Syringes, Pressure, and Density
4th Grade

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References:

- Advanced extensions (Volume and Pressure—Balancing Books on Capped Syringe)
  - http://www.sciencebuddies.org/mentoring/project_ideas/Chem_p011.shtml
  - http://www.geocities.com/CapeCanaveral/Hall/1410/lab-C-19.html

Benchmarks & Objective:

ES1: Explain that air surrounds us, takes up space, moves around us as wind, and may be measured using barometric pressure.

PS4: Predict the changes when an object experiences a force (e.g., a push or pull, weight and friction).

The objective is to build an intuitive model of equal temperature pressure and pressure gradients. When temperature is equal, pressure is directly proportional to density, and so high pressure air can be depicted as densely packed particles. Depicting the insides of the syringes with differently packed particles helps picture what is going on within the syringes. Identifying how the syringes work will help to identify how and why wind works.

Materials:

- Per Student:
  - Two 35 mL syringes (with plungers in place)
  - Plastic tube to connect the syringes
- Blackboard for drawing

Target Concept:

- Air is made of small particles.
- If a tightly packed unit of air is put next to a loosely packed unit of air (at the same temperature), the tightly packed unit of air will "fill in the gaps" of the loosely packed unit of air until both units are packed the same.
- The force of a tightly packed unit of air pushing on a loosely packed unit of air is called "pressure."
- The air that moves from high pressure air to low pressure air is called "wind."

Initial Introduction:

If you could see air, what would it look like? Why can't you see air? If we wanted to draw air on a sheet of paper, how would we do it? We can feel air and its effects, so why don't we try to draw those effects so we can try to understand them more?

Procedure:

Before the lesson, connect each pair of syringes together with the plastic tube. Adjust the plungers so that one syringe is pushed in completely and the other syringe is pulled out completely. This allows each student to have an apparatus to use during the lesson. Additionally, build an extra apparatus or two for demonstration use. The students should be able to follow along with the demonstration. At the start of the lesson, while passing the apparatuses out, be sure to manage the students. Tell them to sit on their hands, for example. Otherwise plungers will soon be removed from the syringes and possibly popped across the room.

At the start of the lesson, motivate the students to come up with a model of air. Make sure that they appreciate that there is SOMETHING surrounding them that they breathe in and out and can feel as they wave their arms about. Perhaps have them stand up and wave their arms to generate wind. Once they are convinced that air exists, get them to come up with ideas about what it might look like. If you can, have them draw on dry erase boards at their desks, or have some come up to the front of the class. Some will draw hair-like lines. Some will draw blobs. Eventually some may draw tiny particles. They may call these things "germs." Eventually have them reject some of the bigger drawings because those would be too large not to see. Consider how particles could not be seen. Ask them to think about looking at their teacher standing far away (say, California) and why they wouldn't be able to see him or her here. Also get them to admit that just because the teacher would be "invisible," the teacher would still be there. Eventually, the students should be comfortable with the idea of air being small particles that can be drawn, for simplicity, as small dots. Have them draw dots on their journals representing the air around them.

Next, start to play with the syringes. At this point, have the students experiment with the syringes and describe what happens. When a plunger is pressed down, what happens to the other side? When a depressed plunger gets pulled out, what happens to the other plunger? What happens when the plungers are pushed on or pulled on at the same time? Once observations are made, then move on to making hypotheses that use your new particle-based model of air.

Have the students draw in their journals what they think the air looks like inside and outside of the syringes. First, have them draw a picture of the air within the syringes (and outside of the syringes) before anything is done to the syringe. Then have them draw new pictures showing the changes that occur when the plungers are pushed in or pulled out. In particular, try to get them to draw snapshots in time just as the state of each syringe is changing. Point out that if 10 particles were in the two syringes at first, 10 particles will stay in the syringes but the distribution might change.

The goal is to have the students start to relate different densities of particles to a drive for the air to move until the densities equilibrate again. You can investigate the actual mechanism behind this (i.e., simple thermodynamics) later on when you teach about heat and vibrations.

Once the students are comfortable with their apparatuses, get them to think outside the syringe. Draw pictures of masses of (equal temperature) air that have different densities.

Draw a stick figure with long flowing hair in between the two masses. Ask the students what will happen to the hair. Have them explain how their syringes relate to the wind blowing on the hair. The students should get an idea that different density air masses can cause winds. Be sure to setup an equal pressure example and have them vote on what the hair will do. Some may suggest that it will stand straight up.

At some point, the term pressure can be introduced as a way of talking about the force on one air mass from the other.

Don't overreach—you'll have time to explain that the air outside is always pushing down in another lesson ("Air takes up space," for example). For now you just want them visualizing wind and air particles.

Target Observations:

- We can build a model that explains behavior we see, including the invisibility of air and the ability of air to push against things.
- That model requires very few assumptions. It's very intuitive.
- **Bonus**: A *vacuum* is much like air with a very low density. Thus, there will always be a wind blowing into a vacuum. So, air is a *fluid*—it will always fill its container.

Final Target Concept:

- Air is made of tiny objects.
- Air can move from one place to another.
- If air is tightly packed in one place and loosely packed in another, it will tend to fill in the gaps in the loosely packed air. It will do this even if people or other things are in its way.
- Students may ask what air molecules actually look like if you could zoom in and see them.
- Students may ask if bubbles in water are air molecules.
- It should be emphasized that air molecules are so small that trying to see them without a super microscope would be like trying to see their teacher from 1000 miles away.

Summary & Discussion:

The students will have built a model of air as collections of particles that try to spread out as much as possible. The students will have related these particles to the force felt when pressing on syringes or even walking around on the planet. Future activities will explore the WEIGHT of the air around them as well as what happens to air when it gets heated up.