SYENSQO
ADVANCING HUMANITY

5èmes Rencontres académie-industrie du CNC

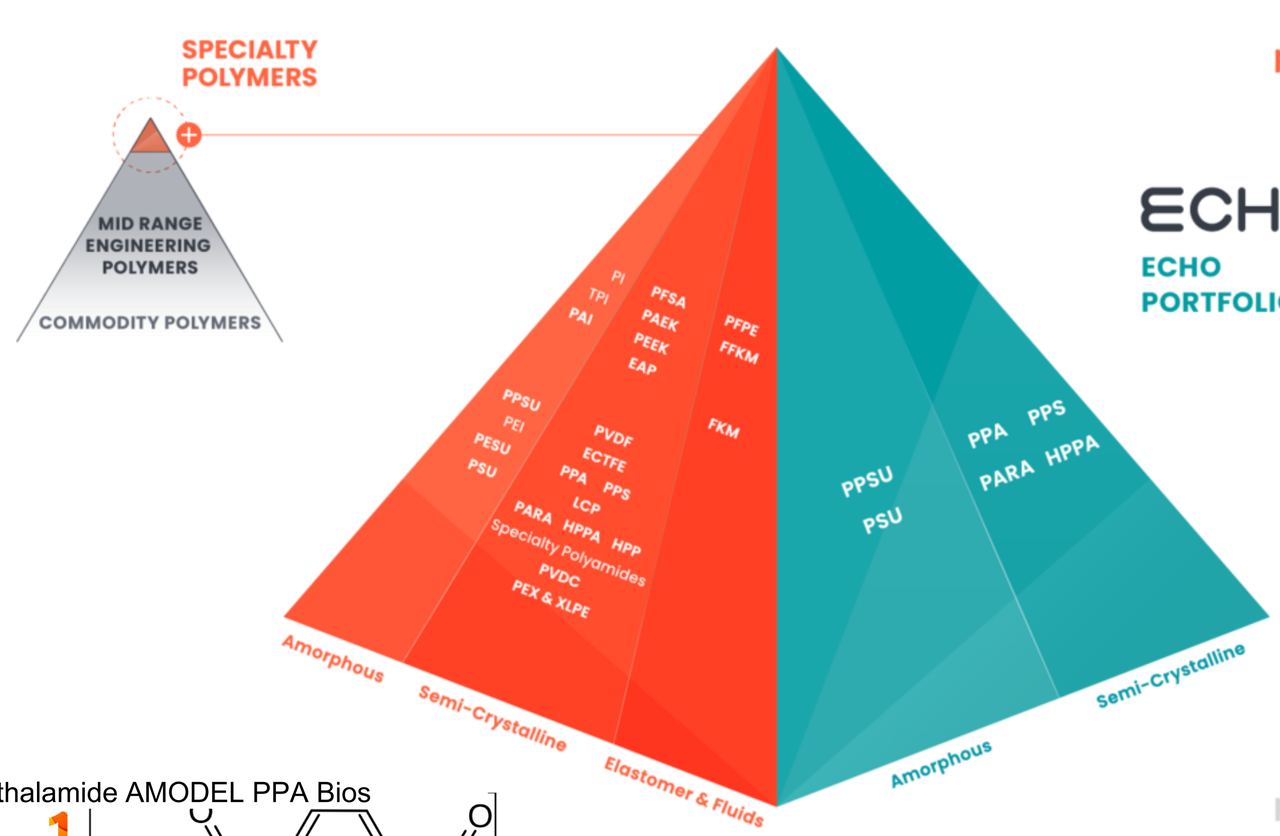
CO2 déchet ou matière première

- recyclage
- ressources biosourcées
- matière première

Vincent Schanen
Prof. Jun. Yannick Geiger

ECHO circular polymer portfolio

High performances polymers



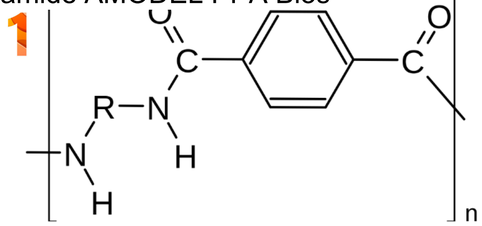
1 Echo bio-based solutions

2 Echo mass balance certified solutions

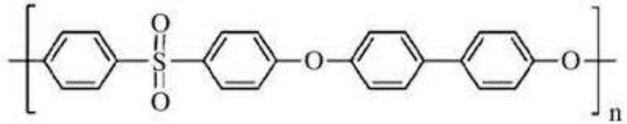
3 Echo recycled solution

PolyPhthalamide AMODEL PPA Bios

1



2 Polyphenylsulfone (PPSU)



3 OMNIX HPPA Recycle (Polyamide, 30-50 %)

SYENSQO

Polymers in Liquid formulations (PLF)
the circularity challenge

Household cleaner

Shampoo

Laundry detergent

Paints

Agrochemical formulations

~36
million tonnes
polymers in liquid formulations produced today

~125
Billion dollars
Market value across 8 markets

Recycling or reuse is impossible for most polymers in liquid formulations. An unseen pollution problem

SYENSQO

Biobased Polymer

Example of Guar

High Mw
(3 million g/mol)

