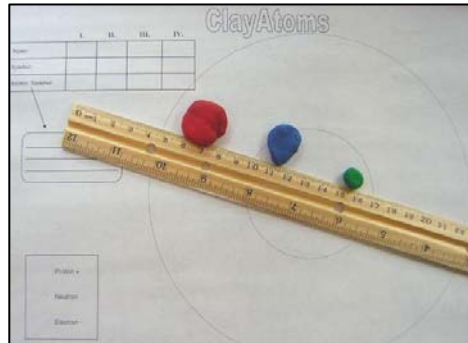


# Teacher Notes- “Clay Atoms- Taming Our Fear Of The Invisible”

If you asked each of your students what an atom is, what would they say? Most students are uncomfortable with the concept of atoms because they mistakenly believe that since atoms are so small they must be hard to understand.

This fun activity will disprove that as students use clay to mold protons, neutrons, and electrons that they’ll combine to make atoms. It won’t be long into this activity before students will be saying to themselves “Is that all there is to it?”



## **Materials per student:**

Red, blue, and green clay (or any 3 colors of your choice)

1-ruler

1-student handout (see last page)

## **Additionally:**

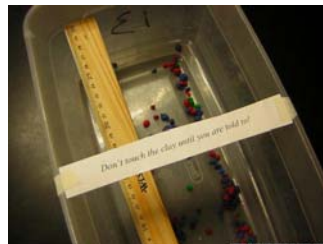
PowerPoint- “Making Clay Atoms” (see last page)

A sample of carbon-useful when talking about the carbon atom (optional)

## **Beforehand:**

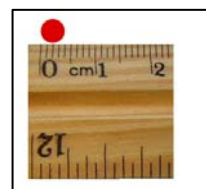
1. Set out the clay and rulers and run copies the day before. In the morning look over the notes and slides one last time. Relax and have fun along with your students. Remember- you’re only as effective as your plan.
2. Locate on what page a periodic table is in your textbook. This will be referred to during the lesson.
3. This activity can last between 25 minutes and 1 ½ class periods, depending on your needs and how you present it. If your goal is to get your students comfortable with atoms and for them have a solid understanding of them, be willing to sacrifice some time. If it takes you 2 days to get through this, that may inconvenience your schedule, but your students will be very well prepared for whatever else you do with atoms. Think of this lesson as an investment.
4. Go into this lesson prepared just for the major points you want to make. One thing you don’t want to do is overdo this lesson with too many comments and facts. Remember- it’s just an introduction to atoms. Keep it simple. When speaking today, be in “observation” mode. Notice all the little things. That’s where your students are at in their understanding, and they need that.

- Before the lesson, make some clay atoms of your own so that you know what your students will be thinking and experiencing. This will also help you see the whole lesson before you even present it. And keep some clay up front during the lesson, and build things right along with your students. Students are more willing to do things that you yourself do, and what you build gives you examples to hold up to students.
- Depending on how you distribute the clay, and on how impulsive your students are, you might want to put a sign on the clay for students not to touch it. That will keep the new class coming in from smashing all the red, blue, and green clay into a useless purple gob. The signs can be cut into strips and then taped across the top of a materials box.



### Procedure:

- If you are using the PowerPoint “Making Clay Atoms”, start it now. It will guide you and your students through the class period.
- As indicated by slide #2, have each student form 8 **red** clay particles, each with a diameter of 4 mm. These will be our protons. Why 4 mm and not 5 or 10? It could have been (and you can certainly change if you want), but the idea was to get students even focused more by choosing an “off” number that requires more attention.



Tell students to make the first red particle and size it with the ruler, and then make 7 more “about as big”. Exactness would be nice, but it’s not essential. Watch students- sometimes they misunderstand and think the *group* needs 8 red particles, which is not true. Each *person* needs 8 red protons of their own. Walk around the room with a 4mm proton in your hand that you’ve made and let them see it.

