

AN EXPERIMENTAL MICROCOSM.

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The great food and energy cycle of living organisms has come to be an interesting and important topic in most courses in biology. The more recent text-books contain the familiar diagram in one form or another, which shows that green plants absorb certain inorganic substances and by the use of the sun's energy elaborate the food for all plants and animals; that this food is used either directly for the liberation of energy or temporarily stored in the form of more complex substances and protoplasm; also that the death of the plants and animals renders available these stores of food and energy for the bacteria and fungi, which in turn redistribute the energy and resolve the organic compounds into simpler substances, making them available for other cycles of transformation.

This concept is so fundamental to an understanding of the interrelations of organisms that an experimental demonstration which would enforce it upon the minds of the students seems most desirable. In devising an experiment to illustrate this principle the following factors of the food and energy cycle are essential:

(1) A sufficient quantity of the elements oxygen, carbon, hydrogen, nitrogen, phosphorus, sulphur, potassium, iron, calcium, magnesium, sodium, and chlorine in an available form, to permit their temporary storage in the organisms and in dead organic matter, and still have at all times an amount adequate for the immediate needs of the living plants and animals.

(2) Green plants which will multiply rapidly and grow vigorously at all seasons of the year.

(3) Sunlight sufficient for photosynthesis, but not too intense for the rapid growth of bacteria and fungi.

(4) Animals that can derive an adequate food supply directly from the plants.

(5) Bacteria and fungi.

(6) Moderate temperatures.

Aquatic plants and animals seem to meet these requirements to the best advantage. In laboratory practice I have found that of the available plants, the very common alga, *Scenedesmus* can be depended upon for the continuous growth throughout the year under laboratory conditions. The common goldfish will live

and thrive on this plant as a food at least for several months. Accordingly the following experiment was set up last year and was found to work successfully throughout the remainder of the school year—seven months.

A cylindrical museum jar 43cm high and 14cm in diameter, having a total capacity of six and a quarter liters, was half filled with a mixture of three parts of tap water and one part of Moore's solution. The tap water has the following composition:

Sodium nitrate66mg.
Sodium chloride86mg.
Sodium sulphate	3.08mg.
Magnesium sulphate90mg.
Magnesium carbonate	8.38mg.
Iron carbonate04mg.
Calcium carbonate	124.80mg.
Silica	1.70mg.
Water	1000.00cc.

Moore's solution for the growing of algae is made as follows:

Ammonium nitrate5g.
Potassium phosphate2g.
Magnesium sulphate2g.
Calcium chloride1g.
Iron sulphate	Trace
Distilled water	1000cc.

To this was added 500cc. of a pure culture of *Scenedesmus quadricauda* (Turp) Breb. The algae multiplied rapidly and at the end of ten days a goldfish 6cm. long was added to the aquarium. The ground glass stopper was then put on the jar and sealed *air-tight* with laboratory cement. The jar was placed near a west window but screened from direct sunlight at all times. The jar was sealed on January 1, 1910 and was still apparently in good condition on July 28, when an accident—allowing the jar to stand in full sunlight for a day—brought the experiment to an end by killing the fish.