Photosynthesis and Respiration

The Biology Team in SSERC has previously published, in this Bulletin and elsewhere, details of methods involving the aquatic plant *Cabomba* [1, 2] and how these can be used to show the processes of both photosynthesis and respiration.

The construction of so-called *Cabomba* towers [1, 2] can be tricky and may require some practice before reliable results are obtained. We wish to report here a simplified version which overcomes some of the technical obstacles associated with *Cabomba* towers.

Materials and Methods

The following items are required:

- 50 cm^3 of hydrogencarbonate indicator (pH approximately 7.8) (see [1] for details of preparation)
- 5 cm^3 of a concentrated suspension of the alga *Scenedesmus quadrica*.
- 50 cm length of glass tubing (internal diameter *ca.* 1.0 cm) with 2 rubber bungs.
- Black card.
- Access to a light source (preferably a fluorescent tube).
- Retort stands and clamps.

The method for producing your 'algal tube' is as follows:

1) Cut a piece of black card to a length of approximately half of the length of the glass tube and make a cylinder which will fit around the tube. This should not be too tight because later on you will need to remove the cylinder without disturbing the contents of the tube.
2) Firmly stopper one end of the glass tube.
3) Pour the algal suspension into a beaker and add sufficient hydrogencarbonate indicator solution to give a final volume of about 50 cm^3.
4) Stir the mixture and add to the glass tube as quickly as possible (try not to let the algae settle). Top up the tube with indicator leaving about 1.0 cm. Add the second stopper.
5) Place the cylinders at one end of the tube.
6) Give the tube a thorough mix to ensure the algal suspension is uniformly distributed.
7) Place the tube under the light bank. We find it convenient to use retort stands as shown in Figure 1.

It is important not to disturb the tubes while they are being illuminated. There is no reason why tubes should not be placed in sunlight rather than under a light bank although control of the light intensity is more reproducible using the light bank! We have found that resting the tubes horizontally using stands and clamps is a convenient way of ensuring uniform illumination with minimal effects of diffusion being apparent.
As the tubes are illuminated the algae exposed to the beam will photosynthesise and the indicator will turn from its original orange colour to a deep purple as carbon dioxide is removed from solution (in our set-up after about 3 hours of illumination) whereas the algae covered by the black cylinder will undergo respiration and the indicator will turn to yellow as carbon dioxide is released into solution.
Before removing the black cylinder it is worth asking students what

Figure 1 *- Delegates at a recent Biology SSERC CPD event carrying out steps 6 and 7!*

Figure 2 *- Suspension of Scenedesmus quadricauda in hydrogencarbonate indicator.*

they might observe. Provided that the cylinder is removed carefully and mixing is kept at a minimum then the tube will look similar to the one shown in Figure 2. The algae were originally placed in indicator at pH 7.6 prior to illumination. The left-hand portion of the tube was exposed to the full beam while the right-hand portion was covered with black paper during illumination. Similar effects can be observed with immobilised algae which can be prepared using standard methods [3, 4] and this is shown in Figure 3. In this case approximately 150 immobilised beads, suspended in hydrogencarbonate indicator (pH 7.6), were distributed along the length of the tube and illuminated for some 3 hours under a light bank.

Figure 3 *- Immobilised Scenedesmus quadricauda in hydrogencarbonate indicator.*

The immobilised algae were originally placed in indicator at pH 7.6 prior to illumination. The left-hand portion of the tube was exposed to the full beam while the right-hand portion was covered with black paper during illumination.

An interesting experiment is to take the tubes in Figures 2 and 3 and illuminate them but in this case cover the purple region with the black paper during the illumination. In both cases a reversal of the colour changes is observed i.e. purple → yellow/orange and yellow/orange → purple.

We believe this to be a simple, effective and above all 'nice' system for demonstrating photosynthesis and respiration in aquatic plants.

References

[1] *Cabomba* Tricolour (2011), *SSERC Bulletin*, **235**, 2-4.

[2] Adams, A., Moore, G., Rutherford, A., Stewart, F., Crawford K. and Beaumont, P.C. (2012), Cabomba - an exocharmic plant! *School Science Review*, 93, 9-12.

[3] Eldridge, D. (2004) A novel approach to photosynthesis practicals, *School Science Review*, **85**, 37-45.

[4] SAPS Photosynthesis Kit: the use of algal balls to investigate photosynthesis (2006), *SSERC Bulletin*, **219**, 2-5.

Nature's Neons

Figure 1 *- Female glow-worm (Lampyris noctiluca). Image courtesy of David Savory/UK Glow-Worm Survey [9].*

Background

Now that the Arrangements Documents for the Revised and *CfE* Highers in Biology [1, 2] and Human Biology [3, 4] have been published the Biology Team within SSERC is preparing to publish a series of protocols to support practical work contained therein. Many of these protocols will appear on the SSERC website [5] or in this Bulletin (see for example [6]). The Arrangements Documents [1-4] all include a suggestion that students might explore *'Experiments on ATP dependent reactions, e.g. luciferase, luminescent reactions'*.

The luciferin/luciferase reaction is probably one of the most alluring in nature and is characteristic of bioluminescent organisms; bioluminescence may be conveniently defined [7] as *'the production and emission of light by a living organism'*. Bioluminescence is not an evolutionarily conserved function; in the different groups of organisms capable of undergoing the process the genes, proteins and substrates involved are mostly unrelated and probably originated and evolved independently [8]. It is worth pointing out that although the substrates and enzymes involved from one species to another are often unrelated the terms luciferin and luciferase are still used to describe key reactants in the process. So, firefly luciferin is chemically different from luciferin found in bacteria; possibilities for confusion abound!

An amazing diversity of organisms is capable of emitting light and