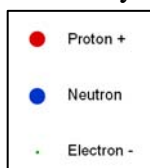
- Caution students about keeping their red-stained hands away from their clothing, especially those wearing white. Reassure them that they’ll have time to wash hands later.
- Advance the PowerPoint slide and have each student form 8 **blue** clay particles that are also about 4mm in diameter. These will be our neutrons. “Blue” and “neu”-tron sort of rhyme, which will help everyone remember what’s what.
- Then have each student form 8 **green** specks they can barely see. These will be electrons. Why specks? Electrons are much smaller than protons and neutrons<sup>\*1</sup>. After students have made a couple of electrons and are wondering about the size for themselves, say to them:

“Students, we’re use clay today to make atoms. Right now, most of the information you know about them is memorized. But if I asked you to

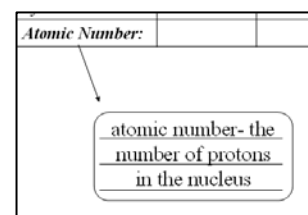
visualize one, most of you couldn't. That will all change very soon. In just a few minutes you'll be making atoms. Then it will all make sense and be no big deal.

It may seem like all we've done today is play with clay, but you've already learned some important things. 10 minutes ago most of you couldn't tell me the 3 parts of an atom. Now you can. You also know their relative sizes. And you thought we were just playing!"

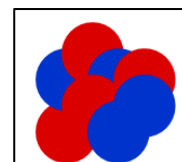
6. When everyone is finished making their protons, neutrons, and electrons have students locate the key in the lower-left portion of the handout. Tell them to put one of the red clay particles next to "Proton +", a blue one next to "Neutron", and a green one next to "Electron -". There's now 7 of each left.



7. Advance the slides until you come to where it explains atomic number. Have students write on the lines coming off Atomic Number- "**the number of protons in the nucleus**". You could have printed this on the paper they got, but by writing it they're paying more attention, and they will remember it better now. Now we're ready to build some atoms!



8. Ask how many of each kind of particle they still have. (7- we made 8, but put one of each in the key)
9. Tell them to *lightly* press 6 red protons and 6 blue neutrons together into a cluster, and set that on the black dot in the center of the handout. Hold your 6 proton, 6 neutron nucleus up so they can all see it. All you want is for the little particles to just stick. Say:



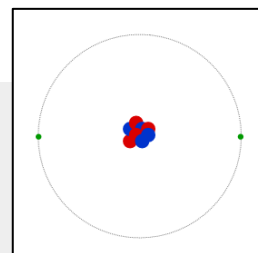
"This is a nucleus. It doesn't look very scary, does it? What two particles are there in a nucleus? (protons and neutrons)  
Just protons and neutrons. Good. That's it. That's all there is.  
Now, the *number* of protons and neutrons can change. And later, we'll have more than and less than 6 protons, but the important thing for you to remember right now is that the nucleus is made of protons and neutrons.

Do you notice about how the *number* of protons and neutrons are compared to each other? (they're the same)  
And that will also be true most of the time. You have 6 protons and 6 neutrons, right? (yes)  
Element number 9, fluorine, has 9 protons and 9 neutrons in its nucleus. And it's the same with element 99- 99 protons, 99 electrons.

Now let's put electrons on. Everyone look at your green specks, if you can find them. How many do you still have? (7)  
And how many do you think we're going to put around our nucleus, which, don't forget, has 6 protons and 6 neutrons?" (6)

10. Have students begin putting electrons on.

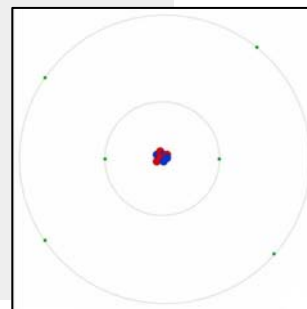
“Very good. Now, notice there are two rings, or energy levels, around the nucleus on your handout. Would you guess we’ll put electrons on the inner or outer one first? (inner). Good job!



I’m going to tell you something special about these so-called ‘inner electrons.’ It seems the first energy level can only hold 2. Go ahead and put those on. Hmm... you started with 6. Then we put two on the first level. Where will the other 4 go? (on the second level)”

11. Walk around the room and look for students who do not have this atom correctly made. If they don’t get it now, they’ll only get more frustrated as you go on.

