

Air 1: Air Takes Up Space

Background:

A fundamental principle of all physical sciences is that the world around us is composed of matter. From the Pre-Socratic theorists to the modern-day search for cosmic dark matter we have been asking the basic question: What gives us and the universe weight, height and breadth?

While the answer has changed over the centuries the desire to explore the question still excites each of us.

This simple experiment helps us to connect to this basic inquiry by exploring the seemingly elusive substance of the invisible air that surrounds us.

Principle:

Solid objects are composed of matter

Objective:

To understand that:

1. Air, though essentially invisible, has substance and is therefore made of matter which occupies a defined space
2. Record keeping is a key component of scientific reporting
3. Theories can only be formulated from conclusions supported by the available data

Materials: See Figure: Materials and Methods

Clear (Glass) Bowl filled with Water

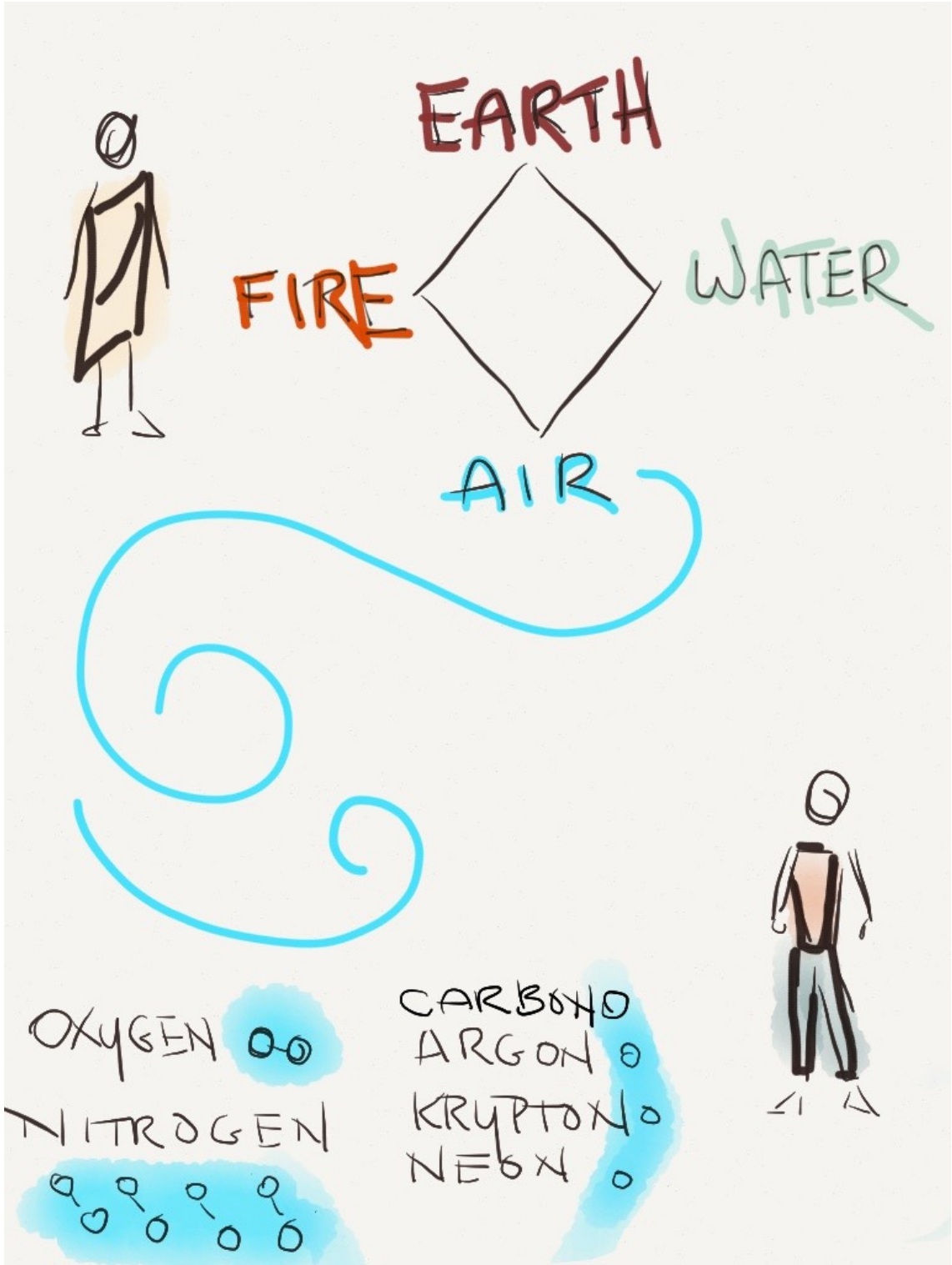
Clear (Plastic) Cup

Paper Towel

Methods: Exercise Instructions: See Figure: Materials and Methods

1. Fill a glass bowl with tap water
2. Tightly stuff a half sheet of paper towel in the bottom of clear cup.
3. Keeping the open end of the cup perpendicular to the water slowly submerge it into the bowl, Observe whether or not the paper towel at the bottom of the glass gets wet.
4. Tip the cup slightly on its side and observe what happens

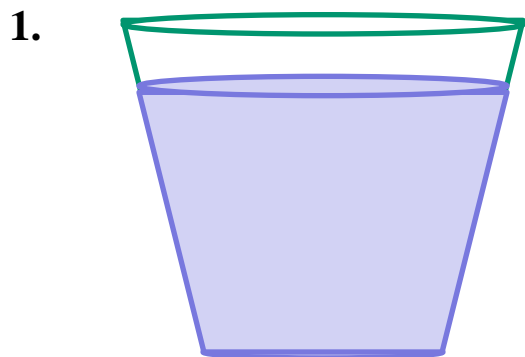
Air 1: Figure 1



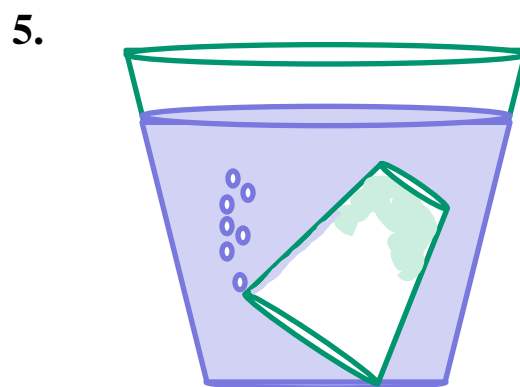
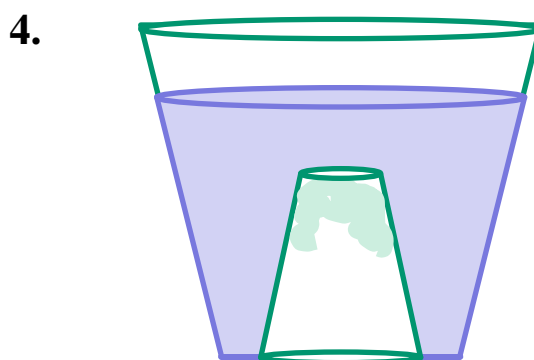
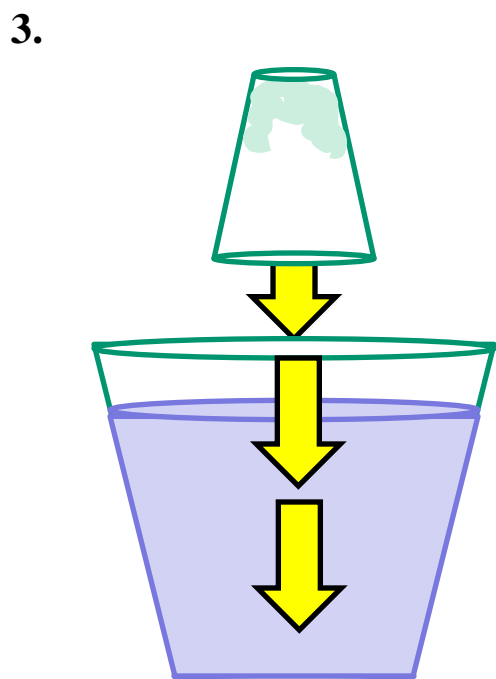
Air 1: Air Takes Up Space: Material and Methods

