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A Biological Light Meter

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A BIOLOGICAL LIGHT METER

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High school experimentation during the study of botany generally includes observing photobiological processes. These might include photosynthesis, phototrophism and photoperiodism. Experiments with these processes often involve exposing a plant or plant tissue to a light source covered with a piece of colored cellophane or plastic. Measurement of the light intensity at a specific wave length is often necessary.

A common but seldom realized error is frequently introduced into the experiment by measuring the light with a cadmium sulfide photo cell which has its greatest sensitivity in the green region of the spectrum. The cadmium sulfide photo cell is used as a photographic exposure meter and, therefore, should have a light response similar to that of the human eye (Figure 1).

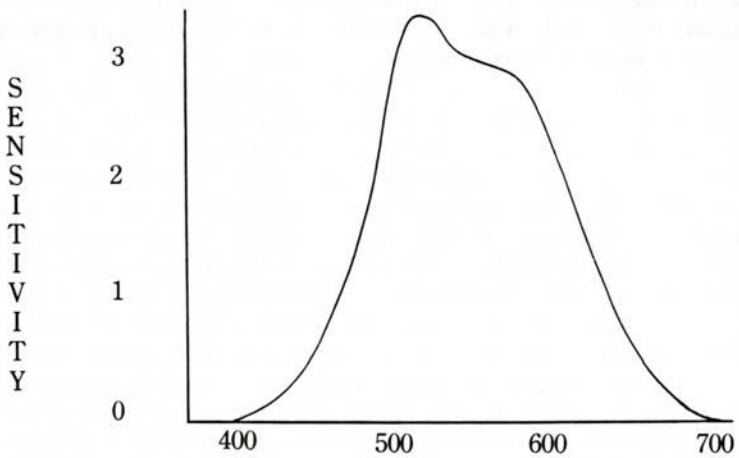

Figure 1
Cadmium Sulfide Cell Response

This response curve shows the sensitivity of a cadmium sulfide (CdS) photocell and is nearly identical to that of the human eye and panchromatic film.

Since the meter is more sensitive to green, and the light needed for photosynthesis is red and blue, a difficulty arises in trying to measure the red and blue wavelengths. (Figure 2).

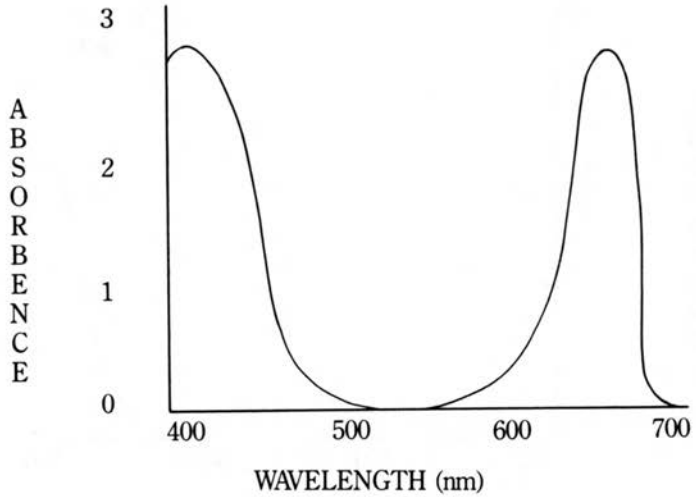

Figure 2

Chlorophyll Absorption Spectrum

The spectrum of chlorophyll absorption is illustrated here. Note the disagreement between this pattern and the CdS cell sensitivity.

A green photographic filter placed over the light sensor will greatly improve the red-blue response of the meter. Wratten filters #35 or #36 are suitable for the study of photosynthesis as they eliminate green light and transmit great quantities of red and blue light. These filters will not alter the meter's sensitivity in any manner, but simply expose it to the desired wavelengths (Figure 3). The results of the experiment are enhanced when the light intensities are measured with a meter so modified. These filters are available from most photographic suppliers in the form of camera filters in a wide range of sizes.

As an alternative, a phototransistor could be used as a detector in a light meter circuit. Figure 4 shows one possible arrangement of the components of such a meter. The sensitivity of this device is again low in the blue region but better than the cadmium sulfide cell and far better at the red end of the spectrum (Figure 5). With the addition of filters, the meter will respond only to red and blue light. Construction of the meter is simple with parts available from nearly all electronics stores. The finished product should cost less than $3. A small plastic microscope slide box makes a fine housing for the finished unit.

