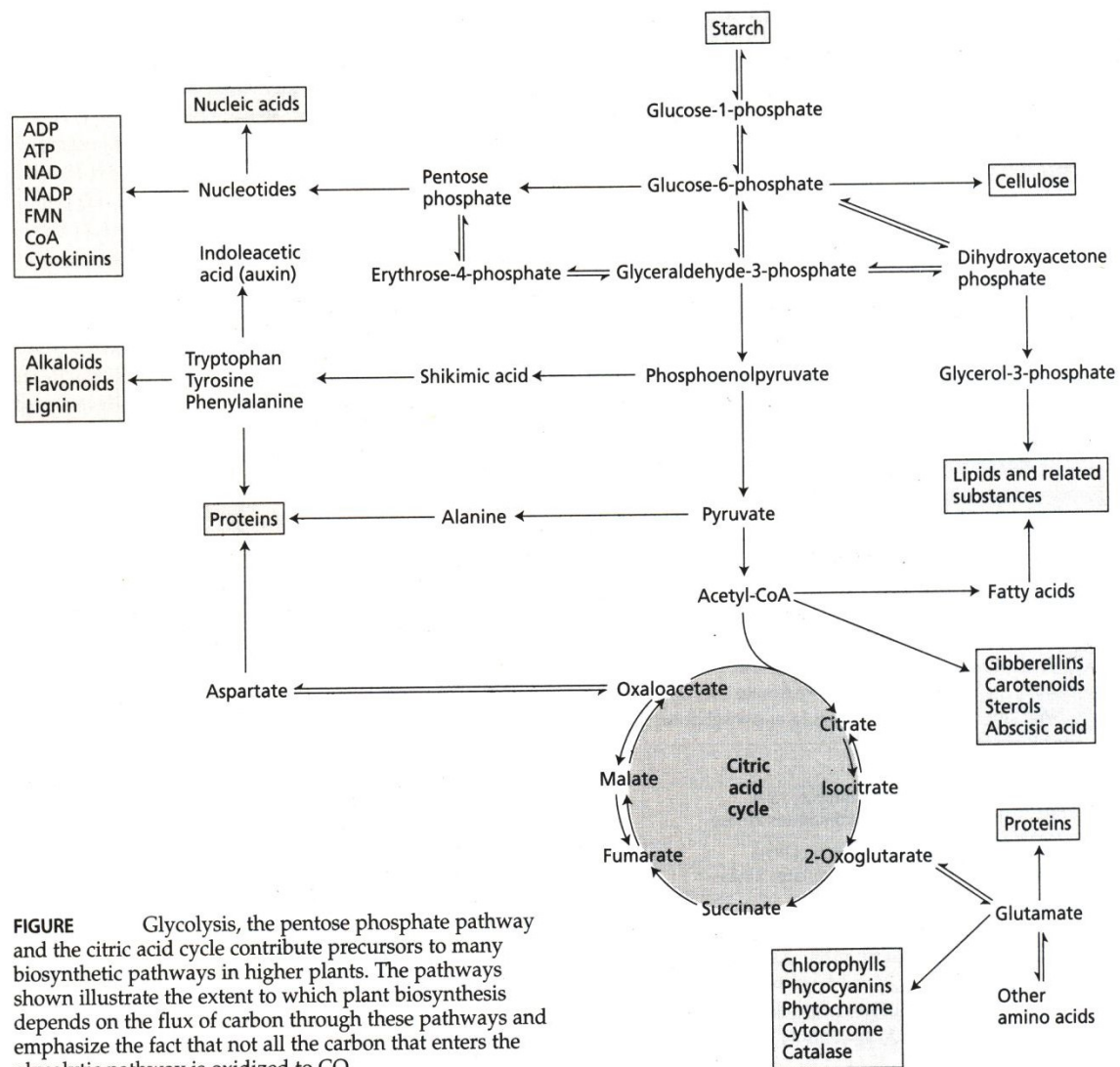


**INTER RELATIONSHIP OF RESPIRATION AND PHOTOSYNTHESIS**

Total dry matter produced by a crop is a function of canopy photosynthesis and canopy respiration. The difference between these two factors gives us the amount of net photosynthates that are actually available for the growth and development of the plant. Canopy respiration includes both dark respiration and photorespiration.

