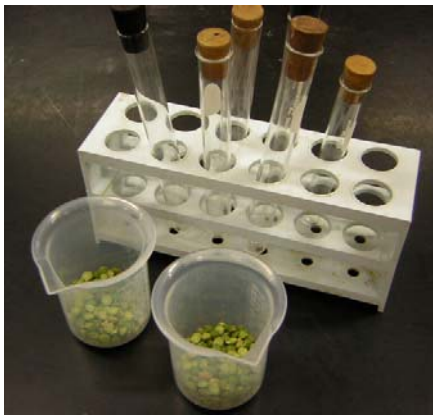
Teacher Notes- "Solids, Liquids, & Gases- Build, See, & Compare"

Trying to teach the states of matter without anything to aid the imagination doesn't do enough to help students fully understanding how the atoms behave in each state.

In this lesson students will be reading about the states of matter from the text, but the test tubes, split peas, and analogies will make it feel more like a mini-lab. What they hear, do, and see will show them exactly what atoms are like in the 3 different states.



Materials per group of 4 students (students will work in pairs today):
6- test tubes
6- stoppers
2-beakers (100 mL or larger; small cups would also work)
1- test tube rack (or something to rest test tubes in)
1- bag of split peas from the grocery store
1-ice cube

Additionally:
1 bar-Ivory soap (fresh; soap older than a couple of months will not work)
1 paper plate
Microwave oven
Magic wand (a meter stick will do)
1 cold and 1 warm can of soda
PowerPoint- "Putting Split Peas In Test Tube" (see last page)

Beforehand:

1. Put just enough split peas in the beaker for students to do this activity, otherwise you're inviting more mess and problems. Fill a test tube 1 1/2 times so you can see how much each group needs for the day. Each beaker should have about 50mL of split peas.

2. Set out test tubes, stoppers, & split peas *the day before*. Leave yourself time to realize you're missing something (did you buy fresh Ivory soap?), research something or even make a change. In the morning, read through the notes one last time. Relax and have fun along with your students. Remember- you're only as effective as your plan.

3. Locate the section in your book (or something you can run off and give students) that discusses the 3 main states of matter. It would also be helpful if there were a couple of "warm-up" paragraphs leading up to it, possibly on atoms or matter in general.

Look over the reading- you may want to skip over a few unnecessary paragraphs. Anything off the main topic of solids, liquids, and gases (like crystals) is not your priority today.

4. Make a random list of student readers, if you want. This is one less decision you'll have to make during class, and will keep you from calling on the same hands that always go up.

5. Fill a cooler with ice.

6. Put a microwave oven somewhere in your room for the Ivory soap demonstration.

7. This activity can adapt to be used with classes that run 25-45 minutes. It is presented in its barest form, so there's plenty of room to add to it. At the end is a list of "accessories", which are further topics you can add on which will lengthen and deepen the discussion.

8. As you read the lesson, don't at all feel obligated to do all the talking points. The intent was to give you the feel and flow of the lesson as it was intended. Make whatever changes will help you feel more comfortable. You may, in fact, decide that there's too much going on for you as is written. If that's the case, start cutting things out you feel aren't necessary and would overwhelm you.

Procedure:

1. If you are using the PowerPoint "Putting Split Peas In Test Tubes", start it now. It will guide you and your students through the class period.

2. Begin class by having students get their materials, with instructions not to touch anything yet.

3. Put an ice cube in front of each group. As soon as you put it down, they'll be observing it, wondering what's going on.*[1a]

4. Introduce the lesson:

"Students, the topic of the day is the states of matter. The ice cube I just put in front of you is exhibiting all 3 states- solid, liquid, and gas. It's just a simple ice cube, but the things going on inside of it right now are amazing.

We're going to be reading from your textbook today. In fact, go ahead and be turning to page _____. You can tell by the materials out today that things are going to be different. Instead of just reading and talking, we'll read a little, do a little, then read some more, do more, and so on.

Beneath your ice cube right now is a little puddle of water. See it? You know that came from the ice, right? (right)
But *how* did that happen? One minute it's ice. The next it's liquid water. What caused the change? (not sure)

Insert page number

Think of it this way- if I had not taken your ice cube out of the cooler it would still be ice in there. And when it was taken out, it started melting. So, what it comes down to is- what's the difference between the inside of this cooler and our classroom here? (it's warmer in the classroom)

Touch the ice cube- how does it feel? (cold?)
Yes, cold. Have you ever wondered why ice is cold?
Cold means there's little energy. And the colder it is, the less energy it has. Feel that ice cube one more time. And this time instead of thinking 'that's cold', I want you to think 'there's very little energy in there'.

These are all clues that we're going to looking into and getting answers about. Let's read our first section."

