U N I V E R S I T Y   O F   B E R G E N

Department of Chemistry

Bioenergy and biofuels

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Photosynthesis

Ingredients | *Product*

Sunlight +

$H_2O + CO_2 + \text{Nutrients} \rightarrow \text{“}CH_2O\text{”} + O_2$

Water

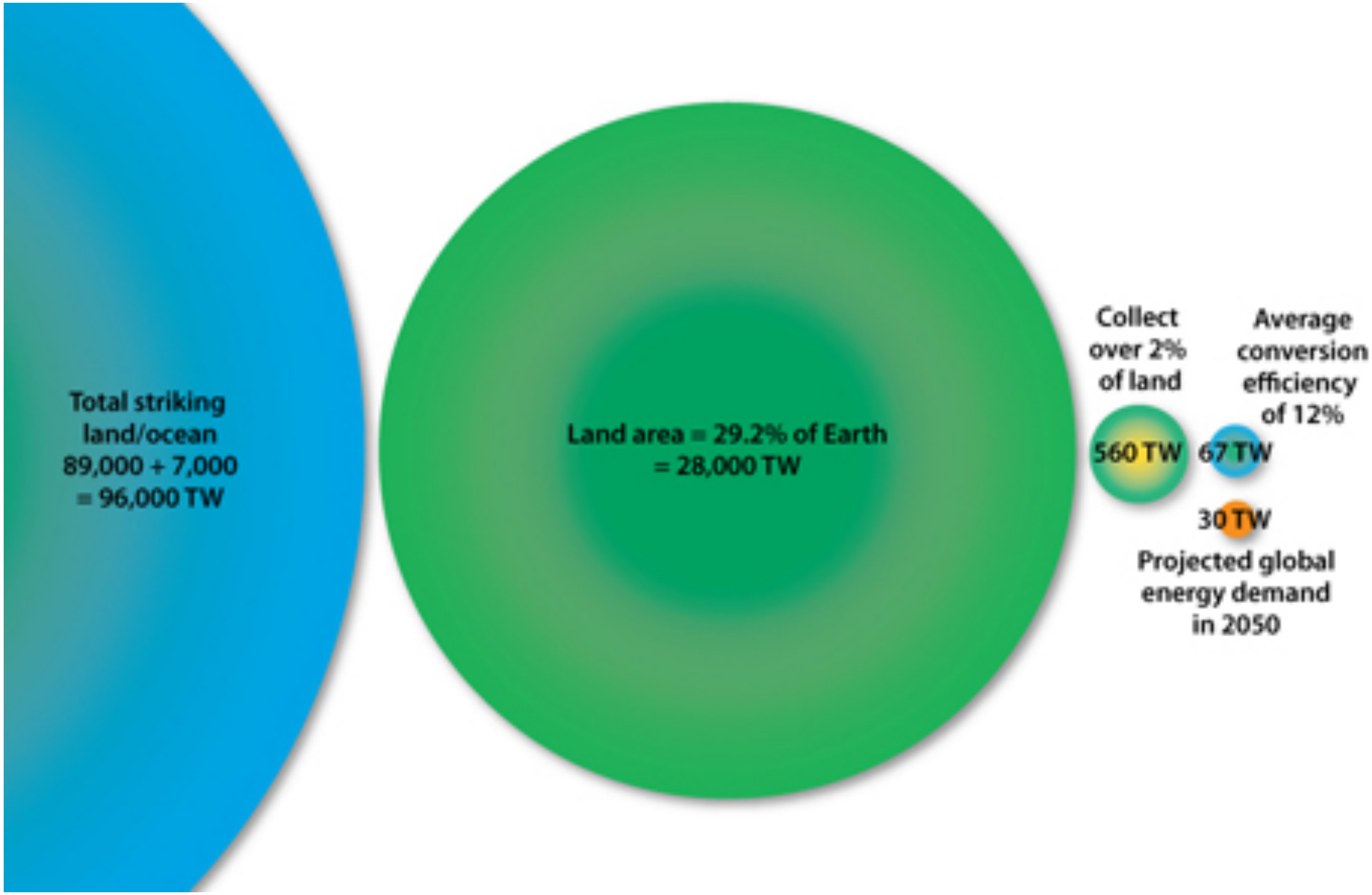
Carbon dioxide

Nitrate NO_3
Phosphate PO_4
Iron
Silica
among others

