out fear of damaging a mounted preparation. Disarticulated skeletons are particularly useful for insuring that the students can identify the individual bones, that they can identify left and right appendicular bones, and that they can distinguish vertebrae from the different regions of the body. With the range of animals that we have obtained, the students can also observe such things as the differences in the limbs of animals adapted for behaviors such as running, burrowing, and flying. Since a large amount of material can be obtained at no cost with the beetle colony at work, I am able to risk loss or breakage from the students handling the bones directly.

Finally, although I was originally skeptical, I do think that these beetle colonies can be used to study various ecological principles of population structure and dynamics. My colony has undergone a number of exponential increases and subsequent falls in population size. Beetles of different ages have distinct variations in size and body form, so life tables and related concepts could be demonstrated with the beetles.

Dermestid beetles can be obtained from International Biologics, Inc., 1991 Sharondale Ave., St. Paul, Minnesota 55113.

In conclusion, I would like to support Multhaup's recommendation of the use of such beetle colonies for cleaning small animal skeletons because of their low cost, ease of use, and the many functions to which they can be put.

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AN APPARATUS TO TEST ENVIRONMENTAL GASES

The Scholander apparatus is designed to test the amount of a specific gas (in this case, oxygen and carbon dioxide) in an air sample. The original design, by P. F. Scholander, was a fairly complicated device. During World War II it was simplified to test for the presence of nerve gases in the field (Scholander 1947). This modified Scholander has the potential to be applied as a classroom or laboratory teaching aid. It can be used in biological, physiological, and environmental studies. An initial practice procedure by students provides the basic experience suitable for experimental determinations.

Background and theory. A gas sample of known volume is introduced into a reaction chamber connected by a length of rubber tubing to a leveling reservior. Absorbing fluids for oxygen and carbon dioxide are maintained in the chambers without a loss of total liquid content. The gas displaces a portion of liquid, with either carbon dioxide or carbon dioxide and oxygen being absorbed from the air sample into the liquid. The difference in the original air volume and the final volume represents the amount of gas absorbed. To simplify calculations, the calibrations on the burette of the modified Scholander apparatus indicate the percent of the absorbed gas in the air sample. The chemical reaction for CO_2 determination is $KOH + CO_2 \rightarrow KHCO_3$. For oxygen tests the following equation applies: $2\,NaH_2SO_3 + O_2 \rightarrow 2\,NaH_2SO_4$.

Materials, supplies and equipment. The apparatus (fig. 1) consists of two gas analysis burettes connected to separate leveling reserviors with rubber tubing (40 cm). Two 10-cc syringes with small needles are placed in holders that have adjustment screws. The solutions needed include a 5% lactic acid solution with methyl red added to give a light red color, a 20% sodium hydrosulfite in potassium hydroxide (storage bottle sealed as tightly and as full as possible), and a 20% potassium hydroxide (KOH) solution. Approximately 400 ml of KOH (200 ml to be added to the sodium hydrosulfite) should be sufficient for several air samples.

Methods and procedural details. The first step includes calibration of the burettes with the syringes. Fill the syringe with distilled water and empty it into the burette. The water should reach the zero mark on the burette. If not, turn the adjustment screw to increase or decrease the amount the syringe plunger can be drawn. Once this volume is determined, do not exchange syringes. It is convenient to label or color code the burettes and syringes to aid in identifying them.

Next, remove one burette from its holder and let it hang down (fig. 2). Pour the KOH solution into the leveling reservoir. Squeeze the tubing until the liquid fills the burette. Fill the tubing with KOH and allow it to rise at least 10 cm into the leveling reservoir. Make sure all air bubbles are removed from the system. Gentle tapping may be necessary. Return the burette to the upright position. The apparatus is now ready to test the carbon dioxide content of a sample.

To prepare the syringe, rinse it several times with the lactic acid-methyl red solution. This will lubricate the syringe, and if a red residue remains after injection, it indicates that none of the base has contaminated the syringe.

After preparing the syringe, hold it with the needle pointing down and flush it with air several times to remove the remaining rinse. Traditionally it is recommended that the syringe in the holder be held above your head and flushed three times. Then fill with air.