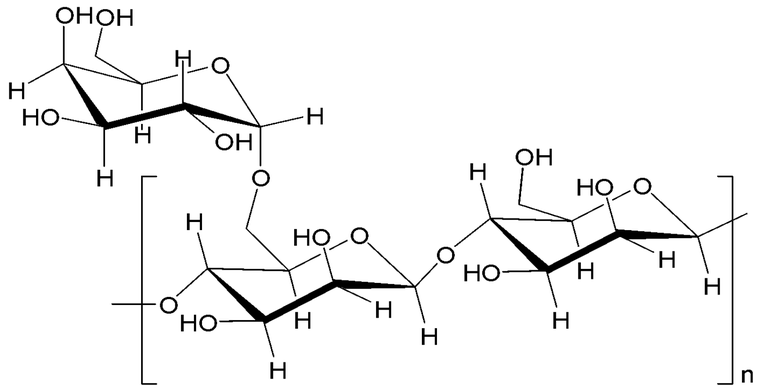
Water soluble

High viscosity of water solutions (1% - 5000 mPa.s)

The guar or cluster bean, with the botanical name "cyamopsis tetragonoloba", is an **annual legume and the source of guar gum**
Guar grows well in semiarid areas

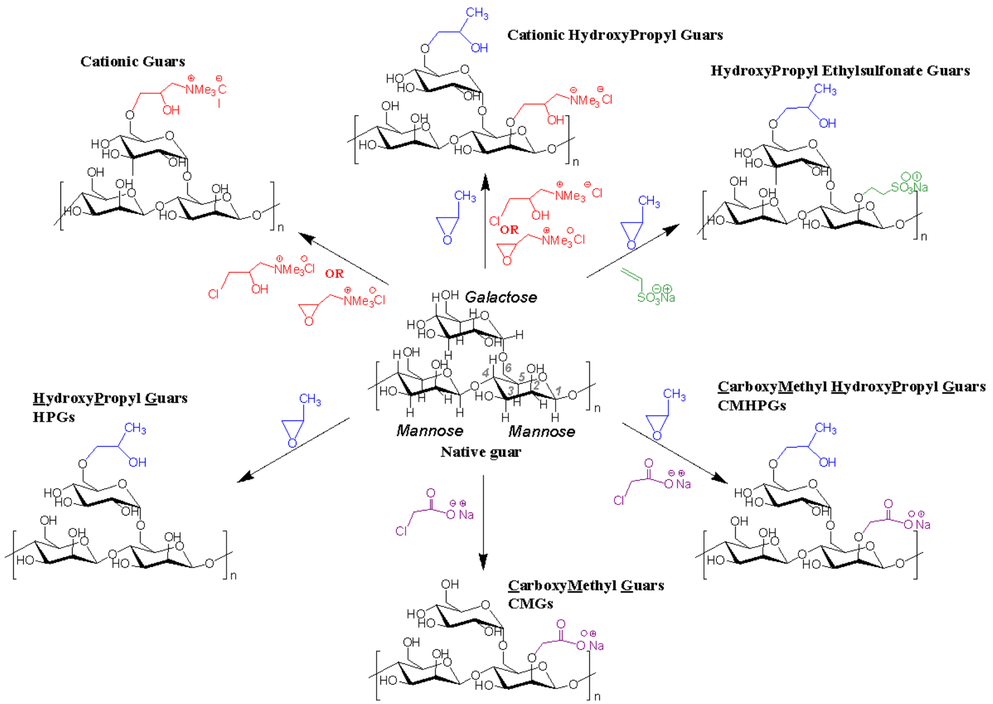
→ 80% of world production occurs in India and Pakistan

→ Beans contain ramified polymannose galactose : the **guar gum**



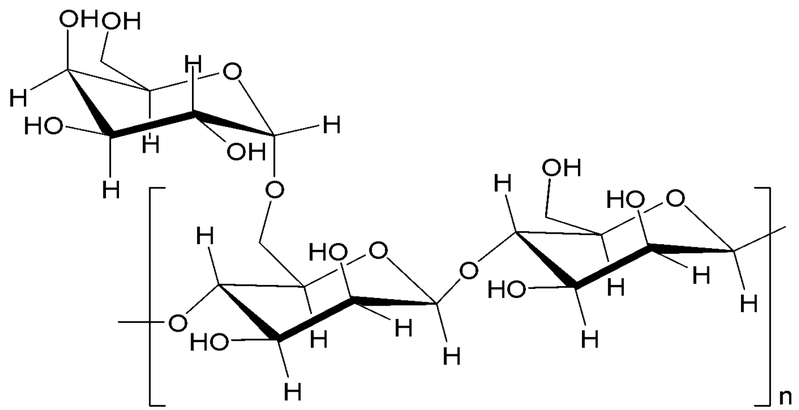
Biobased polymer:
Example of Guar

The classical chemistry
for guars and Polysaccharides



New chemistry developed
for guars and Polysaccharides

- → Quat derivatives with improved biodegradability
- → New functionalized guars
- → **Enzymatic driven modifications**
- → New patents filed protecting innovative products



Laboratory of Systems Chemistry

Fixation abiotique de CO2 imitant le métabolisme microbien anaérobique

Prof. Jun. Yannick Geiger
Laboratoire de Chimie des Systèmes, Université de Strasbourg

Cinquièmes Rencontres académie-industrie, Paris, 04/12/2025

Chimie de la MATIÈRE COMPLEXE
UMR 7140 - CMC

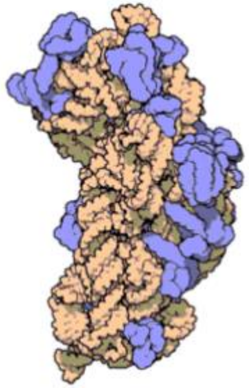
Faculté de chimie
Université de Strasbourg

