Teacher Notes- “Energetic Atoms- Active & Spaced Out”

This lesson is a classic example of how showing someone is better than just telling them. Being told that a 50 foot-long trash bag filled with air will heat, expand, and rise is not exciting news. But take students outside and let them see for themselves, and you’ve got a lesson with “end of the year” status- one they’ll still remember on the last day of school.

Once students understand the cause of what's going on inside the bag, they'll grasp what essentially drives the states of matter: energy.

Materials per student:

Student Handout (see p. 7)

Additionally:

1 solar bag (see *Beforehand* for purchasing options)
2-tennis balls
PowerPoint- “Energetic Atoms” (see p. 6)
Sign on your door-telling students to meet outside

Beforehand:

1. Purchase a solar bag, which is essentially a 50 foot long continuous trash bag. Do an internet search for “science solar bag” and you’ll find some for around $20 apiece (buying 2 is not a bad idea- they do tear). It’s item # WW4648400 at sciencekit.com.

2. While you’re on the internet, search for “mars solar bag” and you’ll find some unbelievable pictures.

3. **When to do this**: you must have sunlight for the solar bag to work. If it isn’t shining the day you planned to do this, go to plan B, which is your next day’s lesson. Hopefully tomorrow the sun will be out.

4. Buy a roll of black duct tape. This is what you’ll use to patch the inevitable small holes and tears that otherwise would render your solar bag useless.

5. Launch the website that streams the video mentioned towards the end- http://streamer.cen.uiuc.edu/var/PhysicsVan.wmv , and cue it to start at the 5 minute mark. Many thanks to the PhysicsVan! program at the University of Illinois for graciously allowing us to use their resources.

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6. Put up the sign that tells students to meet outside. Meet in a clear, open area that's away from power lines, trees, light poles, and anything else that the bag can snag on. The day before, walk around the area and look for things that could cause your "runners" to slip or catch their feet.

7. If appropriate, notify teachers or neighbors whose windows you'll be doing this in front of. Most will appreciate not being surprised.

8. Think about student discipline. Sometimes a change in scenery is all some kids need to go wild. Decide ahead of time what your plan will be to control them. You're going to be busy managing this activity, so you won't have time to deal with problem students.

9. Read all instructions that come with the solar bag carefully, especially the warnings about where to do the solar bag activity. Have 2 people always holding onto some part of it (that way there's no chance it gets away!).

10. 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.

Procedure: (the first 20 minutes outside, the last 20 minutes inside)

1. When students meet you outside, introduce the lesson:

> "Students, we are here today to demonstrate a sophisticated scientific instrument. It's called a solar bag. Actually, it's really nothing more than a 50 foot-long continuous trash bag. Since it's such a nice day, we're going to spend the first part of class seeing what happens when this is filled with air. Then we'll go back inside and piece together an explanation that you'll all understand."*[1]

2. Unroll the solar bag, and explain what it is- 1 mil plastic (very thin!). Two important things about the bag that make it work- 1. it has very little mass, 2. it's black.*[2]

3. Ask for 3 volunteers (who will be your "runners") who have an over-abundance of energy. Two will jog side-by-side holding the mouth of the bag open while the other is the "caboose" whose job is to run behind holding the tail and make sure it doesn't catch on anything. Explain to the two in front to run down a hundred feet or so and back, and to STAY TOGETHER so the bag doesn't get pulled apart. If the grass is wet tell them to not run full speed.

4. Send off the runners. When they return, it will be about ¾ fill, which is full enough. Grab the open end of the solar bag, close it shut, then draw in the slack with your hand until the balloon is firm.

5. In the very first minute of heating, point out to students the wrinkles in the bag, because they will soon be gone. This is important visual evidence that will be referred to later.

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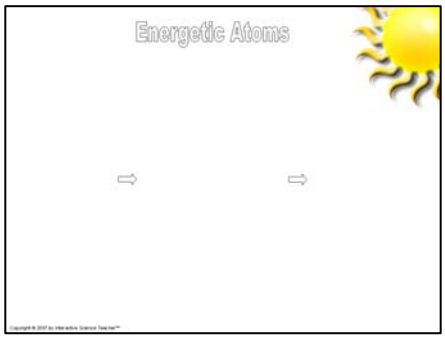
6. While waiting for the bag to swell up, hover, then rise, talk to them about the science going on inside. The sun's heat is being absorbed, so the atoms respond by speeding up, which makes them collide harder, causing them to spread. That's why the wrinkles disappear, and eventually it rises. Kids also like to hear about what happened last hour or last year when you tried this (as long as you assure them theirs is the best).*[3]

7. On a warm day (65-85 degrees Fahrenheit) it will take about 5 minutes for the bag to lift completely off the ground. Colder than that- it will hover just over the top of the grass. You can tether it on a rope, and the directions do recommend this (and it's not a bad backup system), but if you did that, untying it without damaging the bag would be difficult. Just hold the solar bag shut with your hand- it will still lift.