5. Now it's time to the introductory paragraphs from the textbook (don't yet read about solids, liquids, and gases). Call on your first few random student readers to read the first couple of introductory paragraphs aloud. Stop when you get to the section on solids.

6. Before reading about solids students are going to make a test tube representation of a solid. Have each student group take their first of 3 test tubes and fill it to the very top with split peas. It helps when pouring if the test tube is down in their closed hand so it forms a little bowl- that helps the peas to slide in. Take a few peas out at a time until the stopper fits snug enough to hold all the peas without allowing any of them to move at all.

7. Examine the contents of the full test tube:

"Look carefully at the split peas inside your test tube. Notice what happens when you turn it to the side, then upside down, then to the other side. Does anything ever change in there? (no)

They're packed in there pretty tight, aren't they?
Those split peas represent atoms, and atoms can move as much as their energy allows. Since these aren't moving, they must not have much energy.
But here's the thing- they are *capable* of moving around, but they *can't*.*[2]

Take another glance at your ice cube. Frozen water, right? Remember all those split peas packed in your test tube? That's what the atoms in your ice are like."

8. Call on your next few random readers to read about solids.*[3]

9. Have students next make the next test tube state, liquid, by filling the test tube about halfway with split peas.

10. Ask them to again turn it over sideways and upside down, noticing how these atoms behave differently from the "solid" peas. The atoms themselves haven't changed, just their ability to move. There's no definite shape- it's the shape of its container right now, but keeps changing. They may not have definite shape, but liquids are measurable- remind students that we filled the test tube halfway. And we buy 2-liters of soda and gallons of milk.

11. Have student readers read the section on liquids.

12. Revisit our friend the ice cube. Take a close look at the growing puddle of water. It's a hard thought for students to accept, but the liquid water is the *exact* same stuff as the ice cube, even though they look different:

> "Well, now the ice cube has melted even more. Why did that happen? Remember how we compared the cooler with our classroom? (it's warmer here, so the heat, or energy, went into the ice cube)
>
> Great! Let's take the next step, now that I think you're ready for it. The heat, or energy, from the air entered the atoms, which excited them, causing them to become more active. And now they have the ability to move around each other."*[4]

13. Before making the gas test tube and reading about gases, have students put their finger in the liquid water by the ice cube and drag a streak on their desktop. We'll come back and check on it later.

14. Make the last test tube representation-gas. This time put in just one split pea and stopper shut. Before any more discussion and reading, it's worth throwing out the question to students- why just 1?

> "It's all by itself because it's a gas, which has a very high level of energy. There's just one because they're moving so fast that they collide and spread that far apart! The atoms of most gases are 50-100 times more spread apart than they were as a liquid or solid."*[5]

15. Read the paragraphs on gas.

16. Revisit the ice cube:

> What happened to the streak of water? (it's gone). It's got to be somewhere around here. Anyone see it? (no, it's water vapor now)
> Water vapor, huh? That means it's flying! Think about this- you're breathing in water vapor that 20 minutes ago was frozen water. If we had never taken that cube out of the cooler, this would never have happened! Fate or coincidence, you decide.
>
> Well, (sound dejected) it's hopeless. The ice melted… I mean heat from the room entered the solid ice and gave them enough energy to move around, forming a

liquid. Then more energy went into the liquid, and now they're popping into the air. Our little ice cubey is gone. Forever. (*Sniff*)

We can never turn that water vapor back into solid ice, can we? (*hopefully an uncertain hand will go up*)
What's that, there's hope? Really? Let's take this one step at a time- how can we turn water vapor back into liquid (hmmm…..)*[1b]

Cool it, you say? I think you're onto something.
How did water vapor turn back into liquid (silence)*[6]

It's the opposite of our friend, the ice cube. In that case, we heated it, so energy was going in, and the atoms became more active. We did it! We went backwards."*[7]

17. Have students copy the following statement into their notes. You can even have them memorize it for a little quiz on Friday. It sums everything up in 3 compact sentences:

    Energy flows in and out of atoms. More energy causes atoms to become more active so they need more space. Less energy causes them to become less active, so they need less space.

18. In closing, put a ¼ bar of Ivory soap onto a paper plate. Set the microwave for 30 seconds on high and let it cook. When done, the soap enlarges to about 10 times its previous size. Make sure you're using fresh soap that you just bought- after a couple of months it won't work. If you weighed it before and after, you'll notice you lost a few grams of soap. Where could it be? Anyone smell anything? That's right- there now some Ivory soap gas.

19. Homework tonight is for students to explain what happened with the Ivory soap. After doing the demo, call on a student to read the statement one last time now that they've seen what just happened. It will hopefully make more sense, and give them the words to explain it with.

