

Respiration

Objectives

- The basics – Glycolysis, Krebs cycle and cyanide-resistant respiration
- Current tissue or whole-plant model of respiration: functional model of plant respiration - construction and maintenance and other components
- ‘Energy –overflow hypothesis’
- Response of respiration to environment: short-term, and long-term

Glycolysis, Krebs Cycle Electron Transport and its function (Figure 5 from Lambers et al. p103)

Generate energy and metabolites

What is the function of cyanide-resistant respiration?

Functional Model: Total respiration = growth respiration coefficient * (Photosynthetic input or amount of new tissue constructed) + maintenance coefficient * (amount of biomass or living biomass or N content, or...).

Respiration ‘tax’ increases with increasing temperature

Amthor (2000) gives an excellent history of the functional model, how it was developed, and its limitations.

What is the purpose of maintenance respiration? Protein turnover, maintenance of ion gradients, etc.

In models, R_m is estimated first, then subtracted from carbohydrate pool, leaving rest for growth.

Has the functional model been successful? Can we really separate functional components? - example from Hawaii wood respiration

Other models of respiration - Criddle, Dewar

What causes variation in respiration rates?

Cellular activity or growth correlated with protein content - or N

Temperature

‘Sink-strength’ - demand for energy and metabolites

Substrate availability - sugar or starch concentration.

The CO₂ controversy.

Short and long-term controls.

Why is there no universally accepted model of plant respiration? Is there hope for Amthor’s ‘General Paradigm’?

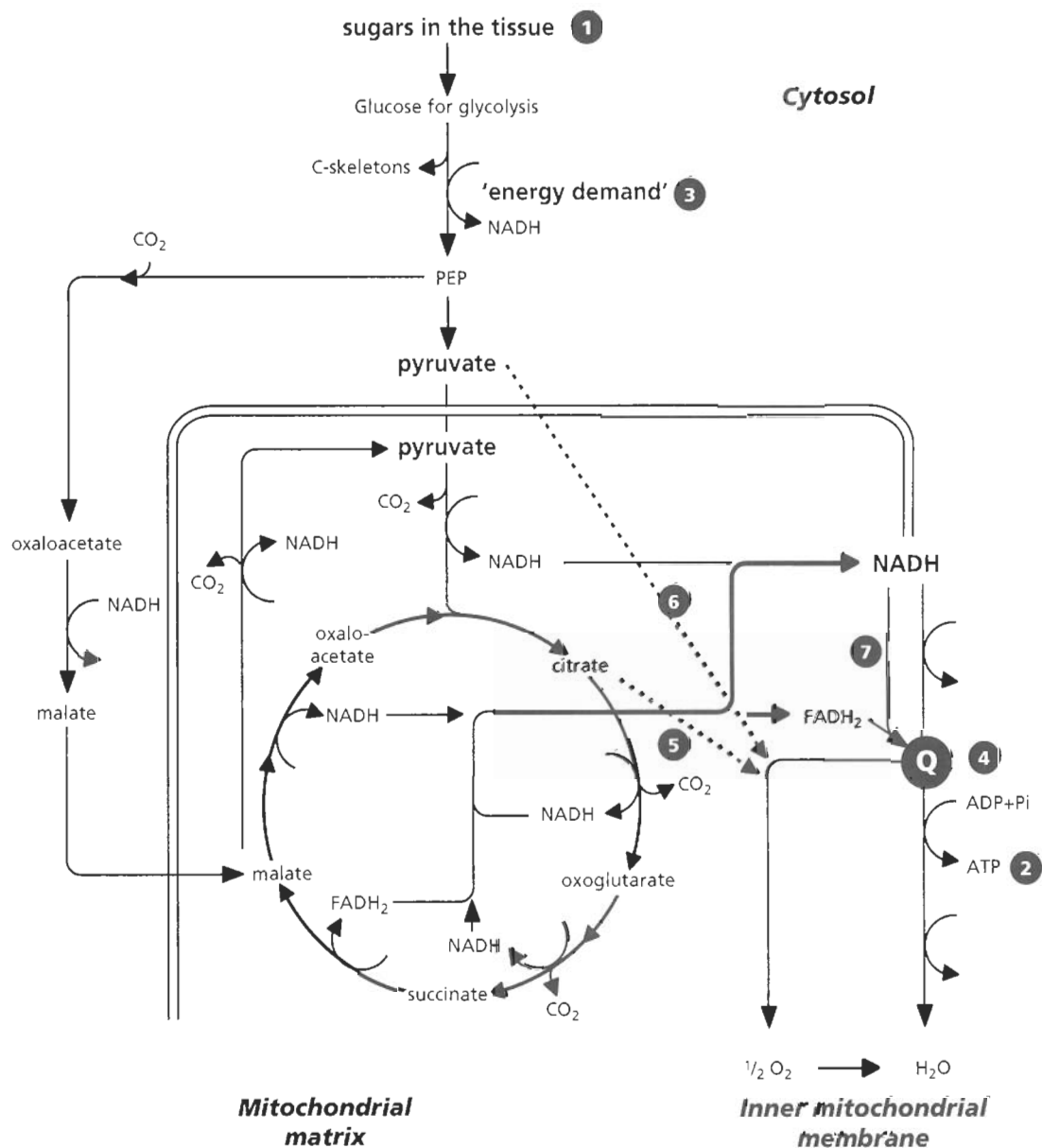
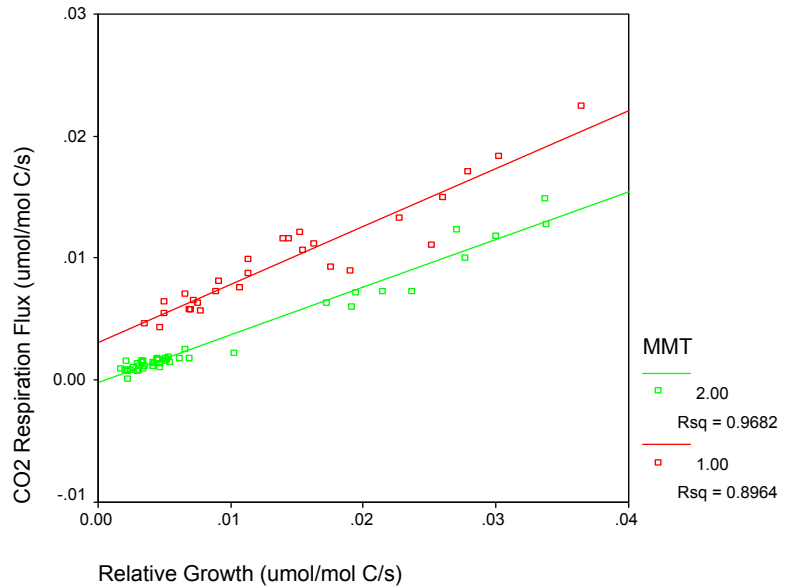


