A Working Model of the Heart

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The motivation was a 5th grade science project and a persistent 5th grader who wanted to make a working model of the heart. The result described here is the combined effort of father and son.

A. *Materials*
1. 2 balloons with ears (see Fig. 1)
   a. Size—about 4″-5″ total length
   b. Color—one red for oxygen-rich side of heart —one blue for oxygen-deficient side of heart
   c. Shape—the long, slim-eared "cat" type of balloon is better than the round "mouse" type of balloon; the latter has too much excess rubber to wrap around the tubing.
2. Clear plastic tubing
   a. "Dime" stores sell packages of 6′ of ¼″ tubing at the aquarium supplies section. This is adequate and makes *two* small heart models or one large one. Bulk supplies can be obtained from scientific supply houses.
3. Plastic tape
   a. Colored: One red, one blue. 39¢ roll has enough in each roll for about 20 models. We bought a ¾″ x 130″ roll and cut ⅜″ x 6-8″ strips for winding.
4. Red food coloring and water
5. Sponge for lungs

B. *Assembly*
1. Snip the tip of each ear of the two balloons with scissors (see B-1, Fig. 1)
2. Cut one 12″ and one 24″ length of plastic tubing
   (a) Insert the 12″ and 24″ tubing in the snipped ears as shown in Fig. 1. (B-3a)
   (b) Wrap the stretchy plastic tape firmly around the ears and inserted tubing, doing one ear at a time and spiralling the tape as in bandaging. (B-3b) Note that the depth of insertion of the tube is different on two of the ears:—the inner ears in Fig. 1—in order to allow "pinching" room for thumb and forefinger operation of the "valves." (C-2a and C-3a) Use red tape on the oxygen-rich side, blue on the oxygen deficient side. Rubber bands can also be used instead of tape, but unless the tubing is very thick and rigid, the rubber bands tend to cause local restrictions. This is avoided by using the stretch tape which clamps the rubber firmly and distributes the pressure more evenly.
   (c) When all the ear connections have been made it is helpful for the prevention of twisting of the entire assembly to tape the two inner ears together.
4. When the configuration shown in Fig. 1 is attained fill, (1) the system with water and coloring, with both balloon ends still open. Twist the balloon ends shut for testing for leaks by squeezing the balloons (first wipe off all water that may have spilled onto the outside). If no leaks are found, close balloon ends by wrapping with rubber bands.

C. *Operation of the System*

The hands provide the heart muscle action and the thumb and forefinger provide the valve action.
1. Grasp the blue balloon in the left-hand with the right auricle (C-2a) between thumb and forefinger (or between the large inside knuckle of the forefinger) and the red balloon