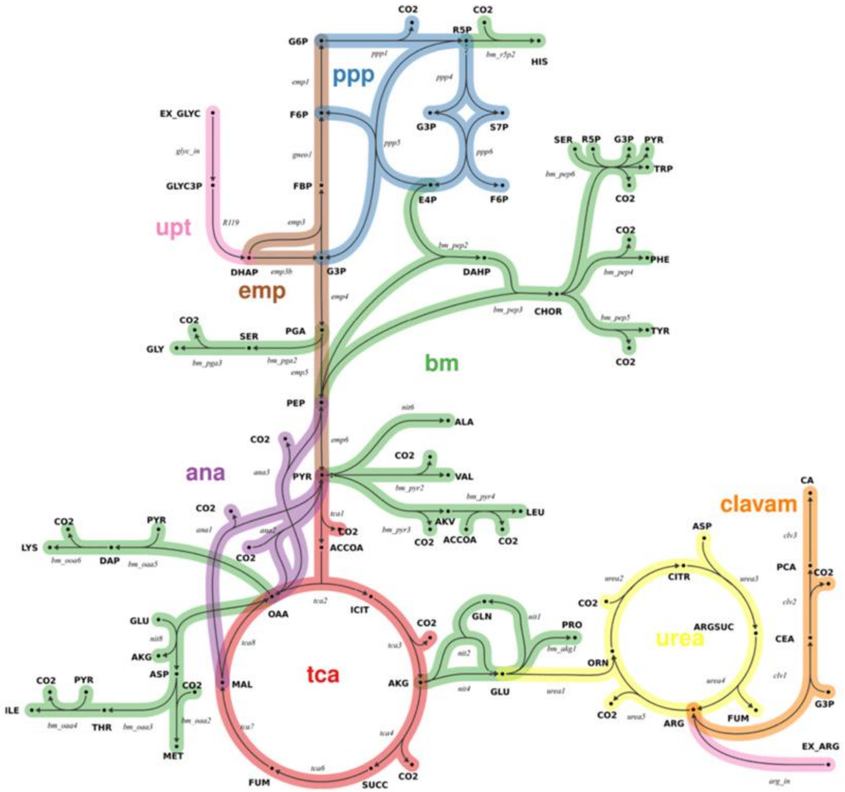
Joseph Moran

uOttawa

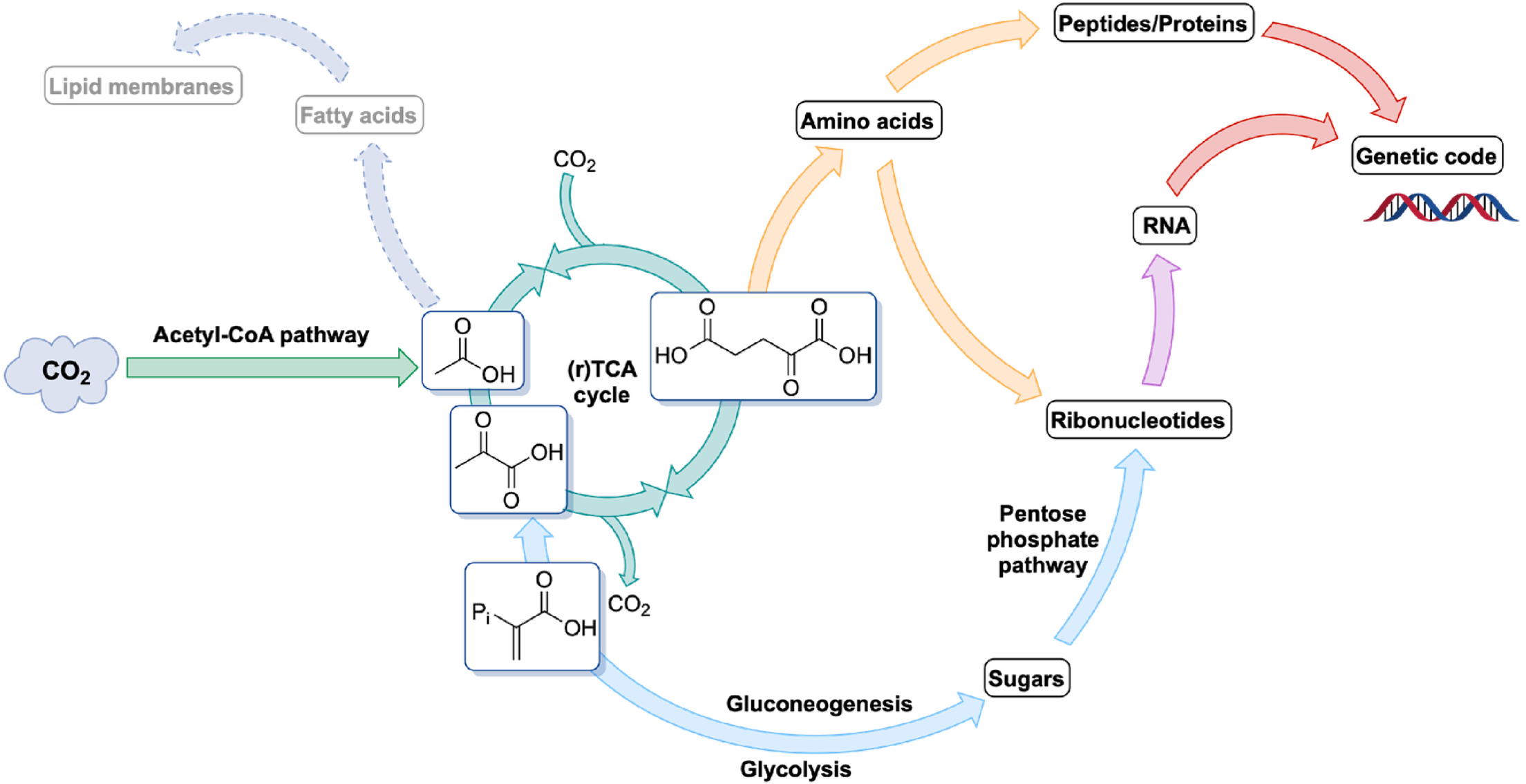
SYENSQO

How did it start?