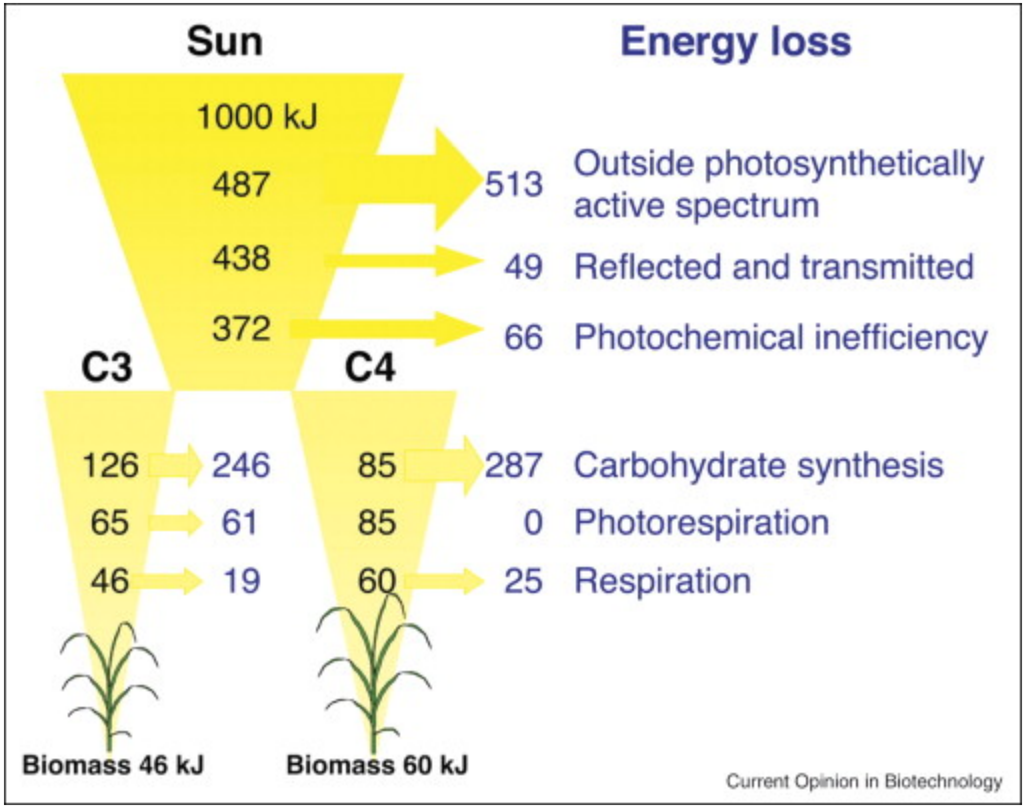
“Organic matter”

Oxygen

http://earthguide.ucsd.edu/eoc/special_topics/teach/sp_climate_change/p_photosynthesis.html



http://web.anl.gov/pse/solar/primer/primer1.html



What is the maximum efficiency with which photosynthesis can convert solar energy into biomass? Xin-Guang Zhu1, Stephen P Long, Donald R Ort, Current Opinion in Biotechnology 19 (2), 2008, P 153–159

