MSU has expertise in the entire spectrum of bioenergy and bioenergetics

“Bioenergy and Bioenergetics”

Biological Energy Capture and Storage
- Chemistry, BMB, Plant Biology, PRL, GLBRC, Horticulture etc.

Photosynthetic:
- Plants
- Algae
- Cyanobacteria

Biosynthetic:
- Other organisms (fermentation etc.)

Biochemistry and bioenergetics of photosynthesis and energy storage
- light reactions
- assimilation
- biosynthetic
- synthetic biology

Interactions of organisms with the environment
- Abiotic and biotic stress physiology
- Genetics, Natural variation, evolution

Engineering
- Agriculture, aquiculture, algal biofuels etc.
- Synthetic biology

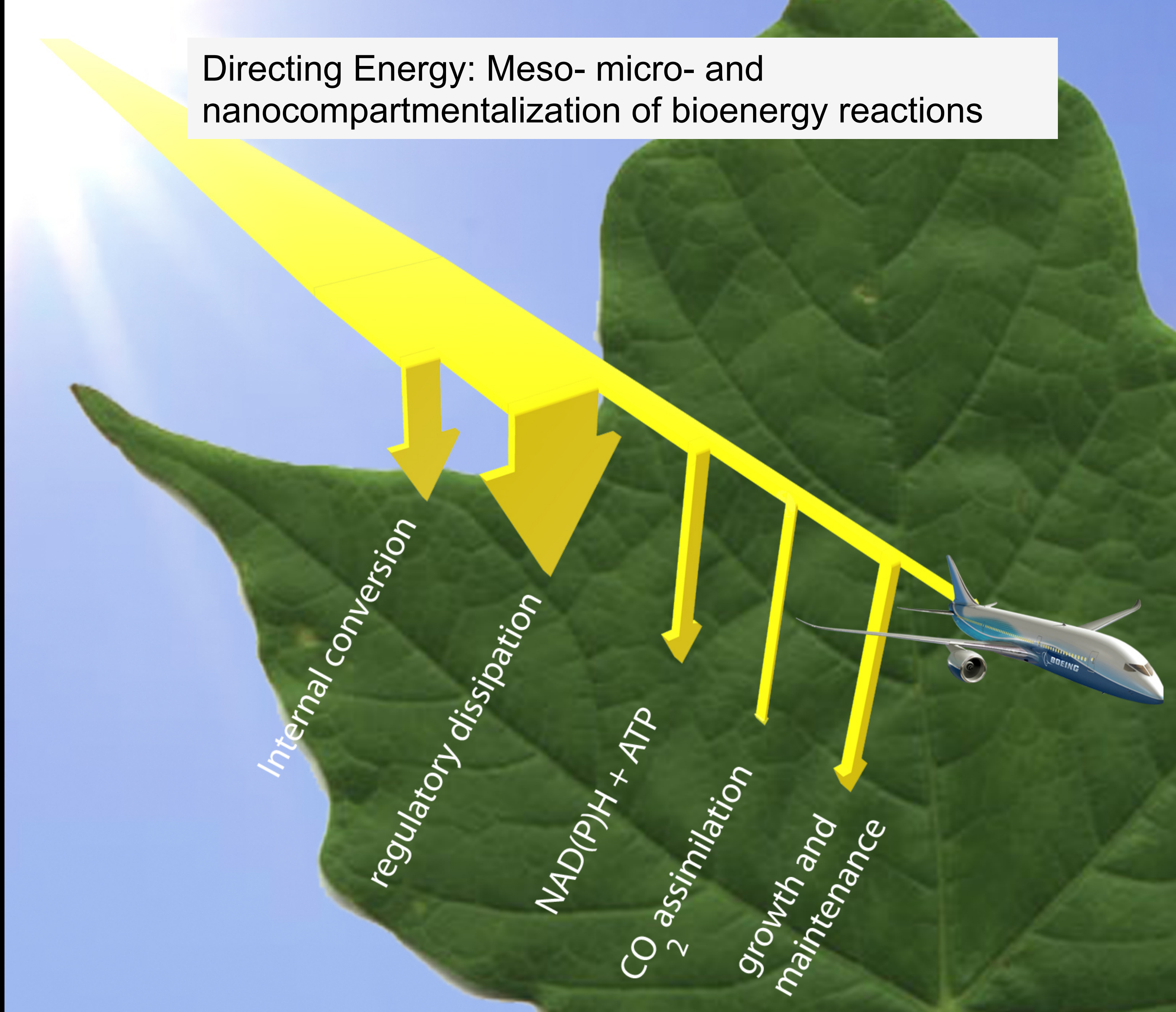
"Unifying" themes that address emerging problems that MSU strengths naturally address:

