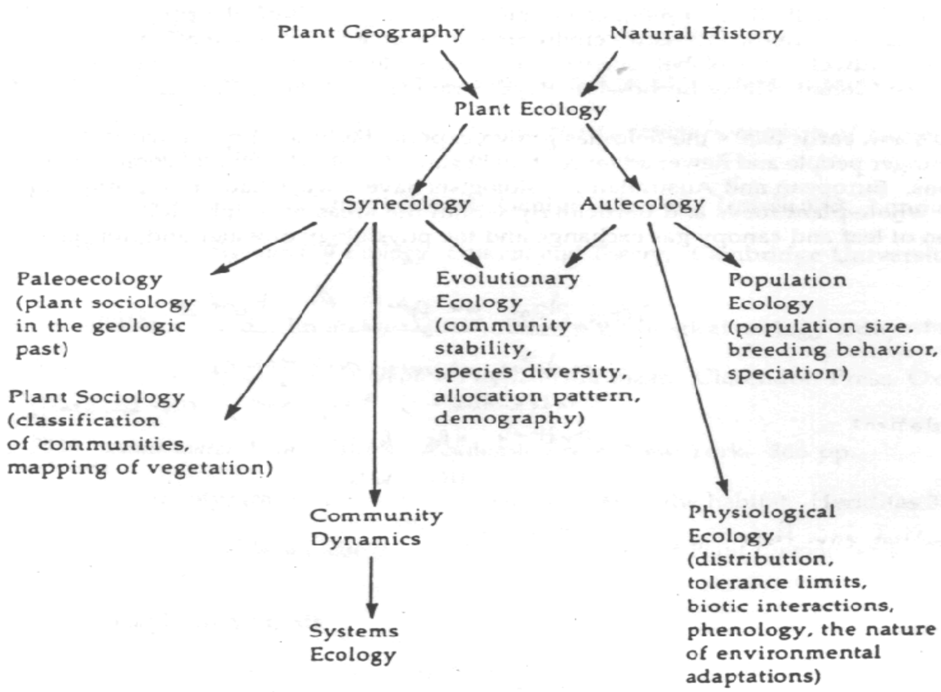
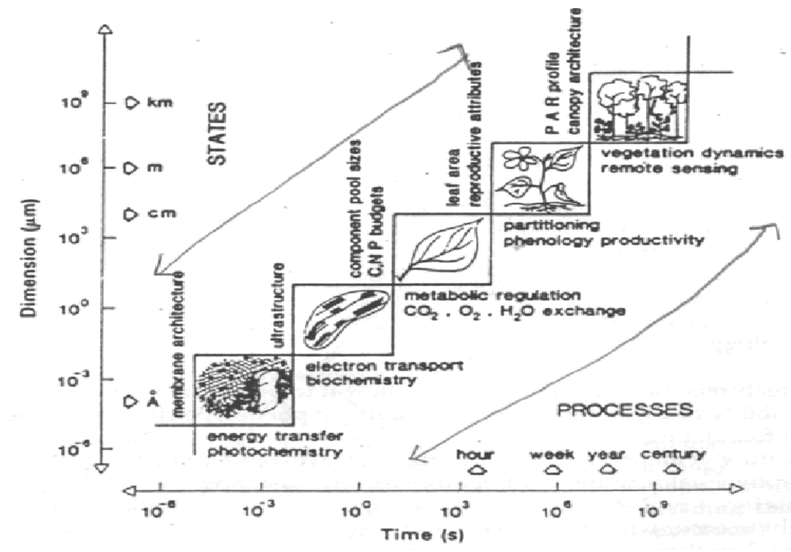
Ecology:
a branch of science concerned with the interrelationship of organisms and their environments

Physiology:
a branch of biology that deals with the functions and activities of life or of living matter (as organs, tissues, or cells) and of the physical and chemical phenomena involved

Eco-Physiology:
the science of the interrelationships between the physiology of organisms and their environment.





Osmond and Wong
(1988; Australian Journal of Plant Physiology 15: 1-9).

What kinds of questions do Ecophysiologists ask?

Examples:

Does physiological function of riparian trees differ from nearby desert shrubs in predictable ways?

What limits tree and forest growth/productivity? (e.g. palms)

Convergent Evolution (Chile vs. S. California)

Why do conifers/broadleaves dominate cold/warm environments? (independent adaptations?)