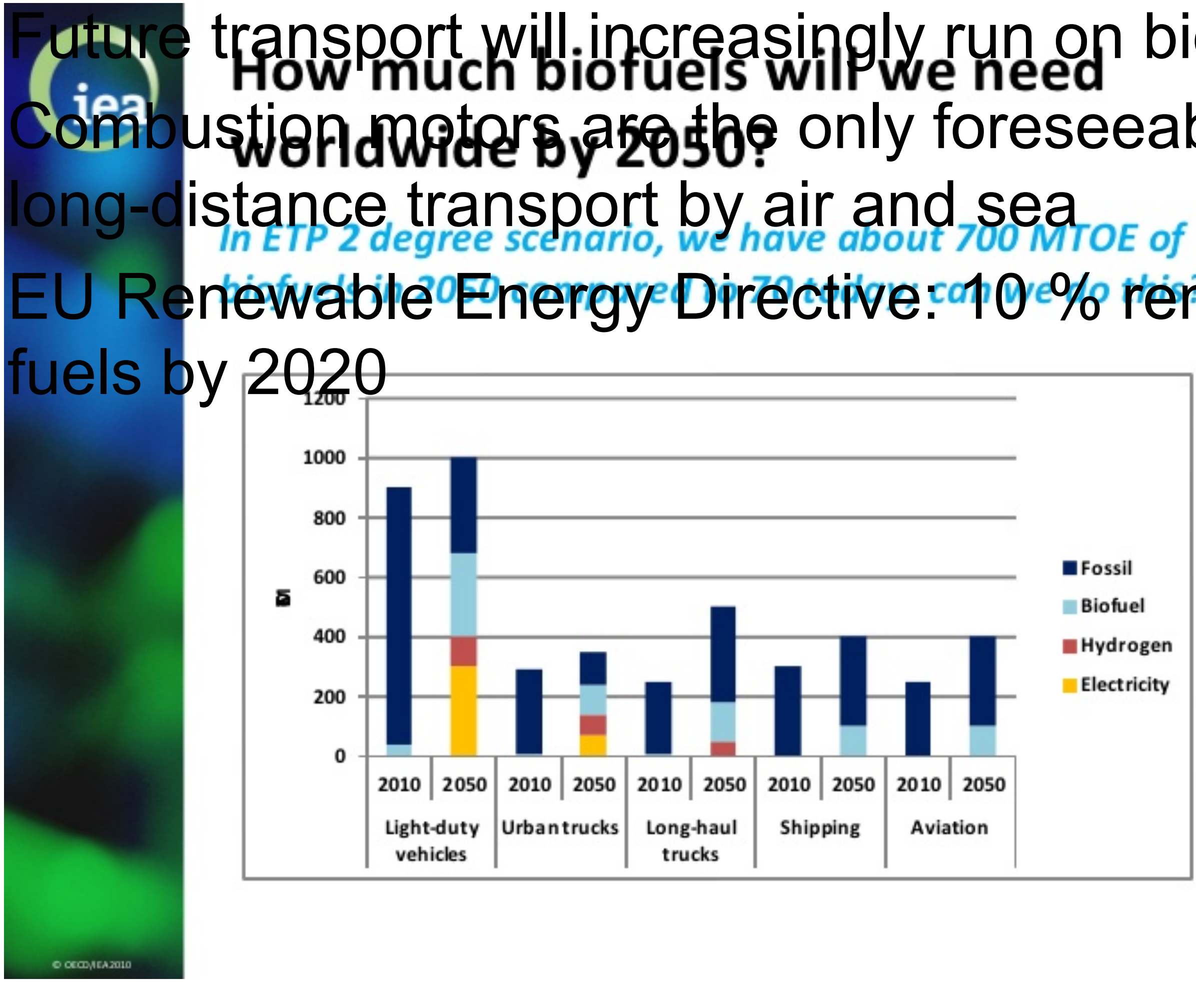
Figure 2. Minimum energy losses calculated for 1000 kJ of incident solar radiation at each discrete step of the plant photosynthetic process from interception of radiation to the formation of stored chemical energy in biomass. Both C3 and C4 (NADP–Malic Enzyme type) photosynthesis are considered. Calculations assume a leaf temperature of 30 °C and an atmospheric [CO_2] of 380 ppm. The theoretical maximal photosynthetic energy conversion efficiency is 4.6% for C3 and 6% C4 plants, calculated based on the total initial solar energy and the final energy stored in biomass.

Biofuels = 63 % of renewable energy use at present,
3 % of transport fuel p.t.:

- Burning wood, peat, dung for heat
- First generation biofuels: Simple technology, competes with food – bioethanol from sugars, starch (Brazil, USA), biodiesel from vegetable oils (Europa)
- Second generation/advanced biofuels: More complex technology, non-food feedstocks

Why biofuel?

- Transport accounts for ~ 25 % of the energy consumption
- Future transport will increasingly run on biofuel
- Combustion motors are the only foreseeable option for long-distance transport by air and sea
- EU Renewable Energy Directive: 10 % renewable motor fuels by 2020



Which biomass?

