

Teacher Notes- “Dunking Duckies- Endless Expansion And Contraction”

When students walk into your classroom and see dunking ducks everywhere, each will express their amazement differently. Some will stop in the doorway and stare. Others will get a friend to show. The rest will go to their seat and begin studying the motions of duck. They’ll remember that days like today are why they like science. And for good reason- the dunking duck is fascinating to watch and simple to understand, as it’s presented today (they’ll be explaining to you how it works later on).

The potential topics you can cover with the dunking duck is almost limitless, so don’t feel limited to the discussion that follows. If you’d like to go further, type “dunking ducks” and “drinking birds” into an online search engine. You’ll be in for some very interesting reading.

Materials per group of 4 students:

1-dunking duck
1-250ml beaker full of water

Additional Teacher Materials:

1-dunking duck
1-250ml beaker with room temp. water
Ice- to put in water
1-lamp with 100 watt incandescent bulb
(the kind that gets really hot)
1-stopwatch or timer (optional)
PowerPoint-(see p. 6)
Student Handout- (see p. 6)



Beforehand:

1. If you don’t have any dunking ducks, they can be purchased for around \$9 apiece. They’re item #WW6579800 at sciencekit.com. You may not need as many as 8 ducks, but have enough so that every student can clearly see what’s going on inside of it. If you have the time and money, pick up a few more than what you think you’ll need. Class sizes change from year to year, ducks break, and some just don’t work as well as others.
2. Assemble the ducks the day before so you don’t have to rush around at the last minute doing all the fine adjustment. Getting them ready that soon will also give you time to tame the feistier duckies that initially refuse to work.
3. 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.

During class time leave your discussion notes aside, and go where the flow of each class takes you. There's no telling what comment will come from what student at what time, and being open to those comments and going with them are what elevate lessons. You will feel a little vulnerable at the beginning of the talk, but things always end up in the right place, though the road there may curve a little.

Procedure: *note- do not give students the handout yet. They need to just focus on the ducky for a while.*

1. The connection between the ducks and the states of matter may not be very obvious at first. Your students will certainly be wondering why, during the chapter on solids, liquids, and gases, these suddenly appeared for discussion:

“I see many of you trying to figure out what these duckies have to do with our chapter on the states of matter. Well, they have *everything* to do with the states of matter. As we go through our day you'll notice that we're going to use the very same words and phrases that we've used with other things, only now they apply to this.”

2. Give students 3 quiet minutes to observe their dunking ducks so they can observe the inner workings closely:

“Students, these duckies didn't just start bobbing up and down just before you came in. I set them up *yesterday afternoon*, 18 hours ago, and I haven't touched them since. He's gone up and down thousands of times all on his own, and without you knowing about it. I'm going to give you 3 quiet minutes to observe it. When the 3 minutes are up I'm going to ask you how it works. Start your observation with what it's doing. Simply observe what's going on inside the ducky, and then how that affects the rest of him. Once you've done that, ask yourself some “why's”. Why does it do this, why does it do that? You may begin observing.*¹

3. After the 3 minutes are up start trying to piece together an explanation. Let the students do as much of the talking as possible. Your job is to repeat, clarify, referee, and guide them from one idea to the next:

“Who'd like to try to explain little ducky? Remember, you can start anywhere you want to because there is no beginning and end. And everything you all noticed is a valuable piece that fits somewhere, so I'd like to hear from as many of you as possible.”

4. Hands will go up. Hold yourself back from talking. Just listen at first.
5. “Suzie's” hand raises. She explains that the liquid rises until it fills the head (she'll skip over why it rises, but we'll cover that later), then ducky becomes top heavy and falls into the water. Liquid inside runs back to the bottom, and it stands back up.

6. 30 other faces in the room are agreeing with what she said. Look back at them and give a long pause, which is the familiar sign to students that we've just begun the journey:

“Well said Suzie. Everything you just said is true.

Let's go back to the part where you said the liquid was going into the head. Everyone, watch your ducky while we talk about this. Watch that liquid go up the tube. As the liquid goes up higher and higher, and into the head, it becomes more top-heavy. Another way of saying that is that its center of gravity changes, in this case moving upward. Eventually his top half weighs more than his bottom half, and because he pivots he tips into the water.”

7. After more student comments and observations, delve into the mystery behind the rising ether:

“So, the ether rises, fills the head, causing him to become top-heavy and he tips in. Is that it? Is there anything missing? (no)
Oh yes there is! Think about it. (*repeat what you just said*)

We still haven't gotten to *why* it rises. Let me ask you a question- at any time during the cycle did the amount of liquid inside change? (huh?)
Do you see how the liquid goes up into the head then back down? (yes)
When it goes up, is it because there's more liquid? (not sure)
Let's do this little test to see- the next time the ether all runs back to the bottom, notice how low it goes. Then compare that with the next cycle.”

Key point in the discussion!

8. Give students a minute to watch the ether in their ducky contract twice:

“What did you see? (it keeps going back to the same place)
Which means the amount of ether isn't changing.*² Hmm.....
If the amount of liquid isn't changing, then what could be causing this? (is it expanding?)
Watch the ether creep up the glass tube and think about this: it's getting bigger. It's expanding.

And what causes liquids to expand? (heat)
Yes! When they're heated! Heat is energy. Energy causes motion. More motion means it's more active and needs more space- it expands.*³

Good job. Can we move on yet? (obviously not, or why would you be asking)
Now we need to find the source of heat. Are these battery operated? (no)
Well, where could the heat be coming from that excites atoms in the liquid, causing them to expand and move up the tube? (the room?)