Global Change Biology (e.g. CO2 fertilization, potential migration, phenological change)

Major themes in Physiological Ecology

• Tradeoffs or costs vs. benefits (e.g. height)

•Multiple functions (e.g. stomata, xylem)

•Evolutionary history/path dependence (e.g. rubisco)

•Performance Optimality (e.g. growth)

•Multiple Interacting Constraints (e.g. T x CO_2 x H_2O)

Identifying project topics - Guidelines

-**Relevent to your research (if you are conducting)**

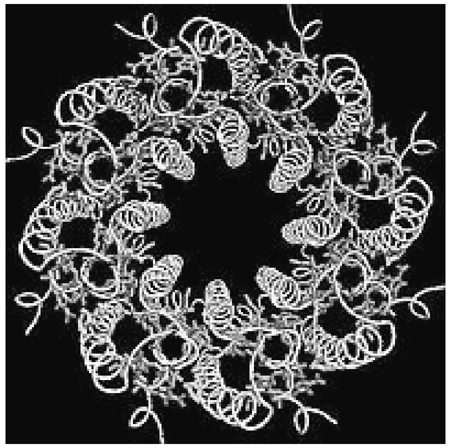
-**I'm flexible on the nature of projects for those who are not in a full-on research project.**

-**Do a quick overview of the textbook and identify areas of interest. Also see the following resource for ideas: http://www.biology.duke.edu/jackson/ecophys/grad.htm**

-**Come see me for ideas. There are many exciting areas open for new discovery:**

-How does Hemlock Wooly Adelgid cause tree death?
-What is the impact of salting roads on plant function?
-What determines the maximum size of vegetation/carbon sequestration potential of forests?
-How do different tree life forms respond differentially to seasonal climate?

Photosynthesis



Light Harvesting Complex

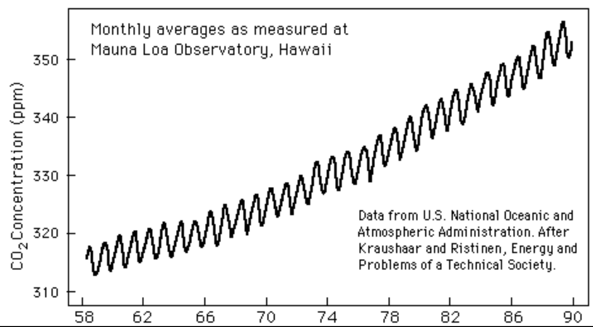
Outline

1. The significance of photosynthesis
2. Overview of the photosynthetic process
3. Overview of the photosynthetic apparatus
4. Details of photosynthesis

1. The significance of photosynthesis

- no life on earth without photosynthesis! (save chemoautotrophs)

- Sensitive responses of PS to environmental variation have large implications for biosphere responses to global climate change.



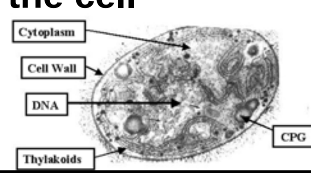
1. The Evolution of photosynthesis

- Endosymbiotic, from prokaryotic photo-bacteria

- Chloroplasts have their own genome (circular, not nuclear)

- Photosynthesis depends on chloroplast + nuclear synthesized proteins, working in conjunction

- Cells can operate without chloroplasts (they just lose ability to photosynthesize), but chloroplasts can't do photosynthesis without the cell



2. Overview of the photosynthetic process

The basic reaction:

$$H_2O + CO_2 \text{ --> } CH_2O + O_2$$

‘reduced’ (energy rich) carbohydrate
(e.g. glucose or fructose = 6(CH20)

•This is an endergonic (‘uphill’) reaction.

•Light pushes the reaction forward, feeding a biochemical energy bank account.

•Respiration (reverse reaction) cashes in on this bank account where other forms of energy are needed.

2. Overview of the photosynthetic process

Not just any light will do. Light must be of high ‘quality’, I.e. short wavelengths

Analogy to an air pump:

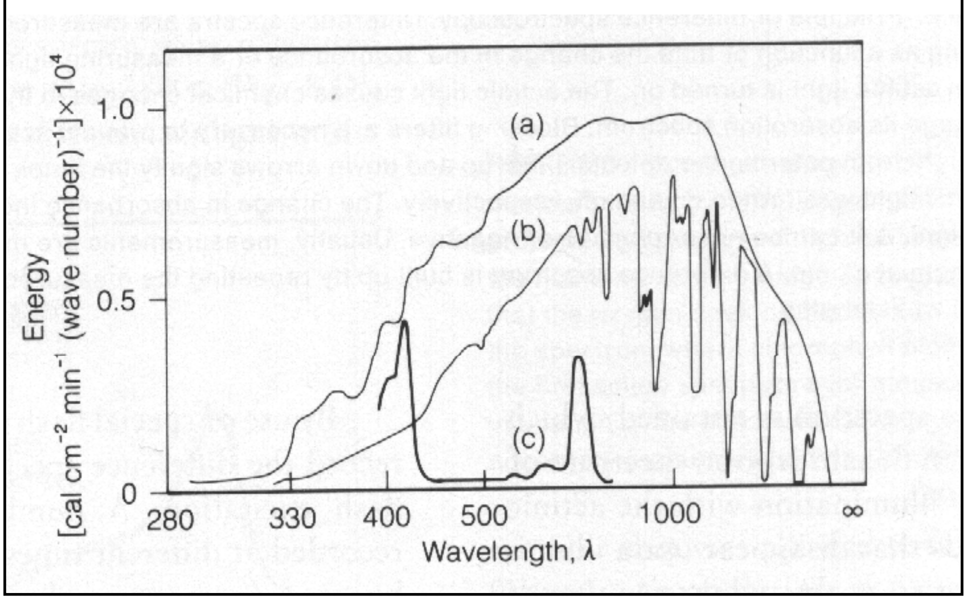
- Can’t use a raft air pump for a bike, even if an equivalent amount of energy (multiple parallel pumps) were used.