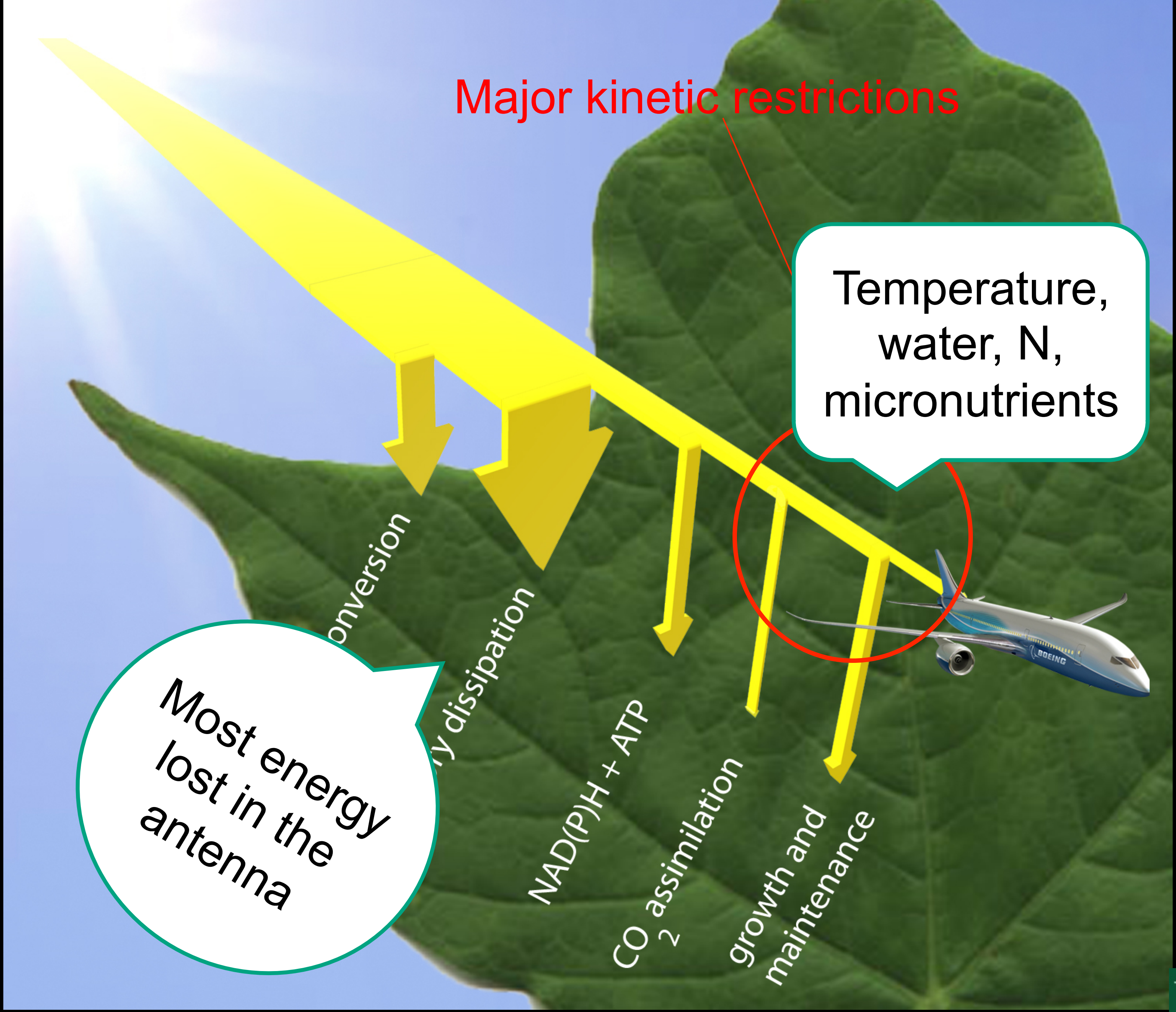
1) Genotype to Phenotype

2) Directing Biological Energy
   meso- micro- and nano-compartmentalization