FIGURE 5. A simplified scheme of respiration and its major control points. Controlling factors include the concentration of respiratory substrate [e.g., glucose (1), and adenylates (2, 3)]. Adenylates may exert control on electron transport via a constraint on the rate of oxidative phosphorylation (2) as well as on glycolysis, via modulation of the activity of key enzymes in glycolysis, phosphofructokinase, and pyruvate kinase ("energy demand", 3). When the input of electrons into the respiratory chain is very high, a large fraction of ubiquinone becomes reduced and the alternative path becomes more

active (4). When the rate of glycolysis is very high, relative to the activity of the cytochrome path, organic acids may accumulate (5, 6). The accumulation of citric acid may reduce the sulfide bonds of the alternative oxidase and thus enhance the capacity of the alternative path (5). Pyruvate accumulation may activate the alternative oxidase and allow it to function at a low level of reduced ubiquinone (6). There is increasing evidence that the nonphosphorylating rotenone-insensitive bypass (7) operates only when the concentration of NADH is very high.

**Example of woody respiration
From Hawaii Euc Study (Ryan
et al.):**

Using plot average respiration and growth, a single equation fits the data quite well (Fig 4). The green line is from 1998 and 1994 plantations measured in 1999, 2000, 2001 and the red line is from the 1994 plantation measured in 1996 and 1997: MMT 1 = 1996 and 1997, maintenance = 3.09 nmol mol C⁻¹ s⁻¹, growth = 0.476 mol mol C⁻¹. MMT 2 = 1999-2001, including new plots, , maintenance = 0 nmol mol C⁻¹ s⁻¹, growth = 0.38 mol mol C⁻¹. Unfortunately, both slopes and intercepts differ significantly...