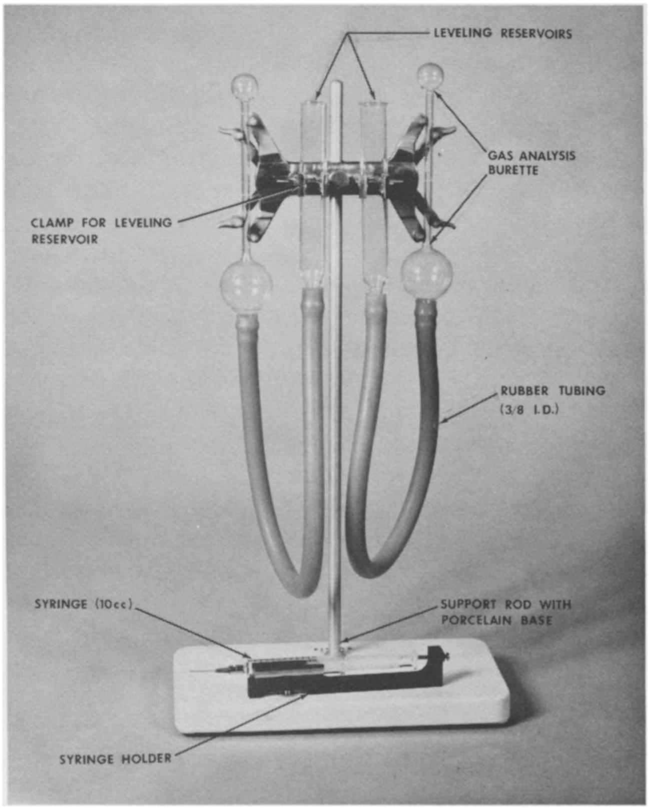

Fig. 1: The modified Scholander apparatus.

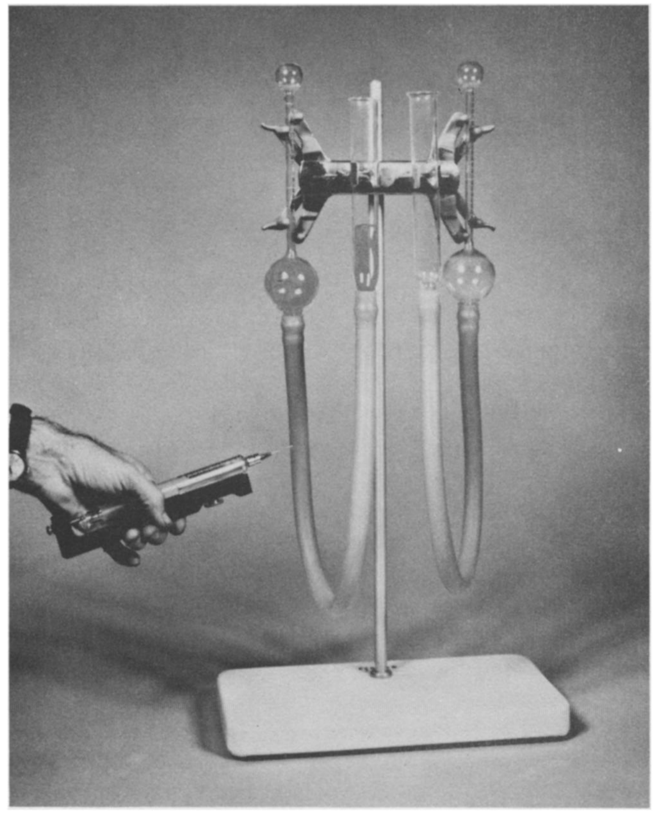

Fig. 3: Injection of air sample.

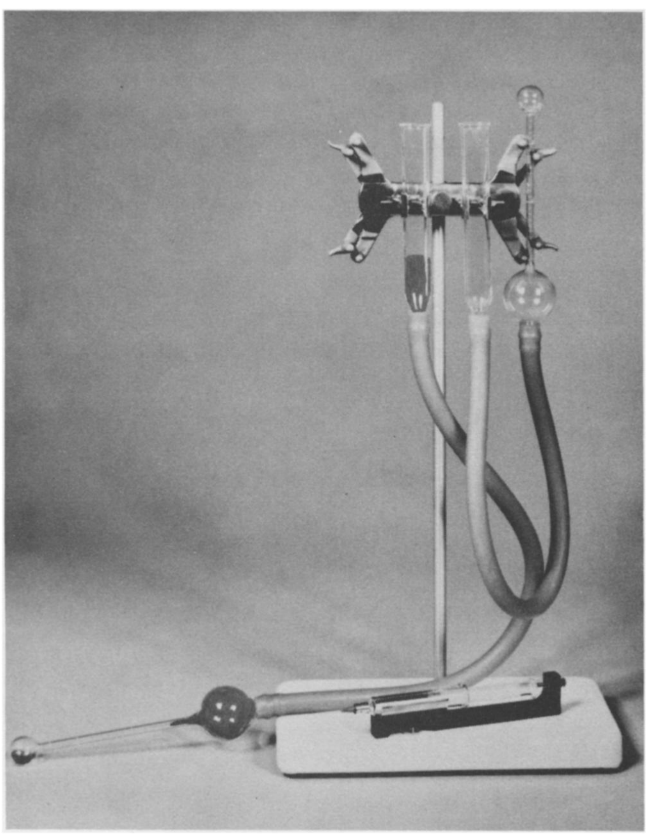

Fig. 2: Burette position for filling with solution.