Which Came First?

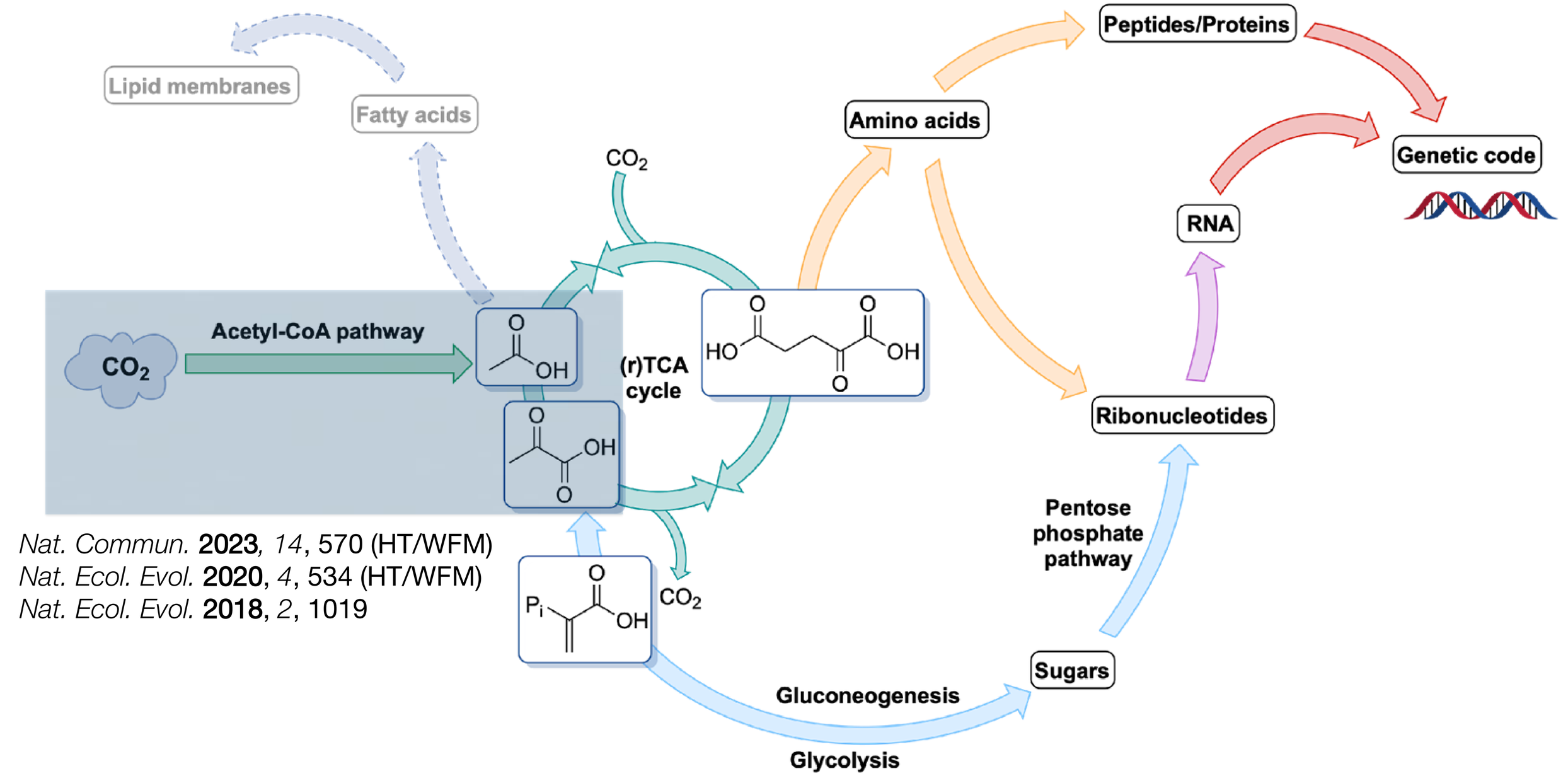


Muchowska, Varma, Moran, *Chem. Rev.* **2020**, *120*, 7708-7744

What I cannot create, I do not understand.