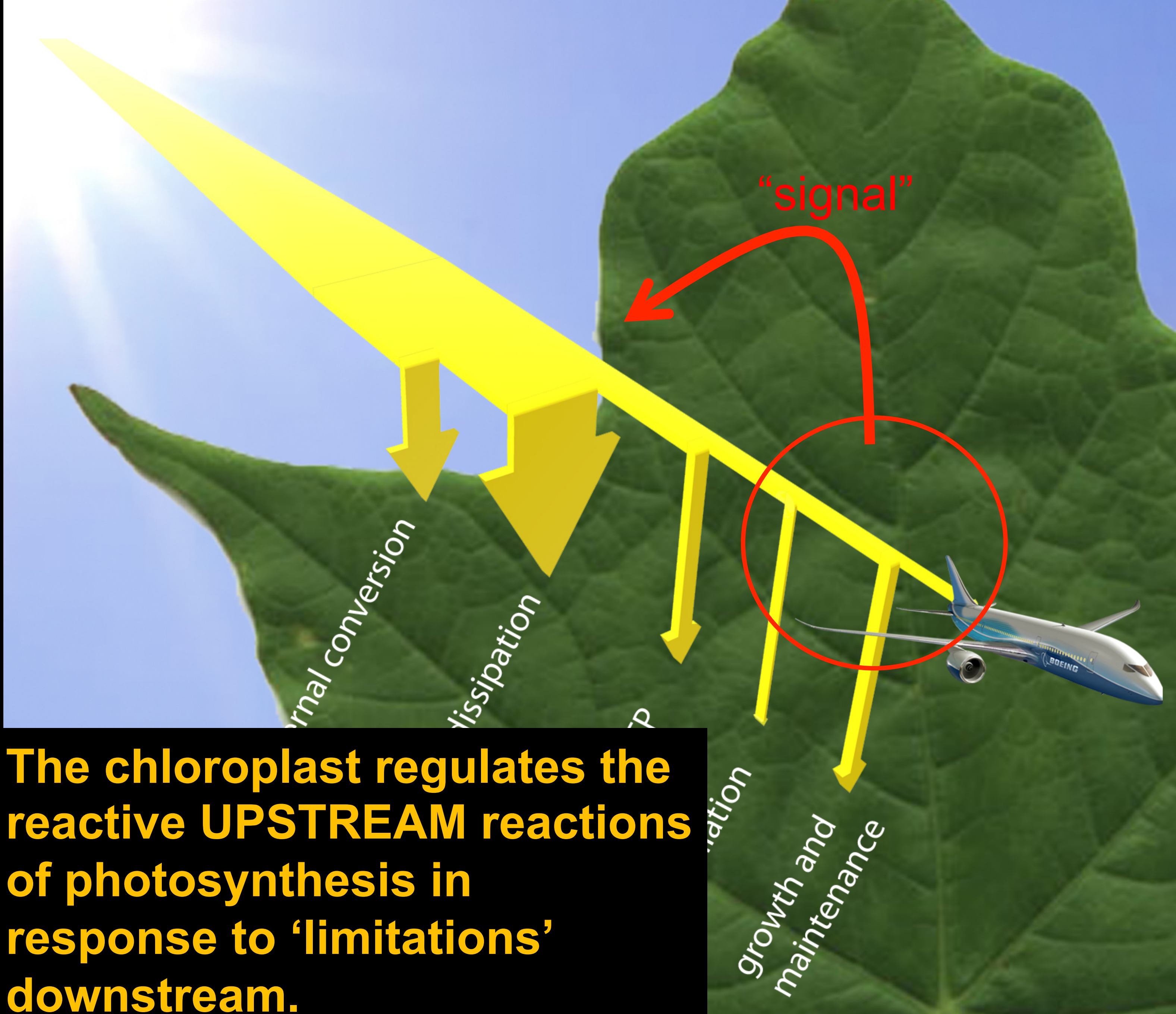
3) Bioenergy and climate change

Directing Energy: Meso- micro- and nanocompartmentalization of bioenergy reactions