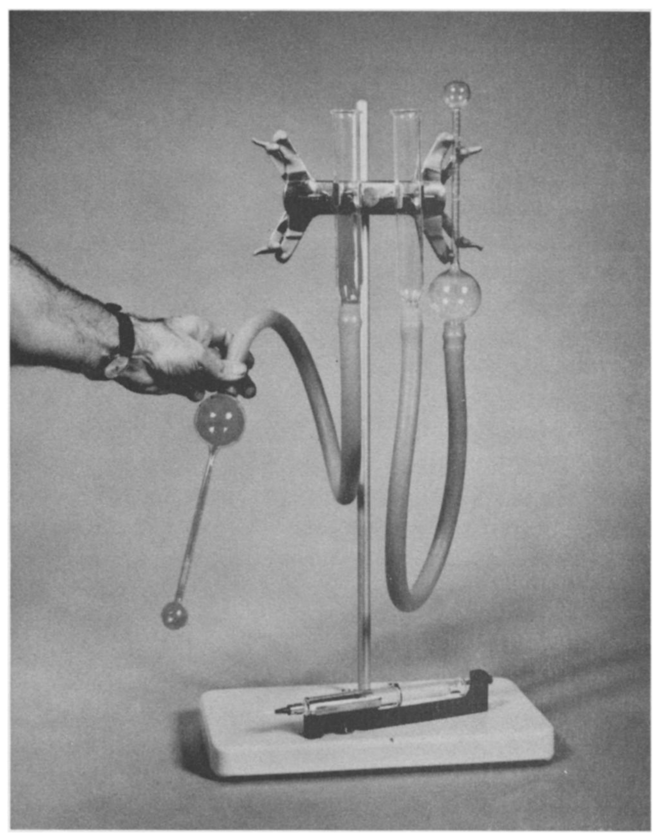

Fig. 4: Rotation of burette.

Release the plunger to make sure the air pressure inside and outside the syringe is equal.

Immediately inject the gaseous sample (in this case air) into the solution. Pierce the rubber tubing just below the burette (fig. 3) at an upward angle. Slowly push the plunger so the bubbles will rise in the burette into the small bulb. Hold the plunger in place as the needle is removed from the tubing to prevent KOH contamination of the syringe. Unclamp the burette and rotate the smaller bulb below the larger one (fig. 4) to mix the gas sample with the KOH. Do not allow any air bubbles to escape through the leveling reservoir. This step requires practice and patience. Hold the burette upright so the bubble returns to the small bulb. Repeat three times. *Important:* Do not hold either the syringe or burette by the glass during this procedure. Both temperature and pressure affect the readings and must be held constant. Reclamp the burette and wait one minute. Unclamp the leveling reservoir and align the level of liquid within it with that in the burette. This adjustment indicates the percent of carbon dioxide in the air sample. When room air is tested the reading should be about zero since the carbon dioxide content of air is 0.04%

Repeat the procedure with the equipment on the other side of the apparatus using sodium hydrosulfite in place of the KOH. This liquid will absorb both oxygen and carbon dioxide. The average reading from tests on room air is 21%. To determine the oxygen content of the air, subtract the reading made with KOH from the one made with sodium hydrosulfite.

Classroom application and uses. As noted earlier, the Scholander apparatus may be used for many different experiments. One physiological experiment could be a determination of the amount of oxygen used and carbon dioxide released during respiration. Differences in air exhaled into a plastic bag and room air will indicate both the amount of oxygen used by the body and the carbon dioxide produced. Fermenting yeast or other organisms may be sealed in a flask and gas samples taken at regular intervals. Knowing the amount of oxygen and carbon dioxide originally in the flask (room air), the respiration rate can be determined. Gases produced by any plant or animal can be measured by keeping the organism in a closed system (Scholander 1949).

Another type of apparatus, the Scholander respirometer (Scholander 1950) is also used for respiratory gas detection (Hoar and Hickman 1967; Battley and Phillips 1971). It would function best for work with small gas samples and would provide for incubation of the sample while attached to the respirometer. This gives a continuous reading of the gas changes. It does not, however, permit the determination of two different gases from the same sample.

Since more and more emphasis is placed on the environment and related pollution, students might be particularly interested in a set of experiments comparing samples of air from various geographic areas. The air could be obtained by flushing a bottle with air several times, then sealing it tightly until used. A piece of rubber held by a rubber band makes an effective cover that can be easily penetrated by the syringe with minimum sample loss. Industrial, urban and rural samples would make an interesting comparison. Also, products such as an automobile's exhaust, air from smoke-filled meeting rooms, and other gas samples could be tested to determine what, if any, effects they have on the environment.

These are but a few of the ways to use the modified Scholander apparatus. The applications are numerous and student suggestions and tests of the gases should be spontaneous and creative, if not original and open-ended. The basic test procedure is cookbook-like and the supplies are not expensive. The instrument we tested is available commercially (Phipps and Bird, Inc., Richmond, Virginia) or can be manufactured from laboratory equipment. It is our hope that students will be encouraged to develop the skills to analyze for carbon dioxide and oxygen and then collect a multiplicity of air samples from various areas for environmental evaluations. Discussion topics may include the carbon dioxide-oxygen levels in the atmosphere during various eras and geologic periods during the earth's development. Also appropriate for discussion could be various eco-cycles, such as water, oxygen-carbon dioxide and others.

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MORAL DEVELOPMENT AND ITS IMPLICATIONS FOR BIOLOGY TEACHING

In recent issues, *American Biology Teacher* has emphasized the importance of Jean Piaget's theory of cog-