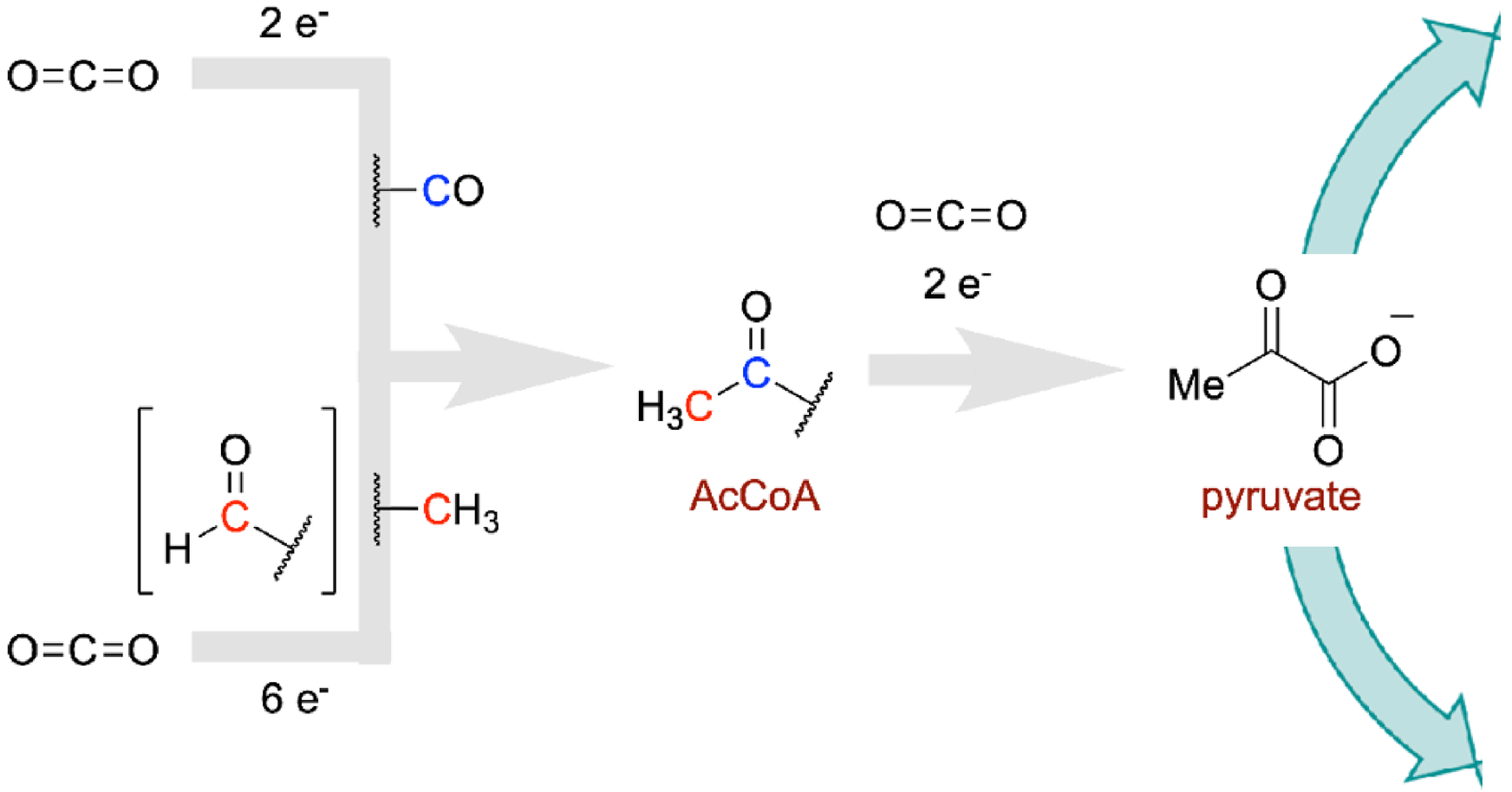
— *Richard P. Feynman* —

Create cell- and enzyme-free metabolism



Nat. Commun. **2023**, *14*, 570 (HT/WFM)
Nat. Ecol. Evol. **2020**, *4*, 534 (HT/WFM)
Nat. Ecol. Evol. **2018**, *2*, 1019

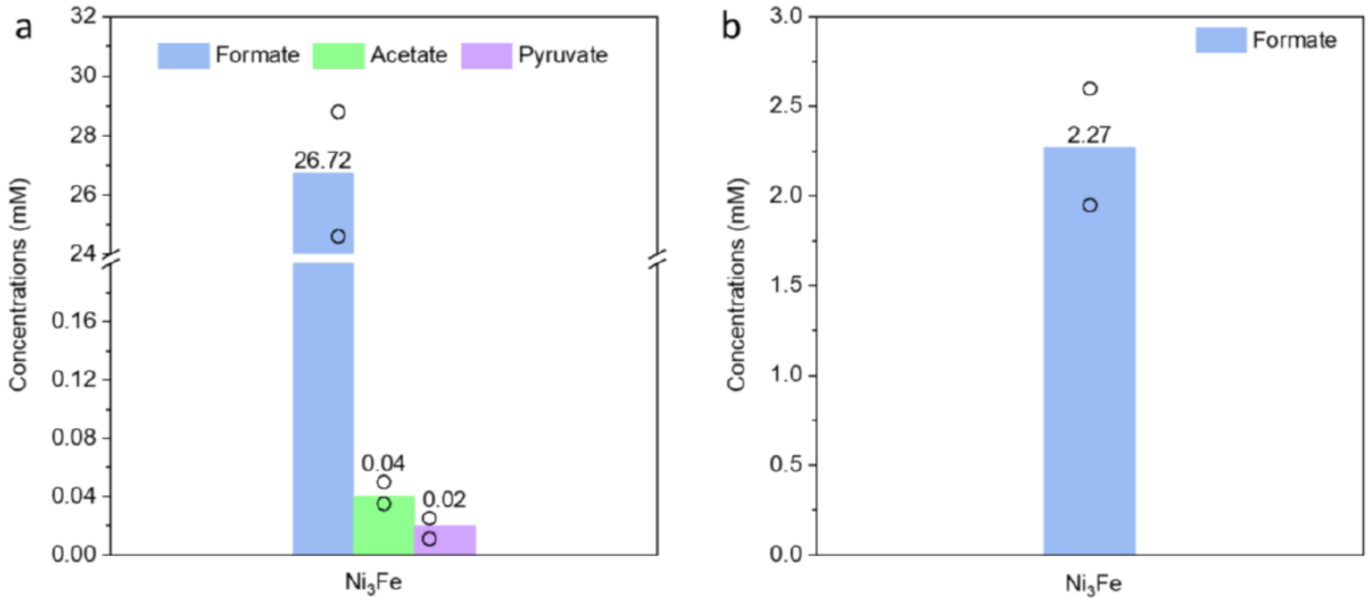
Ancient CO_2 fixing pathways: The AcCoA pathway