Excellent! There's heat in the room. Not a lot by your standards, but enough. Heat from this room goes into the liquid and causes it to expand.”*⁴

9. See if students are catching on at all to the forces driving this:

“What do you think would happen if we took ducky outside and it was zero degrees? In other words, air with very little heat in it? (hmm...)
How much heat is there in zero degree air? (none/very little)
So how much heat would go into the liquid, causing it to rise? (none)
And so, I’ll ask again, what will ducky do if he’s outside and it’s zero degrees? (nothing)”

10. Begin the other half of the cycle:

“We’re more than halfway done now. Do you realize that I haven’t really told you anything? We’ve covered a lot of information, and all I’ve done is ask questions. You’ve figured everything out by answering them correctly. Let’s check out the other half of the ducky cycle.

Ducky’s head fills, he falls in, and the liquid all goes back down. Right? (right).

But we forgot again one important thing- *why*. So let’s do it again for the opposite- why is it contracting? What’s taking the heat out, making the ether shrink?”

11. The contracting ether:

“Easy warm-up question- would this work without water? (no)
What is the purpose of it? (not sure) *⁵
And that’s because water absorbs heat.
When your ducky’s beak dips into the water, the water absorbs heat, which comes from the ether.
Heat lost means that energy is removed.
And when you lose energy you become... (less active)
So you need... (less space)
Bingo!”

12. Now give students the ducky handout and scrambled explanation to work on. Have them put just the numbers by the blanks at first until you later confirm the correct order. Then they can write all the sentences out. Get them started by telling them the first answer- statement #2 goes by the blanks with the star.

Name: _____
☆ <u>Inside ducky is ether liquid (bottom) and</u> <u>ether vapor (head)</u>

If you want, the answers are also on PowerPoint, which you can show your students.

A good Friday quiz would be to memorize this explanation.

13. The homework assignment is to calculate how many times your ducky has bobbed, located at the bottom is something else students can do. The number will surprise them- it’s around 5,000 for the average ducky!

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

- *¹ Have students pretend they are detectives. A detective goes in after an event, and, using the evidence available, attempts to explain what happened and why. This is called making an inference- an explanation based on evidence. Student will observe and then have to infer what causes the ether inside the glass tube to keep rising and falling.
- *² You could also point out that the ether is sealed inside a glass tube, so none can get in out. If it could get out, it would all vaporize in just a few seconds... and permanently stain everything it touches.
- *³ Notice how ducky is put together- 2 glass bulbs forming the head and tail, connected by a glass stem in between. When the ether expands, it can only go one place- up through the stem. It's similar to a thermometer in which the red alcohol, when it heats and expands, can only go one direction- up.
- *⁴ To test and prove this to be true, add a source of additional heat and see if it speeds up. Time how long it takes your teacher duckie to go through 2 cycles before doing anything (so you have something to compare your numbers with). The turn on the lamp with 100-watt incandescent light bulb.

Give it 2-3 minutes to fully warm up before timing it again with the added heat. If you time it as soon as you turn the lamp on, it actually will slow down some before speeding back up.

Later, after talking about the cooling and contracting ether, put ice water in front of ducky. After he settles in with both the heat lamp and the ice water he'll go about twice as fast as his original speed.

With the heat lamp and ice water we've found a way to artificially speed him up. But that excess heat and cold aren't causing ducky to do anything different. He's just doing it faster because the liquid inside is rising and falling faster.

- *⁵ Ask students to put a little water on their fingers and then wipe it across their forearms. Ask how it felt (cold). Really? Water absorbed heat from you, so it felt cold. The water in the beaker is doing the same with Ducky- removing heat, causing the ether to contract, and that's why it all runs back to the bottom.

More information:

<http://www.abc.net.au/science/features/whyisitso/>

-episode 2

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

But the room is still warm, so...	☆ Inside Ducky is ether liquid (bottom) and ether vapor (top).
and Ducky stands back up.	Heat from the room excites the ether atoms
liquid shrivels back to the bottom.	causing them to become more active and need more space.
Water cools the head.	So ether liquid goes up the tube, squeezing the vapor in the head more.
..Ducky tips forward.	Enough liquid rises past the center of gravity that

Your homework: calculate how many times your ducky has bobbed up and down during the test day.

Student Handout

Name: _____

Your homework: calculate how many times your ducky has bobbed up and down during the test day.

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QuickNotes

Teacher *Quick Notes*- "Dunking Duckies- Endless Expansion And Contraction"

Materials per group of 4 students:

- 1-dunking duck
- 1-250ml beaker full of water
- 1-caution sign (to keep students' hands off the duckies)

Additional Teacher Materials:

- 1-dunking duck
- 1-250ml beaker with room temp. water
- 1-250ml beaker with ice water
- 1-lamp with 100 watt incandescent bulb (the kind that gets really hot)
- 1-stopwatch (optional)

Procedure:

1. Give students 3 quiet minutes to observe their dunking ducks so they can observe even more, and put all other thoughts out of their minds.
2. Now start piecing together an explanation. Let the students do as much of the talking as possible. You're job is to repeat, clarify, referee, and guide them from one idea the next.
3. Give students the ducky handout and scrambled explanation (in the Resources folder) to work on.
4. Assign homework: calculate how many times your ducky has bobbed.