Einstein’s Photo-electric effect: To alter chemical structures by light, one must have a specific photon energy (E= hf), which cannot be satisfied by 2 x (h f/2)

The sun provides lots of energy in wavelengths less than that required for photosynthesis – it is useless (at least directly)

Thus, photosynthesis harvests ‘low-entropy’ light to create low entropy life, and returns high entropy heat back to envt.

Solar output (a), insolation (b), chlorophyll a absorption (c)



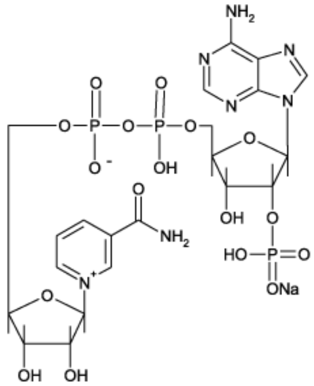
2. Overview of the photosynthetic process

All major processes involved occur simultaneously, but we may distill many events and intermediary processes into the following two steps:

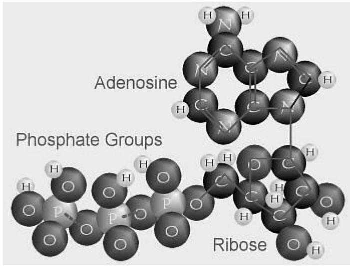
Act I: Light Reactions – in which photons are absorbed, routed to chemical reaction centers, and light energy is transformed into flexible forms of chemical energy (ATP, NADPH)

Act II: Dark Reactions – in which CO2 is captured and converted into sugar, which is subsequently used to build a variety of biochemical compounds. “Dark” reactions can occur in light or in the absence of light.

NADP - H



ATP



3. Overview of the photynthetic apparatus

Dramatis personae:

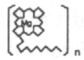
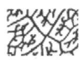
Photons
Absorbing pigments (chlorophyll)
Energy carriers/transformers/transporters.
Chemical substrates, reactants, products
Cellular organelles and substructures (chloroplasts)
Leaf cells (mesophyll)
Stomatal cells

It is very critical to have a clear picture of the spatial and temporal hierarchy in which these actors play their roles.

SPATIAL HIERARCHY

Table 4.1

Hierarchy of Structures and Processes of Mass and Energy Transfer in Plants

Hierarchical level		Structure (and its characteristic size, m)	Transfer mechanism	Integration factor (values are tentative)
1		Antenna (2×10^{-8})	Exiton, resonant	200–400 molecules of chlorophyll per photosynthetic unit
2		Thylakoid membrane (5×10^{-7})	Electrochemical	500 photosynthetic units per thylakoid
3		Chloroplast (5×10^{-6})	Diffusion	50 thylakoids per chloroplast
4		Cell (5×10^{-5})	Diffusion, cyclosis	50 chloroplasts per cell
5		Areolae (2×10^{-4})	Diffusion	1000 cells per areola
6		Leaf (10^{-1})	Hydraulics	10^5 areolae per leaf
7		Branches, roots (1–10)	Hydraulics	10^4 leaves per tree

TIME HIERARCHY

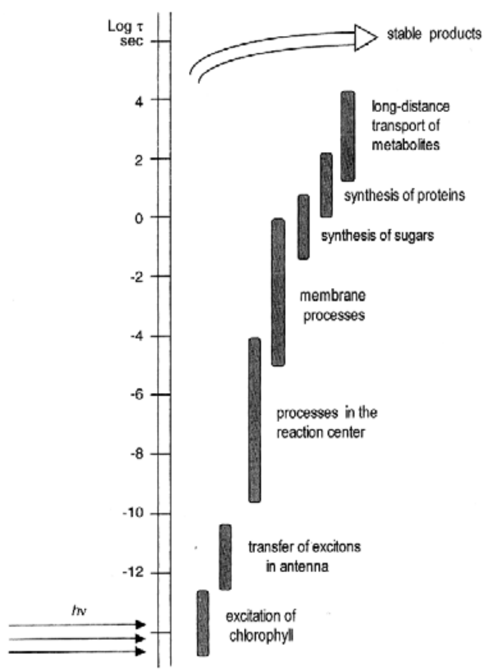


Figure 4.6 Hierarchy of characteristic times of processes in plants.