- Short, linear, starts only from CO_2
- Found in bacteria and archaea
- Thought to be in LUCA (Martin)

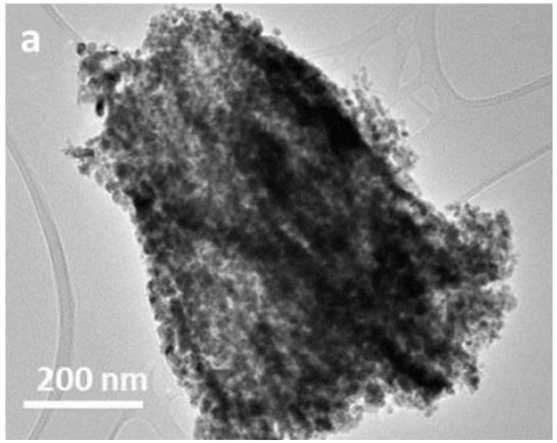
Ljungdahl *Biochemistry* **1965**, *4*, 2771
Martin, Russell *Phil. Trans. R. Soc. B* **2007**, 1887
Electrochemistry: de Leeuw, *Chem. Commun.* **2015**, 51, 7501

An analog of the AcCoA pathway without enzymes



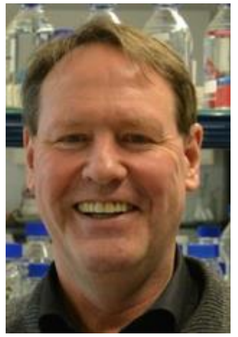
with H_2 (25 bar)

without H_2



TEM of Ni_3Fe (awaruite)

Martina Preiner



William F. Martin

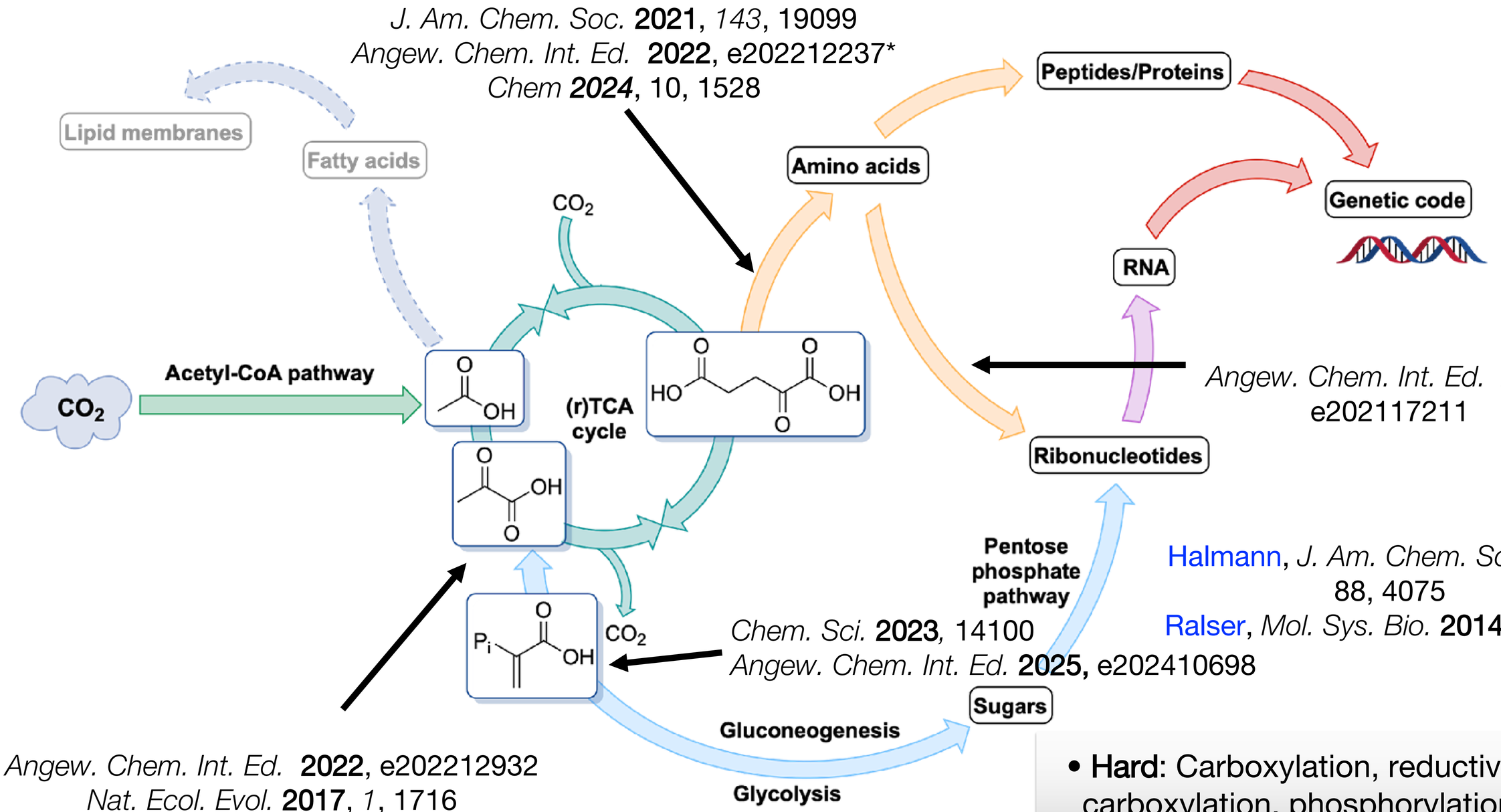
Sreejith Varma

Kamila Muchowska

Harun Tüysüz

- Ni_3Fe; 25 ºC, CO_2/H_2 (3:2, 25 bar), pH 6 (before CO_2)
- H_2 powered metabolisms of the most ancient organisms
- 10^{11} mol/yr of H_2 produced inside Earth during Hadean era