“Ok, there is something amazing I’d like to tell you about electrons...so amazing that you won’t believe it. It has to do with where they’re located. You’ve probably heard that electrons “spin” or “fly” around the nucleus. But do you know how far away from it they are? Let’s assume your nucleus is actual size. If that were so, you wouldn’t even encounter the very first electron for about 1/2 mile. Not only are they very small, they’re very far away.”\*<sup>2</sup>



12. Pause to allow this to sink in, and to wait for any comments/questions. The questions students ask usually lead to much more than what you plan on saying.

“Look again at your nucleus. It’s here, and those teeny tiny electrons are a half-mile away...and THAT’S ALL THERE IS! And since everything is made of atoms, and all atoms are made of protons, neutrons, and electrons, everything is like this!

Everyone hold up your hand and look closely at it. Are you here? Do you take up space? Then you’re made of atoms. Therefore you are... mostly empty space! Welcome to the bizarre world of nuclear physics.\*<sup>3</sup>

“Tired? We still haven’t finished our first atom. Open your books to page \_\_\_\_\_ where you’ll find a periodic table, and let’s see who can be first to identify the atom you’ve created. (carbon)  
Suzie, how did you know that? (its atomic number is 6. And atomic number is the number of protons in the nucleus).  
Very good. Let’s record that information in column one of the table in the upper-left. Our first one is done. Good job everyone.”

Insert Periodic  
Table page number

13. Tell students to now pick up and hold the nucleus of carbon in their hand and add 1 red proton to the nucleus.

“When you did that, it may not have seemed like a big deal, but you just changed the whole identity of your atom. You can no longer call that a nucleus of carbon. What is it now? (nitrogen)

Good! How did you know that? (nitrogen is atomic number 7, and my nucleus has 7 protons in it)

One small change had a big effect, didn't it? Let's do that again- pluck that proton back off- it's carbon again. Put it on- nitrogen. Carbon. Nitrogen. All because of 1 little proton. Pluck that proton back off so you have 6 again. Now look up here at what I'm holding (*hold up carbon sample; if you don't have any, refer to pencil graphite*). This is what carbon looks like. If we could shrink you to the size of an atom, you would walk around in this and every nuclei would have 6 protons. And all hundred billion trillion of them are all carbon, so they're all identical!

	I.	II.
Name:	Carbon	
Symbol:	C	
Atomic Number:	6	

Let's go back to the nitrogen atom.

Put that proton back on. What else do we need to do to complete it? (add one neutron and electron)\*4

Ok, do that then. 7 protons, 7 neutrons in the nucleus, and 7 electrons. How are those electrons arranged? (2 up close, and then 5 on the second ring)

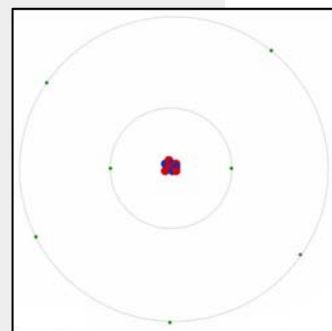
Good, you remembered. Go ahead and put all that on your paper.

Ready for something really bizarre? How many protons are in its nucleus now? (7).

And what element is atomic number 7? (nitrogen)

You know what carbon looks like- a black, messy powder. Does anyone know what nitrogen looks like? (no)

You're breathing it in right now. The air you're breathing is about 80% nitrogen. Nitrogen, atomic number 7, is an invisible gas.\*5 So if you have 6 protons in your nucleus you look like this (*hold up carbon sample*), and if you have 7 you are an invisible gas. Amazing what a difference 1 little proton can make, isn't it?\*"6



14. Record the information for nitrogen in column II.
15. Once you've filled in column II for nitrogen, notice the little black number in the lower-right corner, just above the Interactive Science Teacher logo. That tells you the atomic number of the atom on the next slide, in case you want to have them make it first before showing it.
16. Move onto the next atom:

“Now I’m going to try and trick you. I think you’re starting to catch on, so let’s see if you can handle this. I’m going to name an atom, and I want you then to make it for me. Ready? Make me an atom of...um, lithium!”

