DANCING MOTHBALLS AND FISH BUOYANCY

Nature has invented a marvelous ballast organ, the swim bladder or air bladder, that enables fish to rise, float, or sink in water. Sometimes connected to the pharynx, it absorbs gases (oxygen, nitrogen, and carbon dioxide) directly from the blood by diffusion. Its function is to adjust the weight of the fish to equal the weight of water it displaces, as set forth in the Archimedes principle. Some of the species of the genus *Etheostoma* (darters) lack air bladders and therefore sink to the bottom after each jerky swimming motion.

Adaptive radiation is enhanced in bony fish by the presence of an air bladder that is used to maintain position. Consequently, tails and fins in bony fish assume a variety of shapes and positions because they are partly relieved of the function of maintaining position. Some fish live at different levels in the water during different seasons of the year. The air bladder adjusts to these changes by releasing gas into the blood or by absorbing additional gas from the blood. Bringing a fish up to the surface of water very suddenly causes the air bladder to expand and *may* force the animal's esophagus into its mouth.

The following demonstration with mothballs can be used to simulate the ballast mechanism of the air bladder.

Collect the following materials:

beaker or jar (1 liter)	vinegar
sodium bicarbonate	mothballs
water	food coloring

Fill the jar about half full of water and add a few drops of food coloring, about 250 ml of white vinegar, 4—5 mothballs, and, finally, about 2—3 g of sodium bicarbonate.

The following questions may help student's understand the concept being presented:

1. What gas is being released from this chemical reaction?
2. Why do the gas bubbles cling to the mothballs?
3. What causes the mothballs to rise? What has happened to their overall density as the gas bubbles start to cling to them?
4. When the mothball reaches the surface of the water, what must be broken before the gas can be released into the air?
5. Why does the mothball sink?
6. How do you explain the delay before the mothball rises again?
7. How does the principle of rising and sinking apply to the understanding of the fish's air bladder?

One set of acceptable answers to the above questions follows:

1. Carbon dioxide.
2. The CO_2 gas bubbles cling to the mothballs by adhesion.
3. The mothballs rise because the adhering gas bubbles reduce the overall density of the mothball-gas bubble combination. This is analogous to a fish taking air into the swim bladder.
4. Before the gas can be released from the surface of the mothball, the surface tension of the water must be broken. Surface tension is the result of cohesive forces between molecules in the surface layer of the water.
5. The mothball sinks as a result of losing some of the gas bubbles to the atmosphere, which increases the density of the mothball. This is analogous to a fish releasing air from the swim bladder.
6. Before the mothball can rise again, more gas bubbles must accumulate on its surface. This is analogous to the accumulation of air in the fish's swim bladder.
7. When the mothball, fish, or any other object submerged in water undergoes a change in density, it changes its position in the water (either rises or sinks).

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EXPERIMENTAL DEMONSTRATION OF NITROGEN FIXATION

Nitrogen fixation, the initial step of the nitrogen cycle, is often discussed but rarely demonstrated in the classroom. The following experiment enables students to observe this process of the conversion of atmospheric nitrogen to ammonia with a blue-green alga, *Anabaena cylindrica.*

Materials. The following will be needed:

1. Nitrogen-deficient liquid medium (20 ml per student). Various ready-to-mix sources are available, or a medium can be prepared by adding the following chemicals to 950 ml of glass-distilled water and buffering the solution to a pH of 7.2-7.8:

0.4 g $MgSO_4 \cdot 7H_20$
0.3 KH_2PO_4
0.4 g $CaCl_2$
0.08 g $MnSO_2 \cdot 7H_2O$
0.05 g $ZnSO_4 \cdot 7H_2O$
0.06 g $FeSO_4$

Allen's blue-green medium (James 1973) should also prove acceptable if the nitrate components are omitted.

2. Nessler's reagent. This solution is available from commercial chemical supply houses, or it may be prepared using the method of Bock and Benedict (Oser 1965): (i) Mix 100 g mercuric iodide, 70 g potassium iodide, and 400 ml distilled water. (ii) Dissolve 100 g NaOH in 500 ml distilled water. Cool throughly and add to the above mixture with constant shaking. (iii) Dilute this mixture with distilled water to a final volume of one liter. (iv) Allow a brown precipitate to form. The supernatant decanted from the precipitate is Nessler's reagent.
3. 100-by-15-mm Petri dishes (1 per student).
4. Light source. Blue-green algae bleach easily under high light intensity. Cool white fluorescent tubes or small Gro-Lux bulbs are recommended. These should be placed approximately one meter above the Petri dishes.

5. *Anabaena* culture. Nitrogen fixation will not occur in the absence of heterocyst formation. Living cultures of *Anabaena* with heterocysts are available from commercial biological suppy houses. *Anabaena* will form heterocysts in low-nutrient conditions, or if subjected to low light or succinic acid (Fogg 1949).

Procedure. The student adds a dropper full of the *Anabaena* culture to a Petri dish containing 29 ml of the nitrogen-deficient medium. The plate is covered and exposed to a light source. A daily test for the presence of ammonia is made by adding 3 drops of Nessler's reagent to a 2-ml sample of the culture medium. A cloudy yellow suspension indicates the presence of ammonia. Stock solutions of 10%, 1%, and 0.01% ammonia can also be tested to quantify the results.

Alternative experiments. The basic experimental design can be modified in several ways to provide additional investigations concerning nitrogen fixation. The few examples that follow can be used to establish controlled experiments by using the basic procedure for the control group.

1. Students may wish to observe the differences in nitrogen fixation produced by diffuse window light or darkness.

2. The effects of temperature variations can be determined by refrigerating the culture plates or immersing them in water of different temperatures. However, it should be noted that blue-green algae do not normally survive above 30 °C.

3. Other blue-green algae, *Anabaena cylindrica* which lack heterocysts, or *Azolla caroliniana* (a water fern in which *Anabaena* reside) may be used as prospective nitrogen fixers in a comparative study.

The experimental design can also be adapted for colorometric analysis by using a spectrophotometer to read percentage transmittance as an indication of ammonia presence. A standard curve can be generated with stock ammonia preparations in order to accurately quantify the amount of nitrogen fixed.

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Genetics...

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ments. In my estimation, the world would be a better place without the hundreds of poorly conceived, inconclusive tests dealing with the comparative IQs of Blacks and Whites. These tests should have ceased following the first criticism with which they were unable to cope.

Professional educators rely on a different argument: the annual cost of education in the United States is $50 billion. An expenditure of $100 or $200 million would be justified if it made the educational system more efficient. In reply to this argument, I maintain that the nation's educational system exists to train and develop *individuals* according to their personal abilities and preferences, not to train groups of persons according to patterns determined by group averages. I can imagine no greater threat to a heterogeneous society than that it create incipient castes through the identification of group predilections followed by an insistence that each member of the group follow his group's recognized calling.

There remains a final argument against testing for genetic differences between races with respect to IQ, even if the test could be designed. Scientific data are gathered in order to test hypotheses. Experiments whose results will be accepted only if they agree with preconceived notions are not worth doing. How many persons would accept a finding that Blacks are indeed genetically inferior with respect to IQ? What modification in the educational system would they accept as a result of such findings? How many persons would accept the reverse? Does anyone believe that the nation's educational system would be reorganized if an unbiased test revealed that the intelligence of Blacks exceeds that of Whites? I suspect that a large scale test designed to reveal possible genetic differences between Blacks and Whites in respect to IQ would be, in the guise of science, a tremendous swindle: "Heads we win; tails you lose."

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