- Lignocellulose does not compete with food and feed
- Nordic forests are sustainably managed resources with declining conventional market demand
- Agricultural residues and short-rotation forestry are also sustainable lignocellulosic resources
- No land-use change, and no diversion of water resources

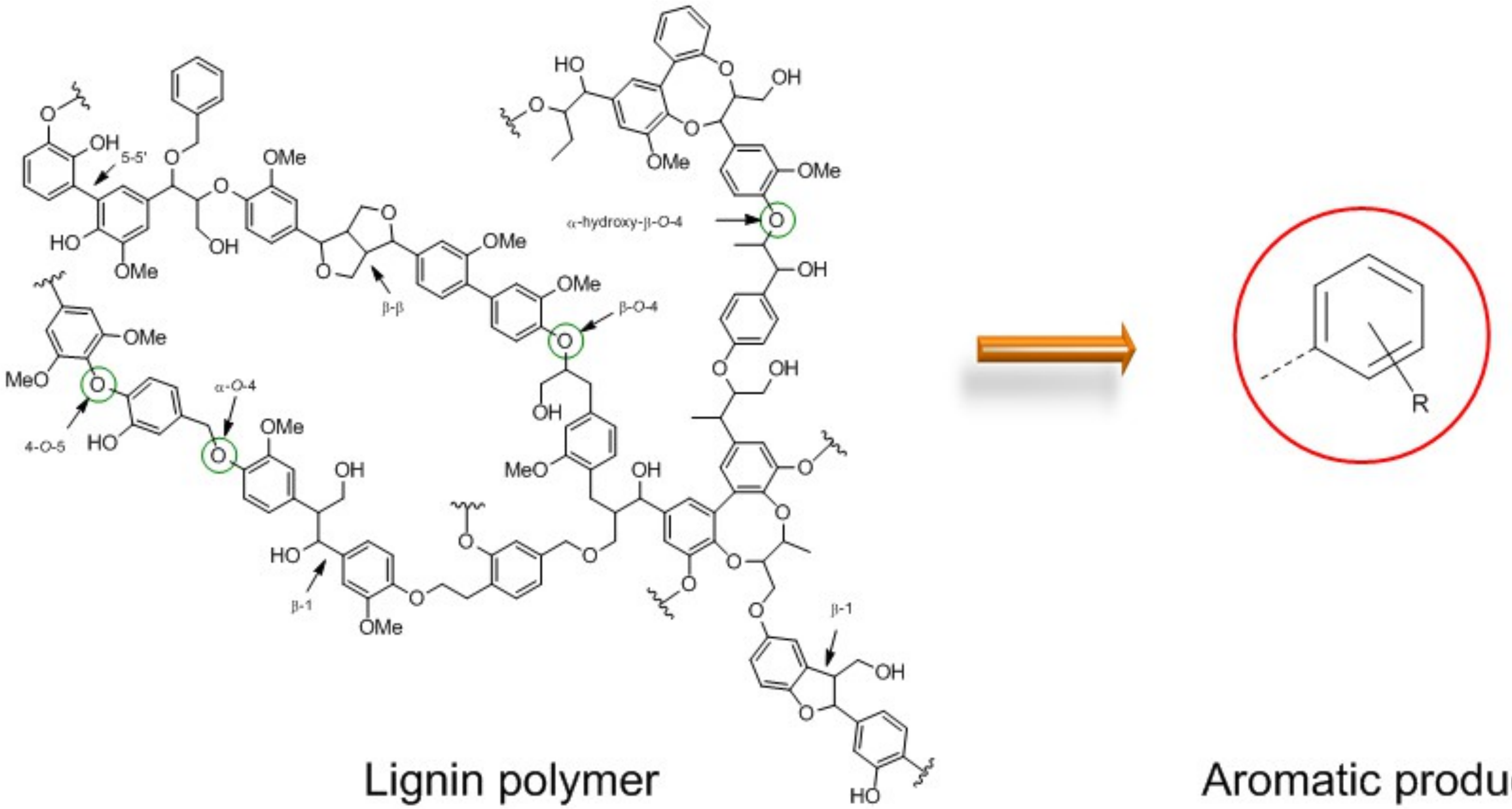
Which process?

- Motor fuels: ~ 10-35 % aromatics required:
  - Produced from fossil resources
  - Only natural source for aromatics: **lignin**:
    - ~ 1/3 of wood, 10-20 % of grass
    - Under-exploited relative to cellulose

40 years of research → no industrial process!

- Goal: *Starting from lignin: Develop key technology for first sustainable production of complete motor fuel*

Heterogeneous catalysts for conversion of lignin to aromatics



Lignin polymer

Aromatic products

Thank you for the attention!

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