萃取為主，因而導致成本較高，我們可透過代謝工程，將此類化合物以微生物發酵方法產出。

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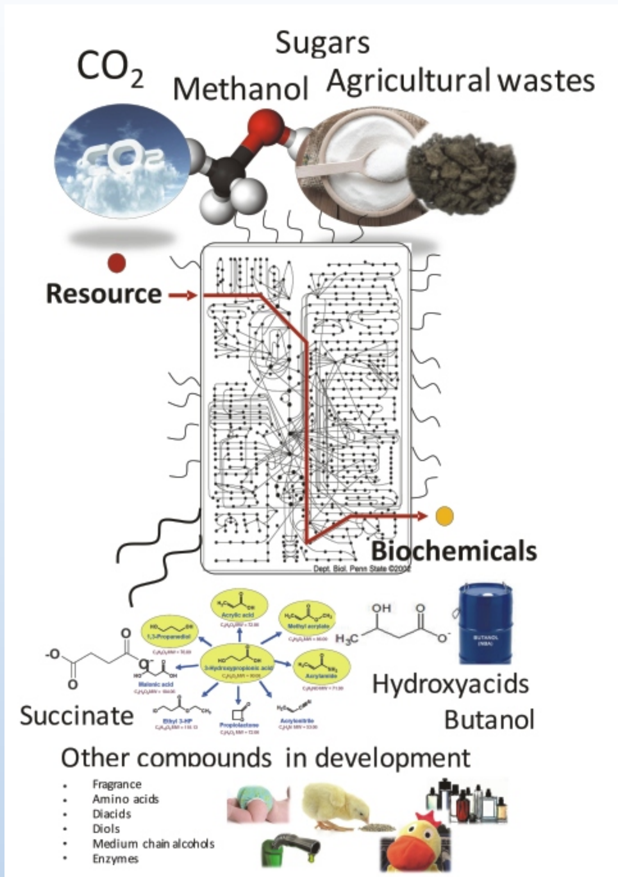
Research Interests

Metabolic Engineering and Synthetic Biology Laboratory focuses on the development of novel microbial strains for utilization of various renewable resources and chemical productions. In addition, we aim to construct synthetic metabolic pathways that increase the productivity of targeted compounds. These compounds cover a wide range of chemicals, including fuels, plastic monomers, solvents, fragrance, pharmaceuticals, neutraceuticals and more. Below lists some of our recent works:

Utilization of CO_2 for production of biofuel & biochemicals. According to the International Energy Agency, Taiwan accounts for 0.77% of total CO_2 emission, ranking 21st in all nations. Utilization of CO_2 as a carbon feedstock for fuel and chemical production is an attractive approach to address threats of climate change due to green house gas accumulation. We aim to convert CO_2 into value-added chemicals through metabolic engineering of cyanobacteria. Below lists some of our recent works:

- Butanol Butanol has an annual production of 3 million metric tonnes, equivalent to that of 6 billion dollar market. It is also a better gasoline surrogate.
- Succinic acid succinic acid has an annual production of 50,000 tonnes, primarily used in food, cosmetics, and pharmaceuticals. It can be converted to 1,4-butanediol which is a major product by Taiwanese chemical company.
- Hydroxyacids hydroxyacids in general are useful molecules for producing biodegradation plastics. In addition, they are useful for organic synthessis. We have successfully engineered cyanobacteria to produce 3-hydroxypropionic acid and 3-hydroxybutyric acid.

In addition to developing novel photosynthetic cell factories, we are also currently working in the below topics:



- **Construction of novel CO_2 fixation pathway** — we aim to overcome limitation of Calvin cycle by using a faster carboxylase with a designed pathway
- **Converting methanol to value-added chemicals** — methanol can be derived from captured CO_2 and from natural gas. Due to its abundance, it will replace petroleum as a major source of chemicals.
- **Production of high value biochemicals** — we aim to reduce cost of high value chemical production, which are typically extracted from plants, through integration of their production pathway into microorganisms.