Respiration and N content.

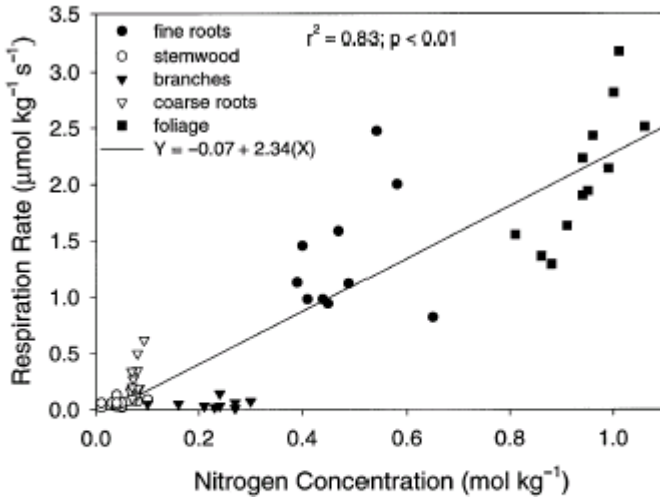
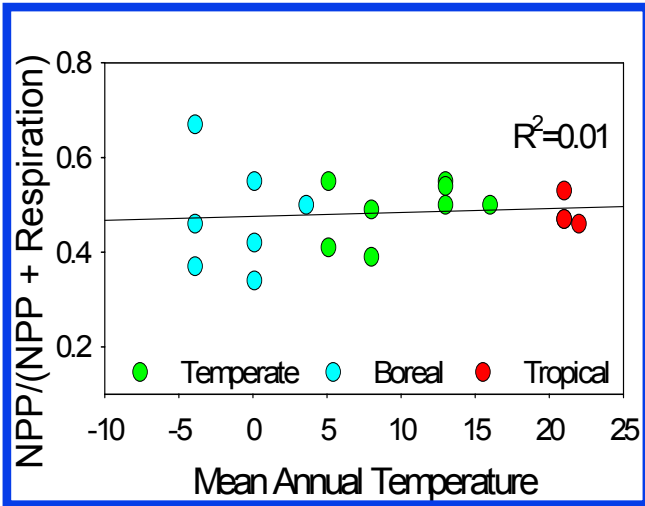


Fig.7 Relationship between *Pinus strobus* dormant season respiration rate (corrected to 15°C) for all stemwood, branches, foliage, fine roots, and coarse roots vs. dormant season tissue-specific N concentration.

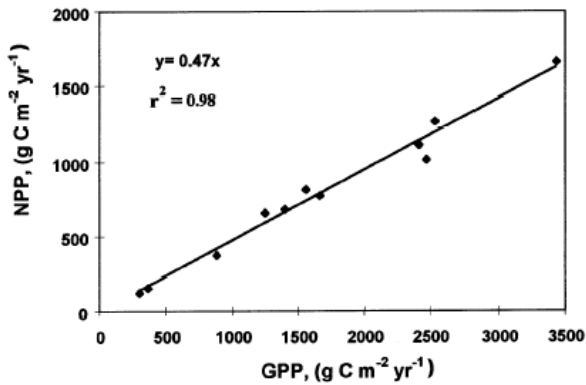
From Vose JM and MG Ryan. 2002. Seasonal respiration of foliage, fine roots, and woody tissues in relation to growth, tissue N content, and photosynthesis. *Global Change Biology* 8:182-193.

Temperature and Total Respiration as a fraction of Canopy Photosynthesis

Data from Ryan MG, MB Lavigne, and ST Gower. 1997. Annual carbon cost of autotrophic respiration in boreal forest ecosystems in relation to species and climate. *Journal of Geophysical Research*, BOREAS Special Issue, 102(D24): 28871-28884 and Hawaii Euc study (tropical).



Ryan et al. *J. Geophys. Res.*



From Waring et al 1998. *Tree Phys* 18:119-134.

Figure 1. Regression of NPP to GPP forced through the origin. The slope of the relationship is 0.47 with a standard deviation of 0.04 for the forests analyzed in Table 2.