17. Give students time to make the atom.

“Lithium<sup>\*7</sup> is atomic number... (3)  
Meaning, it has 3 protons, so it also has 3 neutrons and 3 electrons. The neutrons were easy to figure out.. But where are your 3 electrons? You lost 4 electrons in going from nitrogen to lithium.  
Do you think a nucleus would hold more tightly onto inner or outer electrons? (inner). So it will lose outer electrons first?  
You’re right! And that’s because with them further away, they’re not holding on as tightly? So keep 2 electrons in that first energy level, and now 1 is in the outer, all by itself.”<sup>\*8</sup>

18. Fill in column III for lithium.

19. Now that students are hopefully catching on, see if they can create any atom you choose:

“I bet no one in here can figure out how to make an atom of *Helium*. It’s just way too hard. You can’t do it, so don’t even try. (*Find a number of students doing it right and tell them ‘Good job’, and watch them beam!*)”

20. When everyone gets it, fill in column IV for helium.

“Have you noticed something we pointed out earlier today- that the number of protons, neutrons, and electrons always match? And you’re also starting to catch onto the fact that as you add and take away protons you’re changing the whole identity of the atom. A proton is a proton is a proton- meaning, a proton in copper is the exact same as a proton in hydrogen or lead. So, elements are defined as having a certain number of them. Oxygen will always have 8. And fluorine 9.

Look around this room. Name some of the things you see. (table, glass, chalkboard, pencil, metal). Why are some things wood, some concrete, and some a gas? Or better yet, back to you- you’re made of atoms, which we know are protons, neutrons, and electrons. But so is the carpet in here. What makes carpet carpet, and you you? This reason is right in front of you on your handout, and in our discussion today. When the number of protons change so does the color, behavior, and chemical properties. Remember what happens when you add 1 proton to carbon?

It all comes down to numbers.”

21. The remaining slides are there for you to either keep going through today or use tomorrow as review.

22. Have students separate their red, blue, and green particles and put them into their group container so that next hour won't have to take the time and make the mess in creating them.
23. Leave 5 minutes for students to wash hands if needed.

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

- \*<sup>1</sup> Just how small are electrons compared with protons and neutrons, you ask? They are 1,830 times less massive. To help your students grasp this ask if anyone would like to make their electrons to scale. Restated- to make their electrons so small that 1,830 of them would fit side-by-side across the inside of a proton.
- \*<sup>2</sup> According to the Big Bang theory everything in the universe originally fit in a space about  $\frac{3}{4}$  of an inch. The temperature and pressure was unimaginable. But in the context of this lesson this makes some sense. If all the empty space in atoms were compressed, such a scenario is conceivable.
- \*<sup>3</sup> From those students who are paying attention and understand what you're talking about, you're bound to get the question- so how do things stay together? Or the classic- why am I not falling through my chair? Two points:
  - Think of an electric fan. When the blades spin, they move through the empty space. If they could move fast enough, it would be as if they were filling the entire space all at once. Electrons, we think, are like that except they don't really fly or rotate around the nucleus. They move so quickly (and mysteriously) that they fill in the entire space of the atom simultaneously. They are everywhere at once!
  - So why don't you fall through your chair if both you and it are more than 99% empty space? The negative electrical charges between you and your chair are repelling each other so forcefully that (get ready to lose most of your students here) you're not actually touching the chair, but levitating just above it.
- \*<sup>4</sup> Isotope- when a student has a different number of protons than neutrons in the nucleus, introduce them to the term "isotope". Compare the effects of adding and taking away protons (it become another element) with adding and taking away neutrons (it remains the same element).
- \*<sup>5</sup> Yes, most of what we breathe in is nitrogen. But ask what would happen if nitrogen was all they were allowed to breathe. It wouldn't be poisonous (78% of what you breathe in is Nitrogen), but it wouldn't sustain you for long either. You need OXYGEN, of course. And what separates nitrogen from oxygen is, again, one little proton (and neutron and electron).
- \*<sup>6</sup> 1 little proton- A proton is a proton is a proton. There's no difference between the protons in carbon and those in nitrogen. Just the *number* of them. 1 little proton is literally the only difference between any two elements next to

each other on the periodic table. Look on the periodic table and find examples of how much change that 1 little proton can make- show students more samples: magnesium and aluminum; copper and zinc.

