Notes

Inexpensive metabolism cages and drinking tubes

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The two most basic pieces of apparatus needed in the study of water metabolism are a metabolism cage and calibrated drinking tubes. Commercial glass drinking tubes are not only fragile and expensive but also difficult to fill and clean. Stoppered, inverted-graduated cylinders offer an alternative, but their cost can still be hard to bear on a limited budget.

Commercially available metabolism cages are expensive. Fortunately, the design of a metabolism cage is simple and it can be readily manufactured in any laboratory where hand tools are available. The metabolism cage has three basic parts: a cage for the animal, a funnel, and a collection unit. Our inexpensive laboratory version is shown in Figs. 1 and 2.

ANIMAL CAGE

The animal cage is made from a stove-pipe reducer section. The upper portion is 6.6 cm tall and 15.2 cm in diam and the lower portion is 8.9 cm tall and 17.8 cm in diam. Obviously any number of "found" objects (e.g., plastic 1-gal bottles, 3-lb coffee cans) can be used for the cage portion with minor modification. The cage top is formed from the plastic lid of a 3-lb coffee can by removing the inner portion of the lid and replacing it with window screen or hardware cloth attached to the lid with hot-melt glue. The lid is affixed to the cage by a rubber band stretched between two extended machine screws, 2 cm below the top edge on opposite sides of the cage. The floor of the cage is formed from hardware cloth (20 ga, eight squares/in.) bolted to the bottom edge of the cage with four machine screws. These screws are left to extend outward 2.5 cm from the cage surface to engage four notches cut in the upper edge of the funnel portion of the apparatus. A foodcup, 3.5 cm long x 4.1 cm in diam, is fashioned from a 20-dram plastic pill bottle and attached to the side of the cage with a single machine screw. The foodcup covers a 3.2 cm diam hole, chassis punched in the cage wall. On the side opposite the foodcup, a 9-mm hole admits the drinking tube of a homemade calibrated drinking bottle. Small bottles are held in place with a

rubber band and large bottles are attached with broom clips.

CALIBRATED DRINKING BOTTLES
The calibrated drinking bottles are

Fig. 1. A disassembled view of the apparatus. (A) 12-cc drinking bottle, (B) 60-cc drinking bottle, (C) clip for attaching B to cage, (D) deflector and collection container, (E) funnel, (F) foodcup, (G) cage, (H) cage top. Note the extended machine screw that mates with the funnel notch, J.

Fig. 2. The apparatus assembled and mounted.

made from disposable plastic syringes. For small bottles (e.g., 12 cc, calibrated in .2-cc divisions), the end of the syringe is drilled out slightly undersized for a press-fit for standard stainless steel curved drinking tubes. For larger bottles (e.g., 60 cc, calibrated in 5-cc divisions), the luer end is drilled out and corked, and a press-fit hole for a straight drinking tube is drilled at a slight downward angle, at the base of the syringe on the side opposite the calibration markings. No leaking has been observed when the drilled holes are made sufficiently undersized for a firm press-fit in the relatively flexible plastic. The bottles are stoppered at the top with the syringe plunger. These bottles are exceedingly inexpensive and easy to manufacture. They are practically indestructible, and their removable top makes cleaning much easier than in closed bottles. The fact that the stopper for the bottles is a movable plunger allows air to be bled from the system and fluid level to be preset in a rapid, simple, and accurate fashion that is impossible with corked graduated cylinders.

FUNNEL

The funnel portion of our metabolism cage is a polypropylene funnel available in most hardware stores. The funnel is 19 cm in diam at the top and tapers down over 12.7 cm to 2.5 cm in diam at the beginning of the spout. The spout is cut back to 1.9 cm in length, with a 2.2 cm diam opening. Four points on the upper rim

of the funnel are drilled, then notched to make a snap fit with the machine screws protruding from the base of the cage portion of the apparatus. In use, this allows the funnel and cage to be firmly attached to each other, while disassembly for cleaning remains rapid and simple.

While the surface resistance to liquid flow appears to be no greater for this funnel than for commercial metabolism cage funnels, we find it advantageous to reduce surface resistance further for use with animals, such as the gerbil, whose daily urine volume can be as low as .02 ml. At each collection interval, we wash and dry the funnels and coat the inside surface with "Sil-Spray," an aerosol-canned silicone lubricant intended for use with surgical instruments. This procedure does not affect the pH or specific gravity of the collected urine but is probably unnecessary in experiments where very small changes in the volume of collected urine are unimportant.

COLLECTION UNIT

The collection portion of the metabolism cage consists of two parts: a collection container and a deflector which deflects solid matter from the mouth of the collection container but allows liquids to drip off its surface into the container. After experimenting with a variety of homemade metal cones, we discovered that large outdoor Christmas-tree light bulbs with a conical shape and smooth

glass surface are nearly ideal as deflectors. For use with gerbils, they were mounted directly on the collection container with hot-melt glue. The plastic cap from the pill bottle used as a foodcup served as the collection container. It is best to use only clear bulbs as deflectors or to carefully remove any paint or stain from the bulb before use. We also treat the surface of the deflector with "Sil-Spray" in the same fashion as the funnel. To prevent evaporation loss, the collection container is filled with mineral oil. The urine collects in globules and is pipetted out with microcapillary tubes.

The assembled units are mounted on a wooden platform cut with 17.8 cm diam holes. The base of each unit is enclosed on all four sides, so that solid matter can be collected for each unit and liquid "splash" outside of the container can be detected on the paper liners of the platform floor. The deflector produces no splash and solid matter is almost never seen in the collection container.

These units were built for use with gerbils but can also be used for rats or other small animals. The only practical limitation on the size of a unit to be built is dictated by the size of the funnel, the only portion difficult to fabricate. The cost of the units we built was less than \$2 each. Only hand tools, a drill press, minimal skill, and about ½ h are needed to construct an apparatus. We believe them to represent a good alternative to the higher priced commercial models.