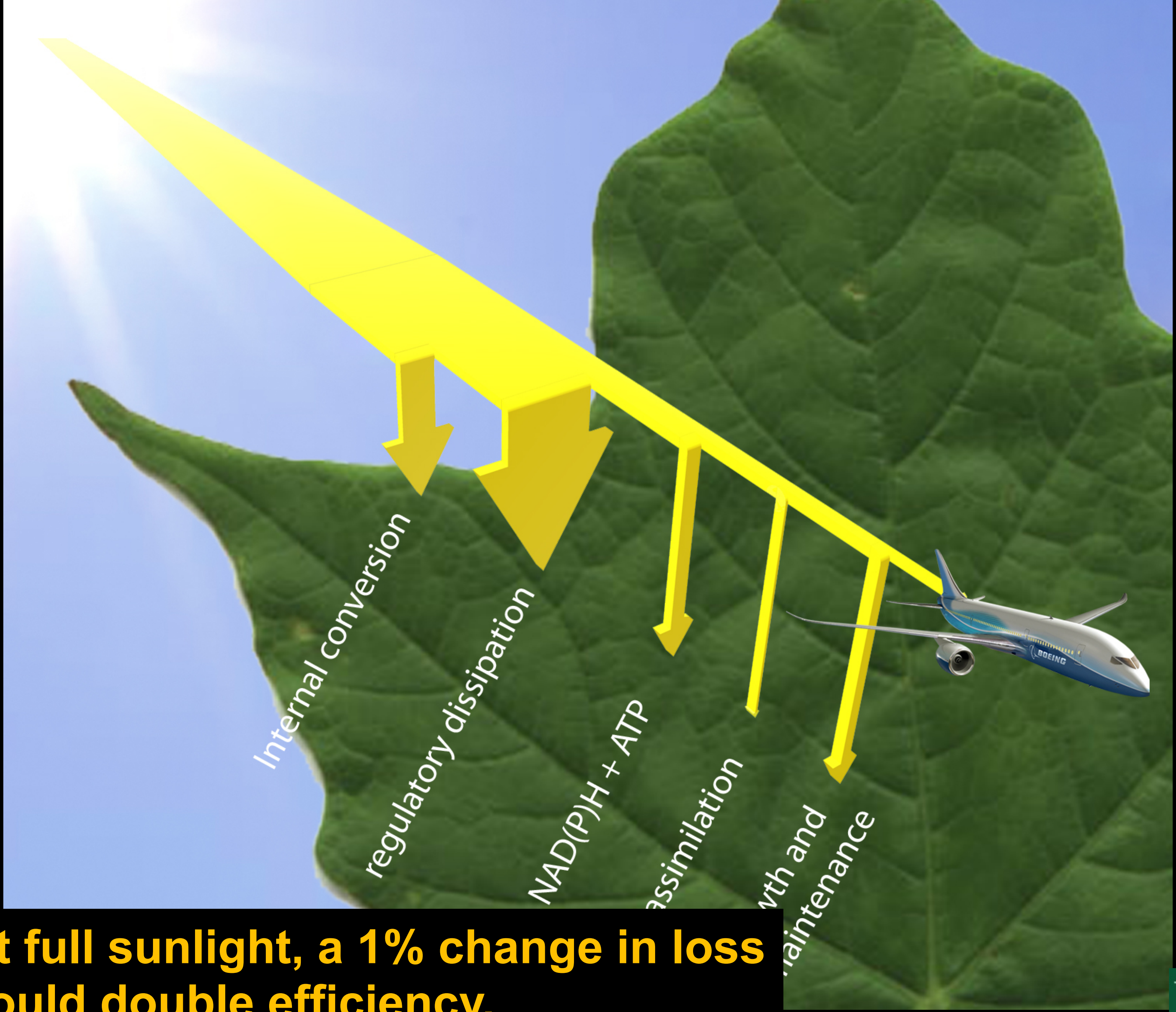




Major kinetic restrictions
Temperature, water, N, micronutrients
Most energy lost in the antenna
onversion
y dissipation
NAD(P)H + ATP
CO 2 assimilation
growth and maintenance
BOEING