Everything is already at home

Glass Bowl filled with Water



2. **Glass stuffed with Paper Towels**



Air 1: Air Has Substance

Mini-Lesson:

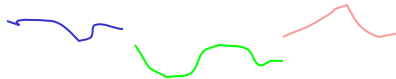
1. On the board or preferable a 2.5 x 2 foot Post-it Sheet so that the exercise may be saved and displayed, write the word “Substance”
2. “Engage previous knowledge” by asking for definitions of the word and record below and slightly to the left
3. With a consensus, formulate a definition for the exercise
4. Transition to air as an example of a substance.
5. Ask and write out the question: How do we experience air?
6. List the answers below, assuming breathing and wind to be the most common responses
7. Point out that seeing air is not on the list adding that the class is not the first to notice that air is invisible and elusive.
8. Using or reproducing Figure 1, point out that ancient cultures, such as the Greeks, concluded from simple observation that the natural world was made of four elements: Earth, Water, Fire and Air which mixed to create trees, cows, people, etc. Not until the 19th Century did chemists use scientific methods identify the individual elements that constituted air. The figure shows the 1part oxygen to 4 parts nitrogen with trace amounts of carbon and noble gases that represents the chemical composition of air. I like to add that kind of detailed information even though it will not be covered in depth because it can used later as a reference point when discussions of chemical composition of materials as in a “Rocks and Minerals” curriculum.
9. Now pose the question: How can WE test whether air has substance? List the six senses and get responses. Note that even with all six senses by themselves understanding the nature of air as a substance in difficult
10. Using all the board work draw the conclusion that, while we experience air in our everyday lives, in order to begin to understand it fully we are going to have to create more detailed experiments to analyze the nature of air.
11. See Materials and Methods

Air 1: Mini-Lesson Board Work Figure

Substance

Class Free Association:

Words →



Definition:



Air

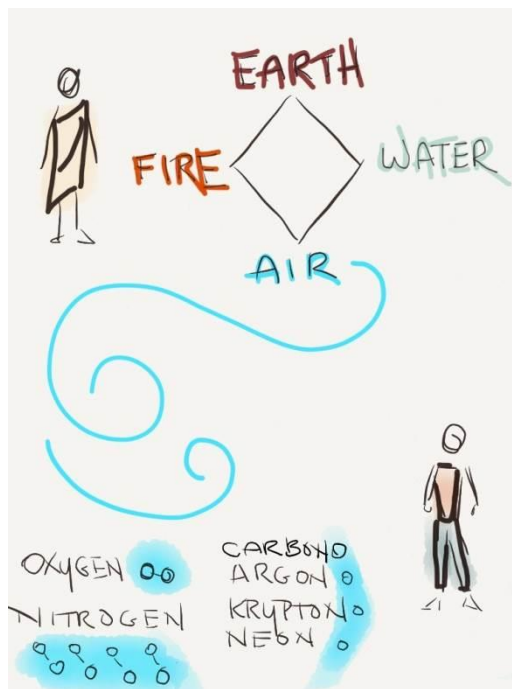
How do we Experience Air:

1. Breathing
2. Wind
3. ?
4. ?
5. ?
6. ?

How can we test whether air is a substance:

1. See?
2. Hear?
3. Smell?
4. Taste?
5. Touch?

Air Then and Now



Conclusions:

Does Air Take up Space?

Date: _____

Name: _____

Hypothesis: Air has substance and takes up space.