Fe/CO_2 (30 ºC, 1 bar): Varma; Muchowska; Chatelain; Moran, *Nat. Ecol. Evol.* **2018**, *2*, 1019
H_2/CO_2 (100 ºC, 10 bar): Preiner; Igarashi; Muchowska; …Tüysüz; Moran; Martin, *Nat. Ecol. Evol.* **2020**, *4*, 534
H_2/CO_2 (25 ºC, 25 bar): Beyazay; Belthle; Farès; Preiner, Moran; Martin, Tüysüz *Nat. Commun.* **2023**, *14*, 570

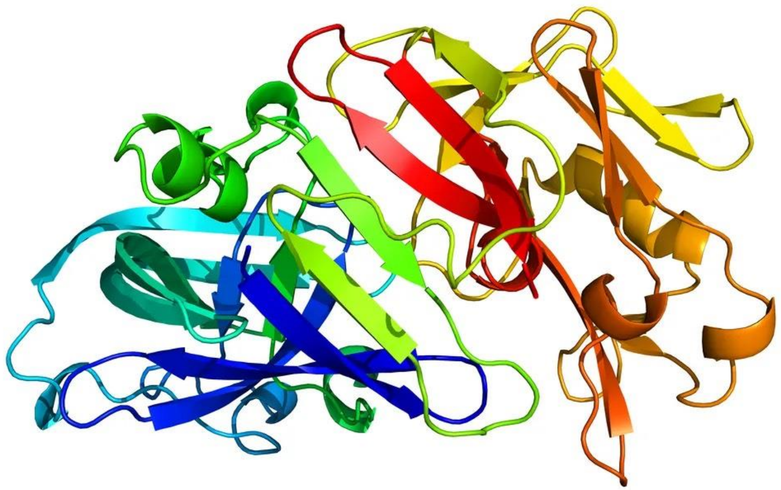


Reductive aldol keto acid synthesis: *Nature* **2019**, *569*, 104

Reductive aldol keto acid synthesis: + reductive amination: *Chem* ***2024***, 10, 1528

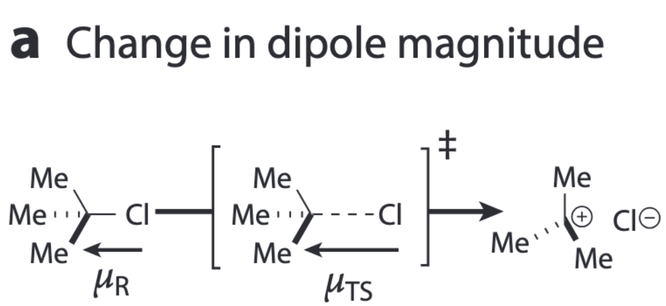
- **Hard**: Carboxylation, reductive carboxylation, phosphorylation, ribosylation of pyrimidines, purine biosynthesis

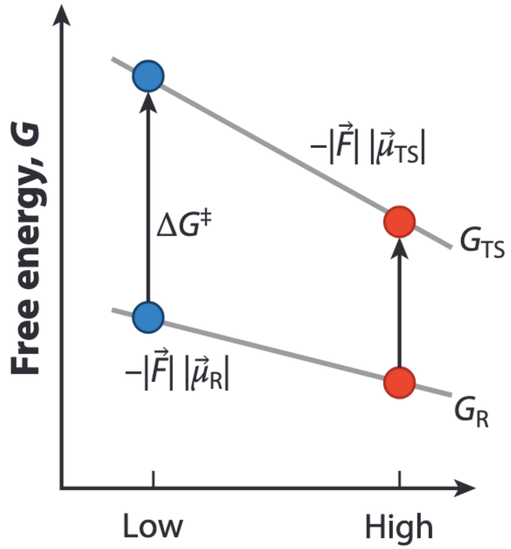
How Electric Fields Change Kinetic Barriers



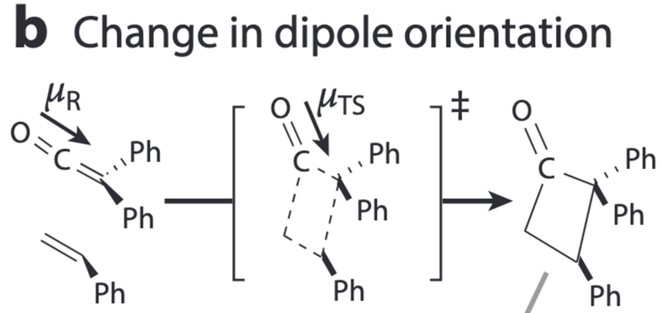
How do enzymes do it?