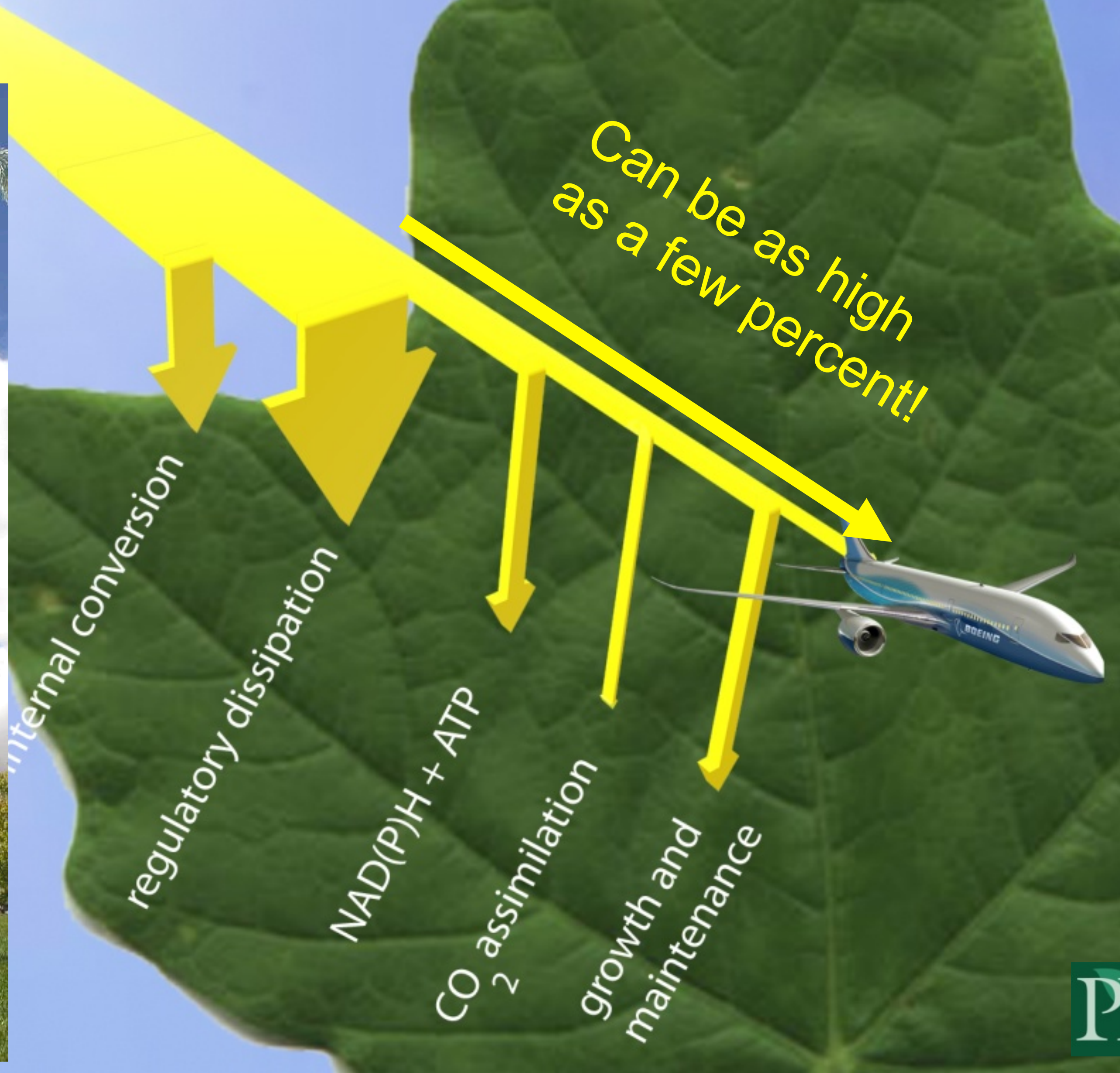


The chloroplast regulates the reactive UPSTREAM reactions of photosynthesis in response to 'limitations' downstream.