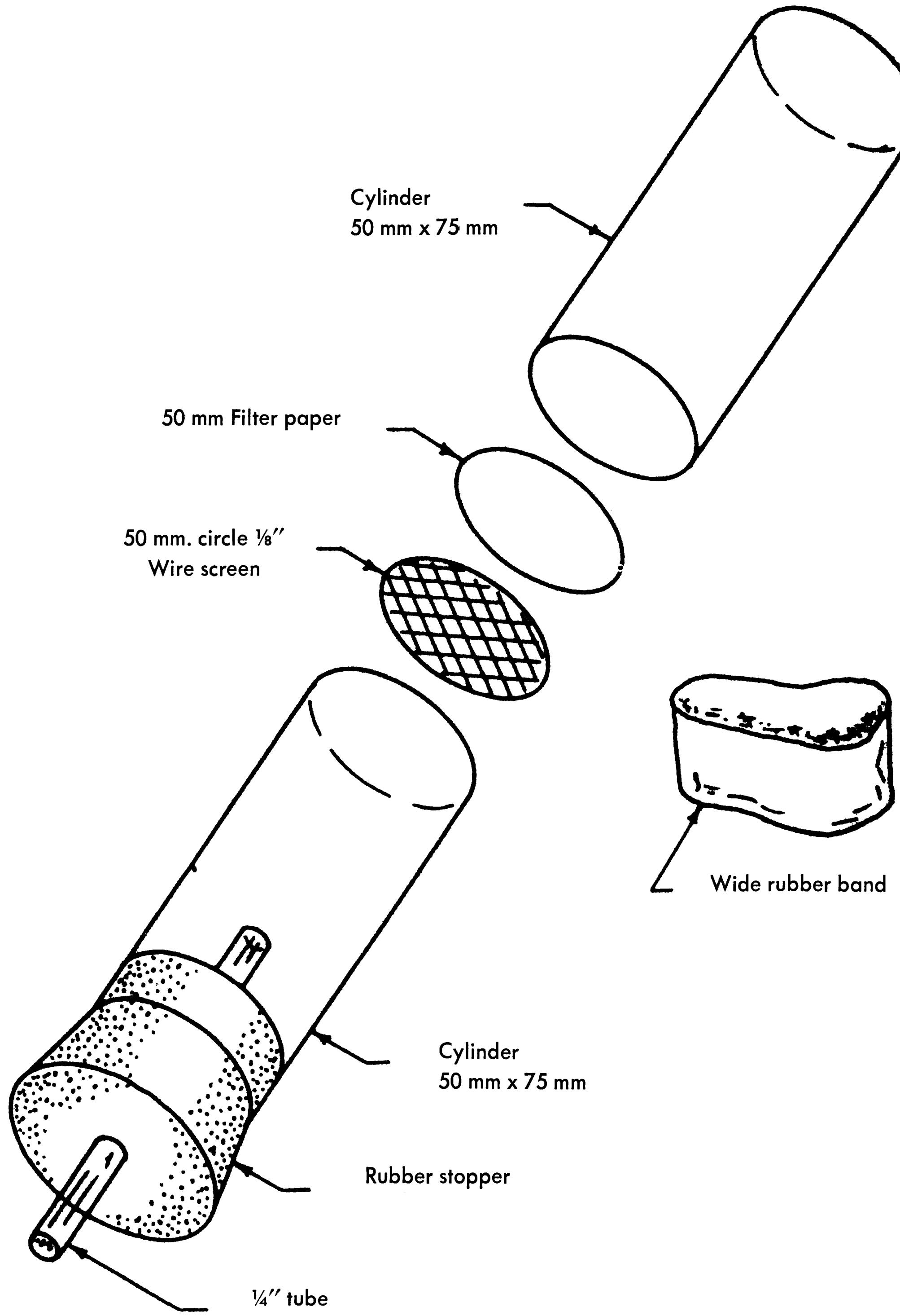

Fig. 1. Working model of the heart. The letter-number combinations refer to the headings and subsections in the text; e. g., B is the heading labelled Assembly in the text and B-3a refers to the directions in the text concerned with wrapping balloons to tubing. Scale: about half-size.

in the right hand with the left auricle (C-3a) between thumb and forefinger. The bulk of each balloon then rests between the palm of the hand and the other fingers.

2. (a) With thumb and forefinger, pinch the ear (C-2a) of the blue balloon (leaving the red balloon lying unconstricted in the right hand) just below the inserted tube. This closes the valve.
   (b) Then squeeze the blue balloon between palm and fingers driving the liquid into the loop representing the passage through the lungs. The red balloon will fill.
3. (a) Now pinch the valve (C-3a) just below the inserted tube in the right ear of the red balloon (leaving the blue balloon lying unconstricted in the left hand).
   (b) Squeeze the red balloon with the valve closed, driving the liquid through the tube representing the rest of the circulatory system, around to fill the blue balloon—and so on, alternately. Soon one establishes a rhythm that provides a continuous flow.
   You can simulate the bursting of a weak wall by improper restriction, and too vigorous pumping, so be careful.

E. *Embellishments*

1. It would be more precise to indicate oxygen-deficiency on the "blue" side of the system. This is partially accomplished with the blue balloon. Perhaps transparent blue plastic paint over or under the tubing would accomplish this. Others have suggested a complex color change via pH indicators.
2. Lungs can be simulated by attaching a sponge to the appropriate part of the system.
3. If the system is made longer—say, with a 2-foot section to the lungs and a correspondingly larger capillary system, then the lung part can be hung around the neck, and the heart portion falls about where it belongs on the body. Also a more complete capillary system can be made by getting T-connectors from the aquarium section of the dime store and dividing it into 3 parts instead of one.

F. *Cost*

On the basis of retailed purchases of the needed materials as described in Part A, we estimate that a model with 4″ balloons and a 12″/24″ combination of plastic tubing will cost about 30¢. This cost is about 60¢ for a model with 5″ balloons and 24″/48″ lengths of tubing. Obviously bulk purchases of materials would cut these expenses considerably.

(1) *Note on Degree of Filling:* It is very difficult to completely fill the system with water, excluding all air. While in the real circulatory system an air bubble is disastrous, in the model–for want of a better technique–the air bubbles make the circulation visible. Thus we have found it advantageous to leave quite a bit of unfilled space in the system. If one doesn't do this, and the model is operated horizontally as on a table, the circulation is difficult to see since the air tends to stay in the balloon part. If operated vertically, this is no problem since the liquid will fill the balloon, leaving a "movable" and visible air space in the tubing.

Perhaps the reader will be able to provide some neat way of making the circulation visible in a completely filled system. We tried adding "dirt" particles. This works, but not too well. With one food coloring we got a fibrous growth on the inner walls of the tubing. This growth was wafted in the direction of the circulation.

FALL FERTILIZATION FAVORED

Decisions to apply nitrogen to spring-seeded crops should be made on the assumption that most of the nutrient, whether ammonium salts or urea, will convert to nitrate by corn-planting time. This change will occur even though ammonium salts or urea is applied after the soil temperature is 50° F. or less.

Agronomists look with more favor on fall and winter applications of nitrogen now than they did a decade ago. The consensus is that, in northern states, denitrification rather than leaching is the main pathway to nitrogen loss except on sandy lands.

Fall and winter nitrogen applications are not subject to appreciably greater denitrification losses than early spring applications, but the loss is greater than from sidedressing. Those micronutrients, which become somewhat unavailable in some soils, are not suited to fall and winter application. Chelates may be excepted from this general rule, says University of Illinois agronomist S. R. Aldrich.

The nearer to the time of plant use nitrogen can be applied, the better, but other considerations are sometimes more important than small differences in efficiency. Fall or winter application facilitates early planting and often increases yields of small grains, corn and sugar beets.

Fall and winter applications of phosphorus and potassium are generally approved by northern agronomists except on bare, frozen and sloping fields, Aldrich concludes.