PHOTOSYNTHETIC CARBON CYCLE (DARK REACTIONS)

22 Nov 91, rvsd 19 Nov 93, 15 Nov 95, 25 Nov 96, 22 Nov 99, 19 Nov 01, 22 Nov 02, 19 Nov 03, 17 Nov 04, 21 Nov 05, 5 Nov 07, 12 Nov 08, 9 Nov 09, 10 Nov 10, 9 Nov 11, 11 Oct 13, 6 Oct 14

Melvin Calvin elucidated dark reactions (Nobel Prize):
1) radiotracer with H14CO3, Chlorella in “lollipop”, quenched in EtOH
2) two dimensional chromatography (two different solvent systems)
3) autoradiography to identify newly synthesized molecules

“REDUCTIVE CARBOXYLATION”

I. CARBON FIXATION in C-3 plants (“Calvin Cycle”: p 310) (“carboxylation”)
Carboxylation of ribulose 1,5 bis PO4 at carbonyl (number 2 carbon),
breaks into two molecules of 3-phosphoglycerate (p 311)
enzyme: ribulose 1,5 bis PO4 carboxylase/oxygenase (Rubisco)
RuDP carboxylase is also oxygenase, low CO2 and hi O2, conducts photorespiration

II. 3 PHOSPHOGLYCERATE ENTERS “REVERSE GLYCOLYSIS”:
1) first phosphorylate with ATP to make 1,3 bis phosphoglycerate
   (phosphoglycerokinase: PO4 bonds hydrolyzed to make it exergonic)
2) 1,3 bis phosphoglycerate reduced with NADPH to 3-PPO4-glyceraldehyde.
   Requires two ATP and 2 NADPH for every carbon atom fixed.
   To make one glucose molecule requires 12 ATP, 12 NADPH for

III. DI- AND POLYSACCHARIDE SYNTHESIS: (p 314)
End product glucose: then used to make either sucrose (cytosol), starch (stroma), or cellulose
Sucrose: glucose-6-P to G-1-P, tied to Uridine TP, UDP-glucose (activated) + PPi
   then F-6-P replaces UDP, sucrose-6-P, dephosphorylated
Starch: an ADP activated glucose added onto growing chain
   (Note that glucose is usually not end product, rather leads to sucrose or starch)

IV. REGENERATION OF RIBULOSE 1,5-BISPHOSPHATE
   (LEARN: reaction names & meanings, not specific molecules:
   complex set of steps, involving
   condensation (erythrose-4-P + DHAP to make seduheptulose-1,7-bis P)
   dephosphorylation (remove a PO4 from seduheptulose-1,7-bis P to S-7-P)
   transketolation (transfer 2 carbon frag. fr S-7-P to G-3-P, make xylose-5-P & ribose-5-P)
   isomerization (ribose-5-P, an aldose isomerized to ribulose-5-P, a ketose)

C-4 PLANTS, HATCH-SLACK PATHWAY: (illustration on p. 318, pathway on p 319)
CO2 from surrounding spongy mesophyll is assimilated in mesophyll cells,
then pumped to bundle sheath cells:
1) fixation occurs in spongy mesophyll cells to PEP at #3 carbon to make oxaloacetic H+
2) oxaloacetic H+ is reduced using NADPH to malate (reverse of one stage of the Krebs Cycle)
   Malate diffuses through plasmodesmata into bundle sheath cells to
3) malate is decarboxylated and oxidized yielding pyruvate, CO2 and NADPH
4) the CO2 fragment fix to RuDP enters the Calvin Cycle, completed in the bundle sheath cells.

ADVANTAGES OF C-4:
   Hatch Slack occurs in mesophyll cells, ready access to CO2,
   Serves to pump CO2 into the cell. Makes them resistant to hot, dry weather.

CYCLIC PHOTOPHOSPHORYLATION:
   Lacking CO2, high energy electrons cycle back to cytochrome b/f, ∴ make ATP (p 308)

PHOTORESPIRATION:
(P 316) ribulose 1,5 bis PO4 is catabolized when no other source of energy is available,
catalyzed by Rubisco , makes phosphoglycolate –glycine (peroxisome)–serine (mitochondrion)
Here are the autoradiographs that Calvin produced when identifying the first stable product of carbon fixation in *Chlorella*.