At full sunlight, a 1% change in loss could double efficiency.

There is large variation between species in energy efficiency, even under similar growing conditions.



2) Directing Biological Energy

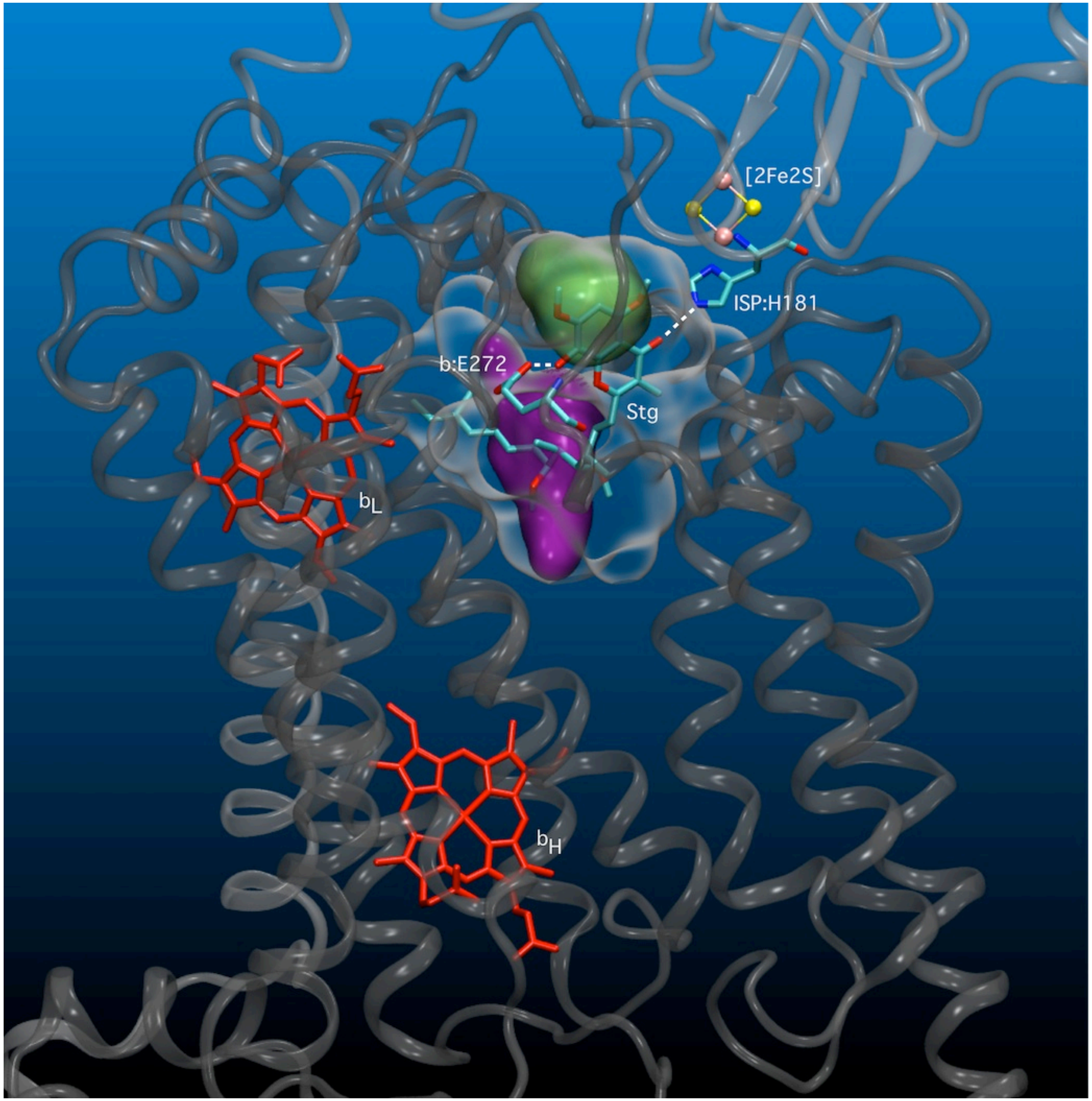
meso-, micro- and nano-compartmentalization