Materials: Clear (Plastic) Cup
Clear (Glass) Bowl
Water
Paper Towel

Procedure:

1. Fill clear bowl with water.
2. Crumple a piece of paper towel into the bottom of the cup.
3. Keep the cup perpendicular to the water surface and push the cup fully into the water.
4. Does the paper towel stay dry or get wet?
5. Tip the cup on its side and observe what happens

Data:

Not Enough Room: Finish on the Back →

Conclusions:

Back →

New Questions: _____

_____ **Back →**

Does Air Take up Space?

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Data:

Not Enough Room: Finish on the Back →

1. The paper towel remains dry
2. The tipped cup releases the air and water begins to seep into the cup

Conclusions:

Back →

1. The paper towel stays dry because the air trapped inside displaces the water around the cup.
2. The tipped cup releases the air and water begins to seep into the cup

New Questions: What are other ways that we can demonstrate that air occupies space?
In everyday life how do we see this principle applied? _____

Back →

Notes:

While no space on the work sheet is provided, a drawing of the individual components and the final product of the experiment can be drawn.

This will be a recurring theme in all data recording from here on in.

Writing a Peer-Reviewed research paper invariably requires a fairly detailed accounting of ALL the materials used. This is at the heart of one of the cardinal rules of science: reproducibility.

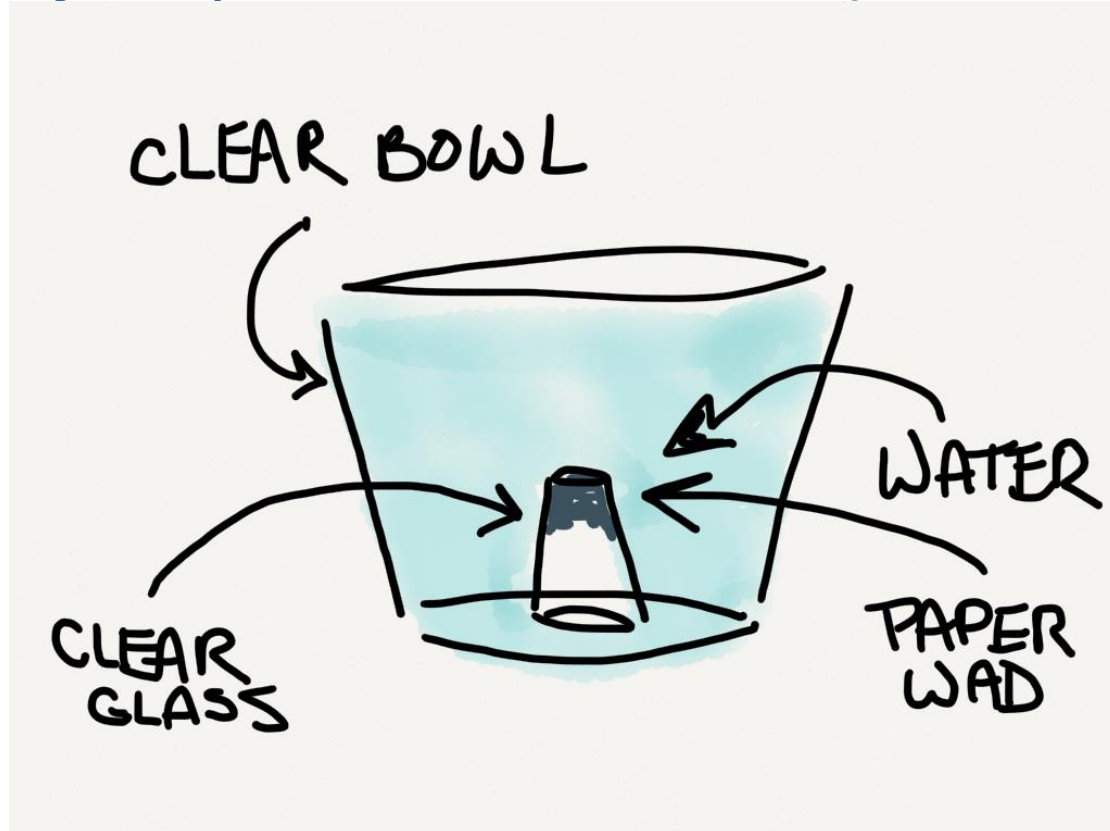
Just because you say it happened, doesn't mean it actually happened.