These modifications or construction projects are simple and inexpensive, and can aid in the accuracy of experiments performed in the high school laboratory. At the same time, the meter can be used for other purposes in science instruction.

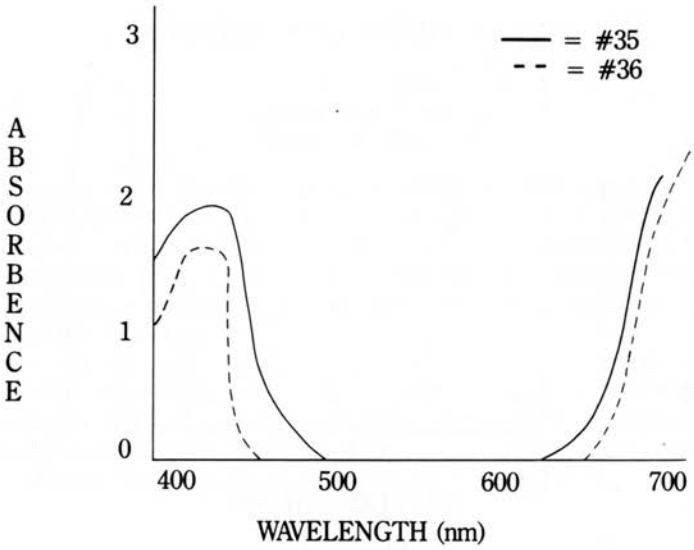

Figure 3

Wratten Filter Response

Wratten filters can be used to enhance the usefulness of a CdS cell by exposing it to red and blue light and eliminating the green. This does not increase the meter's sensitivity but exposes the meter to only the desired wavelengths.

M1 — 0-1 ma meter
R1 — 10 k 1/4 w carbon resistor (a potentiometer could also be used)
R2 — 240 k 1/4 w carbon resistor
C1 — .1 uf capacitor
Q1 — FPT 100 phototransistor
Q2 — 2N2907 transistor
B1 — 9v battery

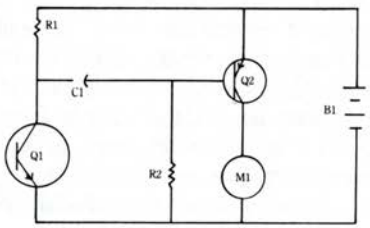

Figure 4

Phototransistor Light Meter

A simple phototransistor light meter is shown here. Several modifications are possible including the addition of an amplifier before the output to the meter thereby enhancing the low light level detection capabilities.

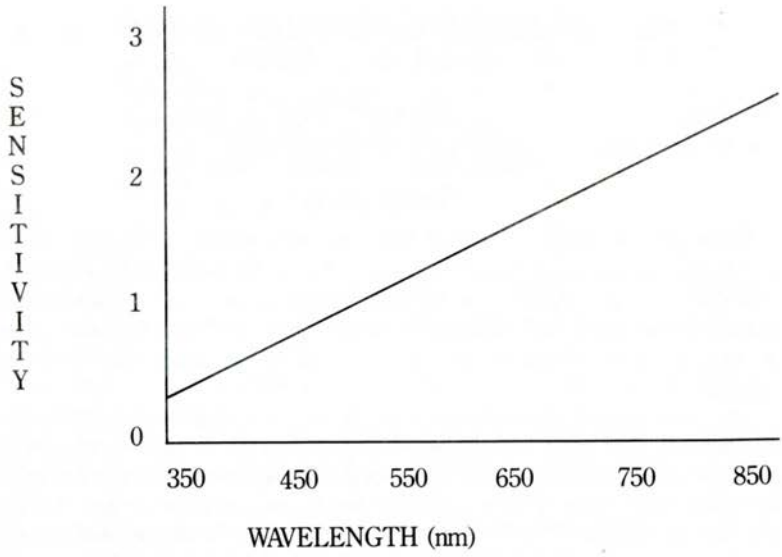

Figure 5

Phototransistor Response

The response of the P-N junction of a phototransistor is better in the red region of the spectrum than the CdS cell. A filter can be used to deselect the green region and allow the device to 'see' only red and blue light.