1) RUBISCO is limiting
   resulting in “excess energy” capture which is wasted and damaging

2) We want to redirect this energy to useful chemistry.
3) The most interesting chemistries are sensitive to O_2, which photosynthesis produces.
   a) Make less O_2-sensitive enzymes
   b) separate the processes

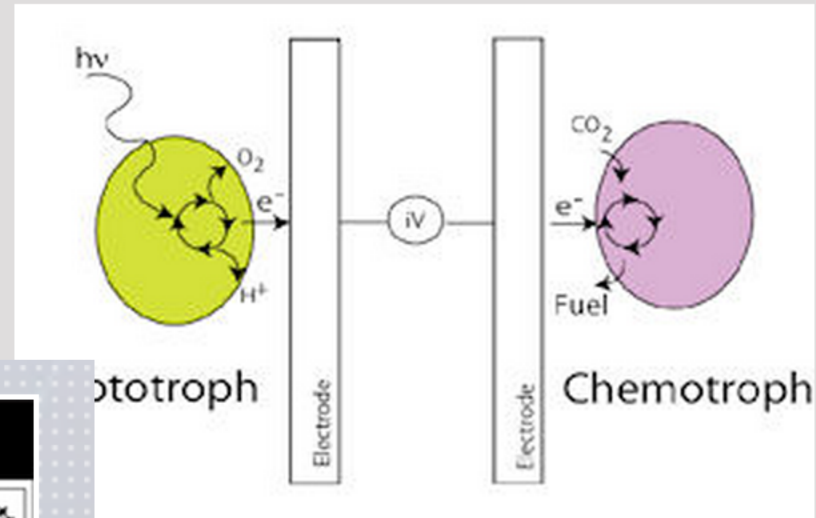
Interface among chemistry, biochemistry, biophysics, synthetic biology and computation. (Most of these pieces are in place…some need to be integrated).

What controls O_2 penetration and reactivity in proteins?