Someone has to read your instructions, repeat your work and get, at least, similar results.

Starting a science notebook with these elements, even for such a basic experiment, is good discipline for future, more complex work.

Animation:

<https://www.youtube.com/watch?v=HoNkGPuwXHQ>

**Results:**

Displacement of water has been used for centuries to capture and understand some of the more elusive elements of science and nature. This phenomenon is the basis for Archimedes' principle. While that paradigm is used for more complex analysis of the weight and density of an object, it serves here to

demonstrate that the air trapped under the cup has substance and takes up a defined space.

The tipped cup further reveals that the substance inside is a gas which is lighter than the water because when it is released it rises to the top. This speaks to the concepts of the state and density of the elements which constitute the air i.e. oxygen and nitrogen. This is well beyond the scope of this work, but can be referred back to, or even quickly repeated, when these concepts and principles are examined in later experiments.

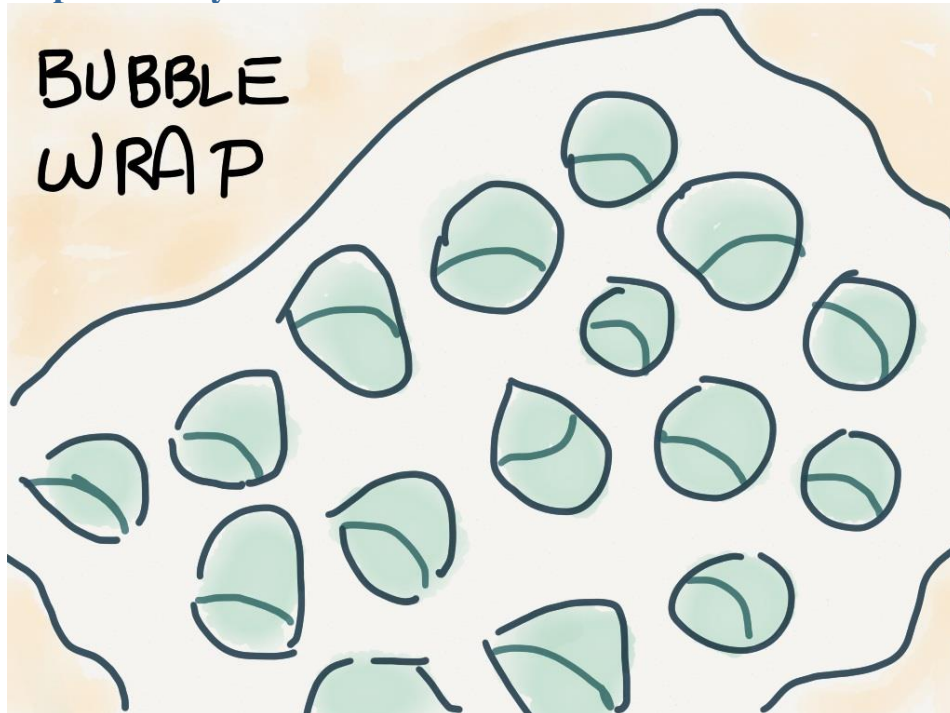
Answering New Questions:

Other ways to demonstrate that Air occupies Space

Bubble wrap: Nothing is more satisfying than bubble wrap. You can cut some VERY small pieces and hand them out at the conclusion of experiment as a very tactile and aural way to drive the principle home. Air trapped inside the wrap cushions packed items during transport. More importantly when packages arrive there is the uncontrollable need in all of us to set that trapped air free.

Animation:

<https://www.youtube.com/watch?v=IfIZS9fYiEo>



Air displacement in everyday life:

Pirates of the Caribbean: In order to travel undetected Will Turner and Jack Sparrow use an inverted canoe to trap breathable air for them to walk safely along the bottom of the ocean floor.