Survival of any plant is decided by its metabolic activities. Plant needs energy in the form of ATP for these metabolic activities to run. This ATP is generated by the oxidation of the stored food materials like carbohydrates, proteins and lipids. The stored food materials are however produced by photosynthesis. (Fig)



**FIGURE** Glycolysis, the pentose phosphate pathway and the citric acid cycle contribute precursors to many biosynthetic pathways in higher plants. The pathways shown illustrate the extent to which plant biosynthesis depends on the flux of carbon through these pathways and emphasize the fact that not all the carbon that enters the glycolytic pathway is oxidized to CO<sub>2</sub>.

\*Figure is from reference 6

Thus, for its survival the plant must always maintain a photosynthetic – respiratory ratio exceeding 1. Otherwise, plants are starved to death. A greater ratio may result from a daily change between relatively cool night temperatures and moderately high day temperatures.

This interrelationship can be better understood from the concept of growth and maintenance respiration.

## 16.2 GROWTH AND MAINTENANCE OF RESPIRATION:

Respiration provides opportunity for two different sorts of processes in plants: maintenance and growth.

**Maintenance** is primarily concerned with repair and restoration and the operation of all the metabolic systems necessary for the normal functioning of the plant. These include turnover, transport, maintenance of gradients of all sorts and the requirements for operating controls and signal system. **Growth** is mainly the synthesis and accumulation of all the material and operational systems that constitute the plant.

Growth and maintenance are two quite different processes. American agriculturist **K I McCree** has shown how they can be quantified independently. Maintenance respiration is clearly a function of plant size (at least in herbaceous plants those do not possess large masses of metabolically inert tissue) so it can be represent as  $cW$ . Where “c” is a constant, W is the dry weight of the plant. Growth respiration, however, depends only on the actual new growth being made by the plant. Which is best measured as the net rate of photosynthesis. So growth respiration may be represented of “ $kP$ ” Where “k” is another constant and P is the rate of Photosynthesis.

Thus the equation for respiration is the  **$R = kP + cW$** .

Therefore, the rate of photosynthesis of a plant should always surpass the total value of growth and maintenance respirations putting together. This is very important for achieving higher yields particularly in root crops and tuber crops where large amount of photosynthates are needed for storage.

## 16.3 Respiratory Substrates:

A respiratory substrate is any organic plant constituent oxidized partially or completely (to  $CO_2$  and water) in respiratory metabolism. Carbohydrates are the principal respiratory substances in cells of higher plants. The most important respiratory substrates among carbohydrates are Sucrose & starch. In addition of Carbohydrates, other substances also some times serve as respiratory substrates in some plant tissues.

Eg: Castor Lipid reserves in endosperm.

CAM plants  $\longrightarrow$  Organic acids ( Malic acid, Glycolic acid etc.)

Detached Leaves  $\longrightarrow$  Proteins

## 16.4 Respiratory quotient: (R.Q)

Respiratory quotient may be defined as the ratio between the volume of carbon dioxide given out and oxygen taken in simultaneously by a given weight of the tissue in a given period of time at standard temperature and pressure.

**Volume of CO<sub>2</sub> evolved**

**Respiratory quotient = -----**

**Volume of O<sub>2</sub> absorbed**

For example  $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$

In this reaction volume of CO<sub>2</sub> equals to volume of O<sub>2</sub>. Thus the RQ of carbohydrates (for example Glucose ) is 1.

The following table enumerates R.Q. values of different substrates

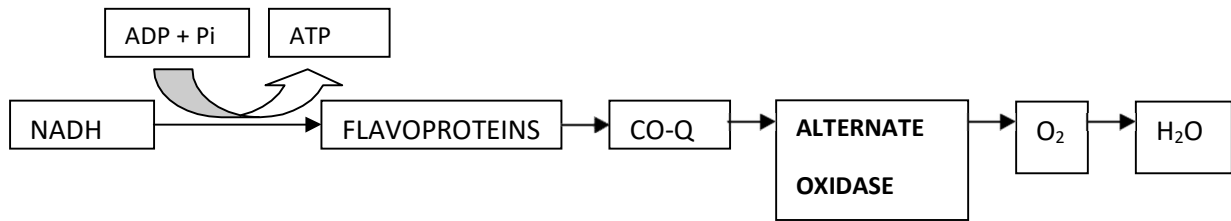
<b>Substrates</b>	<b>R.Q.</b>
Carbohydrates	1.00
Proteins when ammonia is produced in oxidation	0.99
Proteins with amide formation	0.80
Fats	0.70
Organic Acids	1.33

## 16.5 ALTERNATE RESPIRATION/CYANIDE RESISTANT RESPIRATION:

### The Alternative Oxidase

If cyanide ( 1 m/M ) is added to actively respiring animal tissues, cytochrome c oxidase is inhibited and the respiration rate quickly drops to less than 1 % of its initial level. However, most plant tissues display a level of cyanide- resistant respiration that can represent 10 to 25 %, and in some tissues up to 100 %, of the uninhibited control rate. The enzyme responsible for this oxygen uptake been identified as a cyanide – resistant oxidase component of the plant mitochondrial electron transport chain called the **alternate oxidase**.