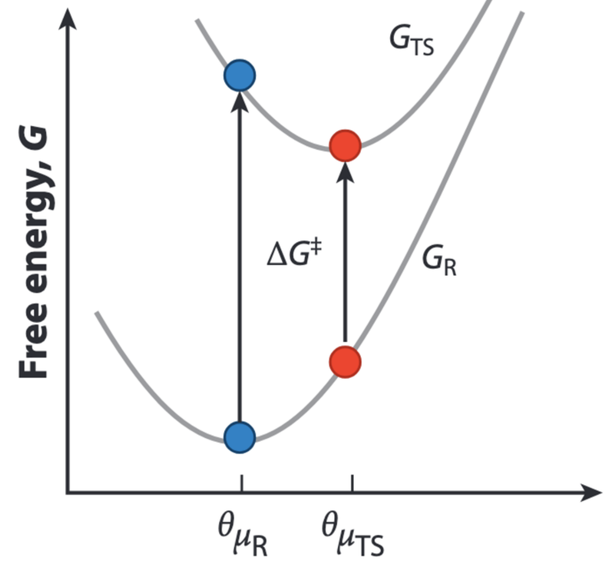
Electric fields





$$\Delta\Delta G^{‡} = -|\vec{F}|\,(|\vec{\mu}_{TS}| - |\vec{\mu}_R|)$$

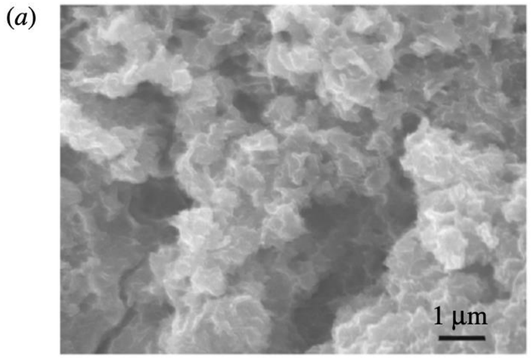


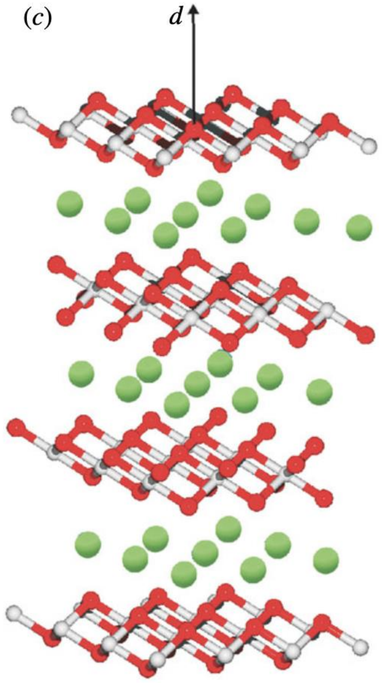


$$\Delta\Delta G^{‡} = -|\vec{F}|\,|\vec{\mu}|\,(\cos\theta_{F,\mu_{TS}} - \cos\theta_{F,\mu_R})$$

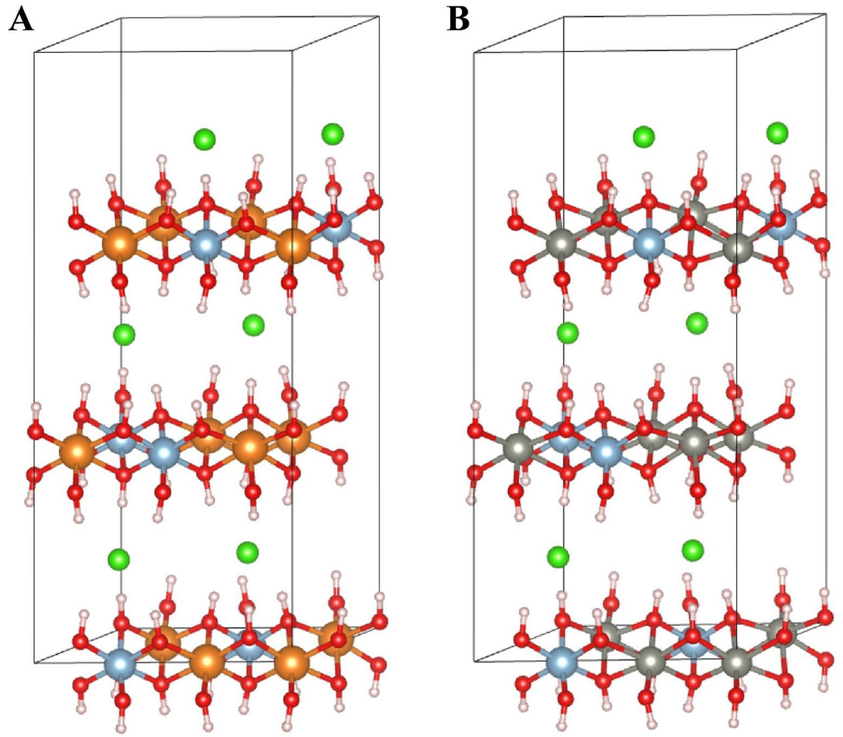
Shaik, *Nat. Chem.* **2016**, *8*, 1091; Boxer, *Annu. Rev. Biochem.* **2016**, *86*, 387

Layered Double Hydroxides Have Just the Gap We're Looking For





6-40 Å



d = 7.8 Å

Russell, Nitschke, Wu, *Interface Focus* **2019**, *9*, 20190063

Pimentel, de la Luz, Hernández-Laguna, Sainz-Díaz, *Applied Clay Science* **2022**, *223*, 106496

Wang, Narayanan, Wu, *ACS Nano* **2017**, *11*, 8421

Coote *Nature* **2016**, *531*, 88

Electrochemical CO_2 reduction

- Induce electric field with electrodes in presence of LDH

CO_2 reduction with electrochemical setup

Fiza Akbar

Objectives du projet confié par Syensqo :

- C_3 & higher products from CO_2
- Incorporation of N, P, S