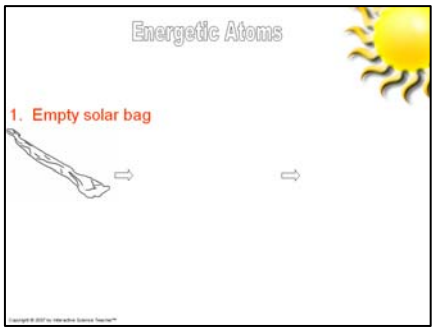
8. After a few minutes of seeing it floating, most students will be ready to go back in inside, which is fine because we still need to talk in detail about what happened. Send everyone back in and roll up the bag, beginning with the knotted end. Tell students to stand at the open end of the bag as you roll it up to feel the hot air blowing out.



9. Back inside, give students the "Energetic Atoms" handout.

10. If you are using the PowerPoint "Energetic Atoms", start it now. It will guide you and your students through the rest of the class period.

11. Advance the slide and show the first drawing of the empty bag and have students draw this in the same place on their worksheet. Tell them their artistic ability will not be graded. As long as they realize this is supposed to be an un-inflated solar bag, that's all we need.



12. Move onto the first statement, "1. Empty Solar Bag". Make sure students number it, because the homework will reference these steps.

13. The middle drawing is of the solar bag that's been just-inflated. Again, students, do your best.

14. Click to show statements 2 ("filled with air") then 3 ("black makes it absorb sunlight"). Statement 3 is the most crucial- it causes 4-6.

15. Ask if anyone remembers what the bag felt like when they touched it. Then those students in black shirts how they felt outside (hot!), then ask the white shirts (didn't notice, really).

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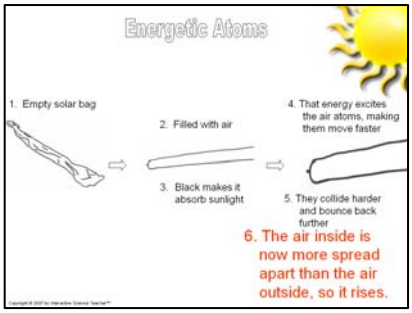
16. For the last drawing ask students to draw the bag noticeably thicker than the middle one. One good thing about drawing is that you can exaggerate to make your point. Remind students of the wrinkles on the bag that disappeared after about a minute, so it actually was swelling up noticeably.



17. Move onto statement 4.*[4]

18. After statement 4, direct your attention to the two tennis balls next to each other:

> "These two tennis balls are able to be next to each other, and even touch, because they're not moving. We could fill a box with tennis balls, and even this classroom, and they would be fine as long as they aren't moving. But watch what happens when they start moving. (*start pushing them around slowly*) They occasionally happen to bump into each other, and when that happens they bounce back. Did you see it? Keep watching.
>
> Now, what do you think will happen when I put more energy into these tennis balls and they move faster? What will the effect be? (they'll bounce back further)
>
> Good! And why is that? (because they're colliding harder)
> And that's because they're moving faster, which is because there's more energy in them. This is what happened to the air inside our solar bag."

19. Copy statement 5 and then statement 6.*[5]

20. Having done the solar bag activity and worked through its explanation, students are now ready to observe it's complete opposite. Launch the website http://streamer.cen.uiuc.edu/var/PhysicsVan.wmv on the screen and let them observe the demonstration the University of Illinois PhysicsVan! group performs between minutes 5 and 7 on the webcast. In it, a small yellow balloon is put into a bucket of liquid nitrogen, which causes it to shrivel up.

21. As soon as that's over assign the following 2 homework questions:

    1. Explain the liquid nitrogen balloon trick by rewriting statements 2-6 from today's worksheet. (*have students number from 2-6 so they can keep track of statements*.)

    2. What would have happened outside if we were using a white solar bag?

22. While students work on these questions make yourself available to students. Wait until someone asks for help on the first question before you discuss it out loud so they can struggle with it some and then appreciate the help you're giving. Statement 2 ("filled with air") will not change because both the solar bag and the little yellow balloon were filled with air. But statement 3 is where it turns. With the solar bag we put energy in. Were they putting energy into the little yellow balloon?

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23. Begin class tomorrow with student sentences.

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

- *[1] "Early this morning the ground was wet. I didn't notice anyone going around with a spray bottle wetting all the grass. Anyone know where that water came from? (it was dew!) Dew? Let's see…dew comes from the air. The air you're breathing right now has water vapor in it, and it's also nice and warm. But tonight it's going to get cold. That means energy will come out of the atoms that make up the air, and once the temperature drops below the, guess what they call it, (dew point?) yes, the dew point, water vapor will be cool enough that it condenses into little liquid droplets on the grass. It's all gone now because the sun came up, heated the air, and the droplets went back in to the air."

  (Check what your current dew point is. As you talk about the dew point, review and apply how things change between the states of matter.)

- *[2] To help students begin to understand how important the color black is to this experiment, locate a student wearing a black shirt and another wearing a white shirt. The black shirt is about 10 degrees warmer than the white shirt. The same amount of sunlight hits both, but the black *absorbs* the heat, but the white reflects it. Also remind them how painful it would be walking barefoot down a blacktop road in the summertime, but not if they walk on the painted white line.