20. Begin class tomorrow with student sentences.

Accessories: Other sub-topics you can add for more length and depth.

- *[1a] Go ahead and set out the cans of soda (1 cold, 1 warm) on your desk in plain sight. Later they'll help you illustrate how a gas can turn into a liquid.
- *[1b] (*Turn to the 2 cans of soda that have been on your desk and pick up the cold can*) What's this on the outside? Drops of water? Where in the world do you think those came from? (The air)

- *[2] Introduce the magic wand. It's just a meter stick that you're waving around, but it will get your students' attention:

  "This is my magic wand. I will demonstrate now is its ability to affect your level of energy. Ready?
  (Wave the "wand' back and forth over students.)
  What I've just done is taken the energy out of all of you. No one has any strength left. And with no energy, how active are you? (we're not)

  Smart, you are! You realize that your energy level is what decides how active you are. The same true with atoms. Their energy level also changes. As it goes up, guess how active they are (more/very).
  And as it goes down, they become…. (less active)"

- *[3] After reading about solids, bring up 1 more analogy- the trampoline. Ask if anyone in class has a trampoline at home (several hands will go up). Then ask if everyone in the class can come over after school today for a little, actually a big, demonstration. The plan is for everyone in class, all 30 people, to get on the trampoline at once:

  "Good idea or bad idea? (bad!)
  I never said anyone would be jumping on the trampoline. What if we all just sat on it together? Wouldn't that work? (ummmmm… yes, I guess so)

  Good! Then we'll all get on and just sit still, and as long as no one starts jumping, we're ok.

  Ok, we're not really going to do that (or, maybe we should), but picture that- would all of us sitting still on a trampoline represent a solid, liquid, or gas? (solid)"

  Revisit the trampoline analogy when discussing liquids. "Now we're all on it, but we can crawl around on it. No one is "stuck" in any one place, because they have enough energy to move over and around the other student 'atoms'".

  And again with gases- "Ok, now all 30 of us can jump around on it? I don't think so. We're going to need a bigger trampoline, and some helmets!"

- *[4] "Your puddle of water is in the shape of your desk. Put your finger in it, now it's the shape of your finger. The atoms moved out of the way because they have enough energy to move around. Push on the ice cube. Did it move out of your way? It didn't? And that's because the atoms have no energy, so they can't move."

- *[5] "I don't play the lottery, but it's neat watching the ping pong balls inside that machine fly around. At first, all the balls are still, and packed in a small

space together (sounds like a solid, doesn't it?). Then the machine is turned on, and the ping pong balls start flying. At first, they're not moving very fast. When two balls collide they bounce back a little. Then they go faster and faster. And what happens when two fast moving ping pong balls collide? (they bounce back further).

Now, you can have a whole box full of ping pong balls, and they can be packed tight in there as long as none of them are moving around. But, give them energy, and they start banging into each other. It's a simple formula- more energy = faster = harder collisions = more spread apart. That's why some containers will explode when heated- they atoms inside are pushing harder on the container than what it can hold."

- *[6] Think of your freezer at home. It probably has frost in it. Every time you open the freezer door air goes in. And when you close it, it's trapped inside. The water in the air cools and then freezes as energy comes out. What started out as water vapor condensed into a liquid, then froze into a solid.

- *[7] "But that's not the end. In fact, life for a water molecule never ends. Let's say (wave the magic wand again) that you're all atoms of water. Right now life is good because room temperature is warm, so you're a gas, just flying around, smashing into others and just bouncing around. But tonight it's supposed to get below freezing outside. Oh, no! What happens to you? (freeze).

  That's right. Then the sun comes up tomorrow morning, you thaw, then later pop back into a gas. Then tomorrow night it happens all over again. Over and over and over and over. What if that was your life?"

*Quick*Notes

Teacher *Quick* Notes- "Solids, Liquids, & Gases-Build, See, & Compare"

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6- test tubes
6- stoppers
2-beakers (100 ml or larger; small cups would also work)
1- test tube rack
1- bag of split peas from the grocery store

PowerPoint-"Putting Split Peas In Tube" (optional; located in Resources folder)

Procedure:
1. Pepper students with questions to put them in the right frame of mind. Put in some easy ones to build their confidence, then work your way up.
2. Have students fill test tube #1 with split peas until it's so full that when they stopper it shut and shake it they hear nothing. This is shown on slide 1 in the PowerPoint.
3. Referring to the now-full test tube, talk to the students about how the peas are behaving, then relate that to how solids behave.
4. Read the section from the book on solids.
5. Fill test tube #2 halfway and stopper shut. Talk them through this and compare with liquids. Read the liquids section.
6. Put just 1 pea inside the 3rd test tube and stopper. Discuss of how this one is most like a gas. Read the gas section.