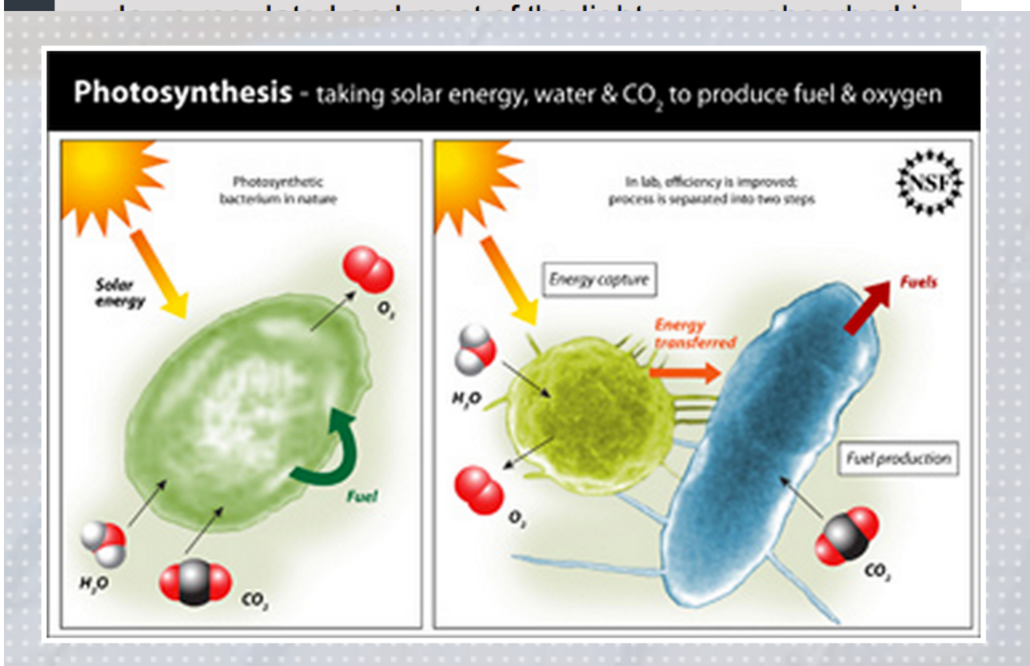


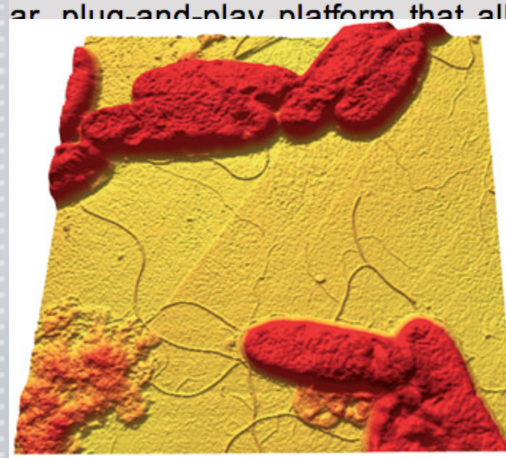
Plug and Play Photosynthesis for RuBisCO Independent Fuels

Phototrophs convert sunlight and carbon dioxide into chemical energy, but photosynthesis evolved to optimize biological fitness rather than human fuel production. Under excess light, Ribulose 1,5-Bisphosphate Carboxylase/Oxygenase (RuBisCO), the enzyme catalyzing the rate limiting step in CO_2 fixation, becomes saturated. Its metabolic pathway, the Calvin Cycle is



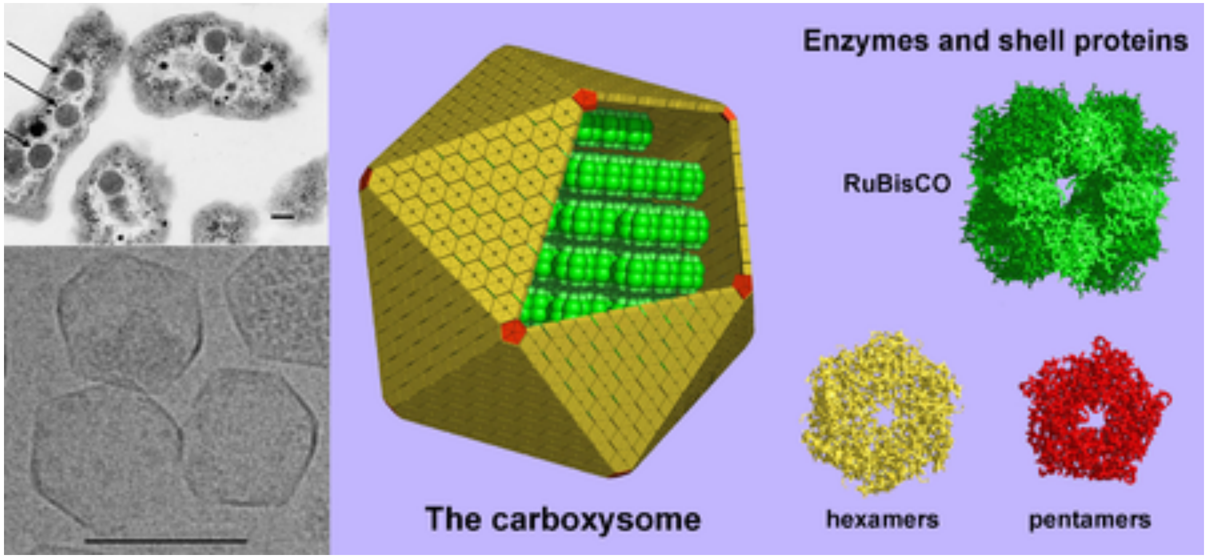
ar, plug-and-play platform that allows us to shunt





Kramer et al.

Carboxysomes as nano-reaction chambers



Kerfeld et al

Heterecysts and bundle sheath cells as cellular mico-reactions chambers