It appears probable that mitochondria in tissues exhibiting the alternate pathway have two *parallel* electron transport chains from substrate ( e.g., NADH ) to O<sub>2</sub> . One is the cyanide – sensitive respiratory chain terminated by cytochrome oxidase. The second (alternate) pathway is terminated by the alternate oxidase. Electrons feed off the main electron transport chain into the alternative pathway at the level of the ubiquinone pool. The alternate oxidase, the only component of the alternative pathway catalyzes a four – electron reduction of oxygen to water.



### **Alternative pathway contribute to plant metabolism:**

One example of the functional usefulness of the alternate oxidase is its activity during floral development in certain members of the Araceae (the arum family) – for example, the voodoo lilly.

Just before pollination tissues of the club like inflorescence, called the *appendix* which bears male and female flowers, exhibit a dramatic increase in the rate of respiration via the alternative pathway. As a result, the temperature of the upper appendix increases by as much as 25° C over the ambient temperature for a period of about 7 hours.

During this extraordinary burst of heat production, certain amines, indoles, and terpenes are volatilized, and the plant therefore gives off a putrid odor that attracts insect pollinators.

It has been suggested that the alternative pathway can function as an “energy over flow” pathway, oxidizing respiratory substrates that accumulate in excess of those needed for the growth, storage, or ATP synthesis.

**16.6 SALT RESPIRATION:** When roots are absorbing salts, the respiration rate rises. This rise has been linked to the fact that energy is spent in absorbing salts or ions, and that required energy is supplied by increased respiration. This phenomenon called as **salt respiration**.

The inference is that respiration represents the increased metabolism needed to generate energy for the active transport of ions. Unfortunately the relationship is not always linear, and salt respiration may persist after the salts are removed. Consequently, salt respiration does not offer many useful clues to the nature of the coupling of respiration and ion transport.

### **16.7 WOUND RESPIRATION:**

Wounding of a plant organ stimulates respiration in that organ. It initiates meristematic activity in the region of the wound resulting in the development of ‘wound callus’. It has been shown that wounding is correlated with an increase in the sugar content of the half cut potato tuber. Perhaps the increase in respiration is due to an increased availability of respiratory substrate in wounded tissues.

## **16.8 MEASUREMENT OF RESPIRATION:**

Methods for measuring the rates of respiration involve quantitative determination of the CO<sub>2</sub> evolved or the oxygen consumed. An individual plant or a plant part or tissue slices, or cell suspension or tissue homogenate or mitochondria forms the sample

### **DIFFERENT METHODS OF MEASUREMENT OF RESPIRATION:**

There are five methods of measurement of respiration

**A. Weight method:** The CO<sub>2</sub> produced during respiration by a plant tissue is trapped in a *barium hydroxide solution*. Weight of the barium carbonate formed indicates the amount of CO<sub>2</sub> produced.

**B. Titration Method:** The CO<sub>2</sub> produced is made to *dissolve in NaOH* and the amount of CO<sub>2</sub> absorbed is determined by titration.

**C. Quantitative method:** Release of CO<sub>2</sub> can be measured by passing an air stream through a sealed chamber containing plant tissue into *an alkaline solution* where changes in P<sup>H</sup> or E.C. are recorded. From these recorded changes the quantity of CO<sub>2</sub> released by tissue is calculated.

**D. Mano metric method:** The rates of O<sub>2</sub> uptake or CO<sub>2</sub> release by plant tissue are measured with a mano meter. In this method, sliced samples of plant tissue are suspended in water in a flask. Changes in the amount of respiratory gases within the flask are reflected in changes in its pressure. These pressure changes can be measured with a manometer.

**E. Infra red CO<sub>2</sub> analyzer or paramagnetic O<sub>2</sub> analyzer method:** This is a Sophisticated instrument capable of measuring changes in CO<sub>2</sub> or O<sub>2</sub> of the atmosphere and chambers in which plants, or bulky tissues such as large fruits are sealed.

In addition, a membrane bound polarographic electrode sensitive to O<sub>2</sub> can measure changes in the concentration of O<sub>2</sub> in a solution. It should also be mentioned that **mass spectrometric methods** are often used in the recent years to study the gas exchange between plant tissues and the external atmosphere.

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