- *[3] If students want (or *have*) to touch the bag tell them to pat it just once using their palms. Make sure no rings, watches or fingernails get near the bag! Have students notice how hot the bag feels- it will be hotter to the touch than most students expect.

- *[4] Announce to students we're taking an imaginary field trip to the mall. As they get off the bus each student will be given a crisp, new 100 dollar bill. Some will spend it in the first 5 minutes, and have no idea what they even bought. Others will spend some and save some. Some might even come out of the mall later with 100 dollars. What's the point? Atoms are like people that can't keep money in their pocket. They spend the energy they're given as soon as they get it. When the heat hits the black solar bag, the air *immediately* speeds up and begins spreading. We know this because the wrinkles in the bag were gone after just 1 minute.

- *[5] Ask if anyone has ever ridden in a hot air balloon. If not, has anyone ever seen how they get the balloon to rise?

  "How'd they do that? (they used fire, and that cause the balloon to rise) So, they don't use any special gas?

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Sounds sort of like our solar bag, except with a lot more heat. Fire is well over 1,000 degrees Fahrenheit. Imagine how fast those atoms inside that balloon must have been going, how hard they were colliding, and how spread apart they must have been. Atoms are just about indestructible, aren't they? And that's why it lifted off the ground. When the balloon finally stood up and took shape, there was actually very little air inside of it. Inside that great big balloon was just a little bit of air, but it took up all that space because the atoms were moving un-imaginably fast.

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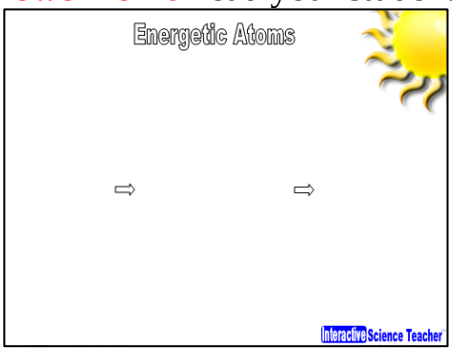
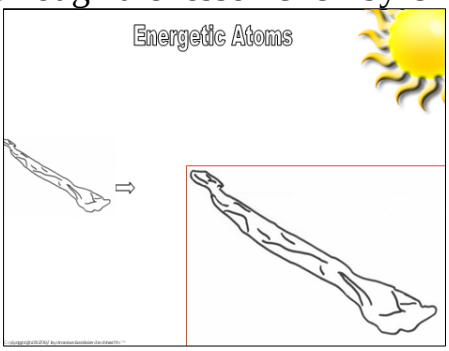
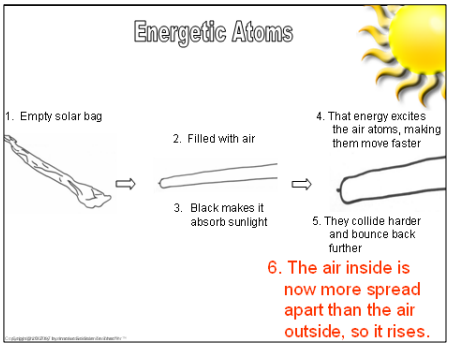
PowerPoint- lead your students through the lesson click-by-click

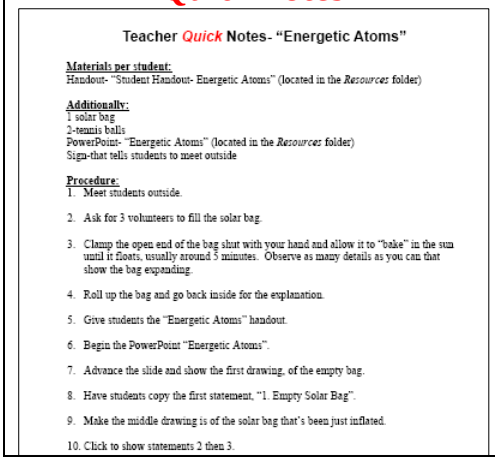






Student Handout

***Quick*Notes**



Teacher *Quick* Notes- "Energetic Atoms"

Materials per student:
Handout- "Student Handout- Energetic Atoms" (located in the *Resources* folder)

Additionally:
1 solar bag
2-tennis balls
PowerPoint- "Energetic Atoms" (located in the *Resources* folder)
Sign-that tells students to meet outside

Procedure:
1. Meet students outside.
2. Ask for 3 volunteers to fill the solar bag.
3. Clamp the open end of the bag shut with your hand and allow it to "bake" in the sun until it floats, usually around 5 minutes. Observe as many details as you can that show the bag expanding.
4. Roll up the bag and go back inside for the explanation.
5. Give students the "Energetic Atoms" handout.
6. Begin the PowerPoint "Energetic Atoms".
7. Advance the slide and show the first drawing, of the empty bag.
8. Have students copy the first statement, "1. Empty Solar Bag".
9. Make the middle drawing is of the solar bag that's been just inflated.
10. Click to show statements 2 then 3.

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