Do-It-Yourself Lung: Part 1

1 Insert a drinking straw into the mouth of a standard party balloon. Make sure the balloon fits securely—but not too tightly—over the straw.

2 Drill a hole in the bottom of a large, clear plastic drinking cup. The hole should be just large enough for the straw to fit through.

3 In one hand, hold the cup upside down. Holding the straw at the balloon end, push the other end of the straw up through the hole in the bottom of the cup. (The balloon should now be inside the cup.)

4 Use some putty to seal any gaps between the straw and the hole in the bottom of the cup. Stretch some thin rubber material across the mouth of the cup. Make sure it's airtight. Voila! A lung.

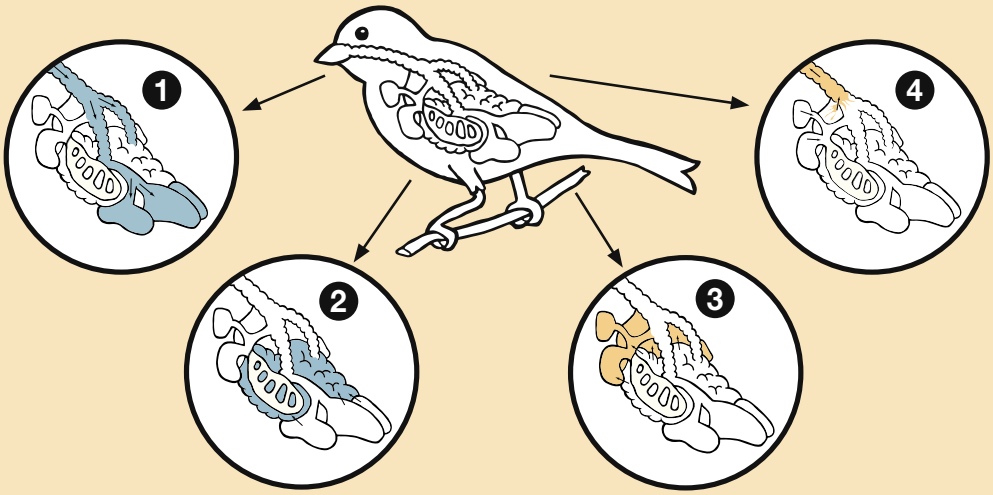
5 Hold the cup with the straw end up. Use your thumb to push up on the thin diaphragm over the mouth of the glass. What happens? The balloon deflates. You have exhaled. Remove your thumb and let the rubber sheet spring back. What happens? The balloon inflates. You have inhaled.

Pushing and releasing the rubber diaphragm changes the air pressure inside the cup, causing the balloon to inflate and deflate. Pressing the cup's diaphragm up produces the same effect as when an animal diaphragm contracts. Pressure in the chamber goes up, and the air in the balloon (lung) is forced out. When the diaphragm is released, pressure in the chamber decreases, and air flows in to equalize the pressure.

The diaphragm may be thin, but it's quite powerful. You know this if you've ever had the hiccups. A hiccup is breathing in, unintentionally. The diaphragm contracts involuntarily—rather like a muscle spasm. This pulls air into the lungs very quickly. The opening between the vocal cords closes unexpectedly, and the vocal cords come together so quickly they vibrate, causing the familiar 'hic' sound.

Here's a brief overview of how the bird breathing cycle works:

- In ***stage 1*** (first inhalation), some of the fresh air goes into the lungs, but most of it goes into the posterior air sacs.
- In ***stage 2*** (first exhalation), the air moves from the posterior air sacs into the lungs, where oxygen is exchanged for carbon dioxide.
- In ***stage 3*** (second inhalation), the air moves from the lungs to the anterior air sacs.
- In ***stage 4*** (second exhalation), the air passes up the bronchus and out of the bird's system.



The Plot Thickens

Here are two critical questions. What would it take to transform a reptile's diaphragm breathing system into the birds' flow-through system? And, could this occur in a series of step-by-(survivable)-step transformations?

The two stage breathing apparatus of reptiles (and mammals) is an integrated system, made up of separate parts working together to perform a function. The four stage flow-through breathing apparatus of birds is also a functionally integrated system that performs the same function. But these two systems are very different. What's more, they are different *as systems*—that is, they perform the same function in different ways using different anatomical structures in different configurations. From an evolutionary point of view, this poses a problem.

A gradual evolutionary scenario from reptilian respiration to avian respiration requires a series of intermediate structures and systems. Each of these intermediates would have to be advantageous to the organism, and they would all have to be fully functional at every step along the way.