This is essentially the basis for submarine travel. Breathable air is chemically generated and then trapped inside the body of the submarine so that it may be safely submerged for days at a time.

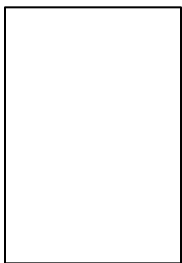
NASA: Oxygen generators also provide the International Space Station with breathable air

Possible Hypothesis Generated from Data:

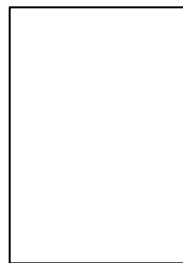
Something inside the cup pushes the water aside when we submerge the cup into the filled bowl, keeping the paper towel dry. When we tip the cup, tiny bubbles of the substance inside the cup rise to the top. We can hypothesize that we have trapped a gas which is lighter than water in our experimental apparatus. Further, testing is necessary to carefully define this gas, but we will speculate that it is air.

Complete Package: Basic: Kitchen Middens 4.15.14

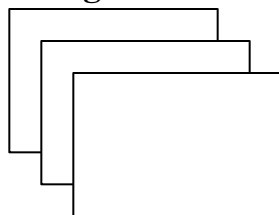
Background



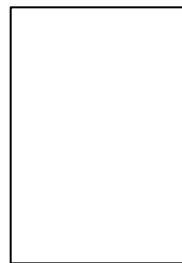
Mini-Lesson



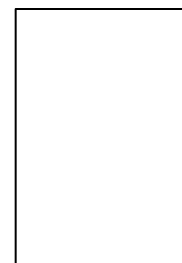
Figures



**Materials
and Methods**



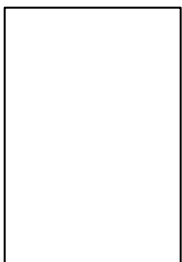
Worksheet



**Worksheet
Teacher's Edition**



Conclusion



Video



Complete Package: Basic

Background: Text placing the unit experiment in context for the subject and explaining the goals of the unit

Mini-Lesson: Text providing teaching points for the lecture

Figures: Images outlining the experiment which can be used as slides or blueprints for the teacher's own board work

Materials and Methods: The nuts and bolts of the experiment

Worksheet: Handout for the kids work

Worksheet Teacher's Edition: Suggested key points to look for assessing the kid's work

Conclusion: Wrap up and additional suggestions

Video: Supplementary Visual

Air 1: Air Takes Up Space

Conclusion:

The goal of our work was to create and employ an apparatus to observe the phenomenon that the air around us takes up space.

Objective:

We met our objectives which were:

1. Air, though essentially invisible, has substance and is therefore made of matter which occupies a defined space
2. Record keeping is a key component of scientific reporting
3. Theories can only be formulated from conclusions supported by the available data

Principle:

This is our first step in examining the principle that solid objects are composed of matter

Gateways:

As discussed in the “Answering New Questions” section of the Work Sheet, NASA and Navel Engineering are possible extension points, as is Scuba Diving, High Altitude Climbing or any other activity which uses trapped air (oxygen) for exploring the world around us.

Currently, understanding the impact of air pollution in developing economies around the world is extremely important, not only as a key factor in climate change, but also from a public health standpoint. The strain on the health of the people of Beijing from devastating smog problems, for example, could easily create a breeding ground for organisms which might initiate greater and more dangerous pandemics.

While we are not ready yet to place this work in the context of the weather curriculum, keep the subject of the devastation created by wind generated during the current ever present Super Storms which have risen to prominence in the news in the last few years. If air did not have substance the destruction we see worldwide almost every day would not exist.

I will try to link, in future work, the science we will discuss with art, history, music, dance, etc.

Outside of Dutch Genre Painting and lawn whirligigs there isn't too much to say. Posing the question to the students however may get a flood of ideas.