- **\*7** Dangerous Atoms- if the atoms students make turn out to be an alkali metal (anything in group 1) or a radioactive element have some fun telling them how dangerous it is. Real lithium would burn their skin. It's also a medicine used to treat mental illnesses and migraines (and it has some nasty side-effects).
- **\*8** The reason why- all group 1 alkali metals are volatile and unstable. If your students created an atom of each one they'd notice that they all have just one electron in their outer level. And the higher the element number, the further out that lonely outer electron is. Being further from the nucleus, it's given up more easily. That's why the group 1 alkali metals become progressively more explosive. You could also swing over to the other side of the periodic table and demonstrate why the noble gases are so "noble".

**Teacher Quick Notes- "Clay Atoms- Taming Our Fear Of The Invisible"**

Materials per student:  
 Red, blue, and green clay (or any 3 colors of your choice)  
 1-ruler  
 1-handout- Student Handout- "Clay Atoms" (located in the Resources folder)  
 PowerPoint- "Day 1-Making Clay Atoms" (also in the Resources folder)

Procedure:

1. Begin the "Making Clay Atoms" PowerPoint.
2. Have each student form 8 red clay particles each with a diameter of 4 mm.
3. Have each student form 8 blue clay particles about as big as the reds.
4. Have each student form 8 green clay "specks" that they can barely see.
5. Have students put a red clay particle next to the word "Proton +", a blue one next to "Neutron", and a green one next to "Electron -".
6. Tell them to gently press the 6 red protons and 6 blue neutrons together into a cluster and set that on the dot in the center of the handout. Put 6 electrons around the nucleus- 2 on the first ring, 4 on the second.
7. Walk around the room and look for students who do not have this atom correctly made.
8. Fill in column 1 on the chart for carbon.
9. Tell students to add 1 red proton to the nucleus, then a blue and green also. Identify what it is (nitrogen) and fill in column 2.
10. Create 2 more atoms and fill in the information for them in their columns.

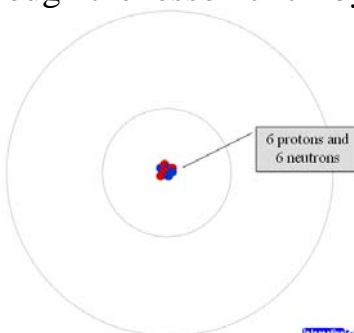
- Make more- make 10 or 20 more protons. Making those elements will reinforce that, yes, further on down the periodic table it just continues what was started earlier. Just more. Make seaborgium, element number 106.

- Franken-nucleus- have students grab every available proton and neutron and see what nucleus they end up with. No one will have any idea what element it is until they've put the last proton on.

Come back and visit [InteractiveScienceTeacher.com](http://InteractiveScienceTeacher.com) to upgrade this lesson with:

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

1. Make 8 red protons, each about 4 mm in diameter.
2. Make 8 blue neutrons, each about 4 mm in diameter.
3. Make 8 green electron specks.



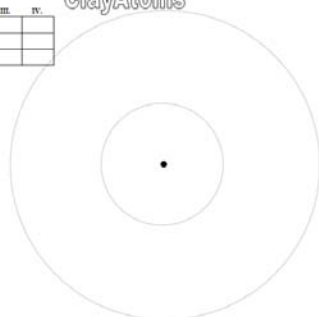
	I.	II.	III.	IV.
Name:				
Symbol:				
Atomic Number:				

atomic number- the number of protons in the nucleus

# Student Handout

## ClayAtoms

	I	II	III	IV
Name				
Element				
Atomic Number				

Proton +
Neutron -
Electron -

## QuickNotes

### Teacher *Quick Notes*- "Clay Atoms- Taming Our Fear Of The Invisible"

#### Materials per student:

- Red, blue, and green clay (or any 3 colors of your choice)
- 1-titler
- 1-handout- Student Handout-"Clay Atoms" (located in the *Resource* folder)
- PowerPoint- "Day 1-Making Clay Atoms" (also in the *Resource* folder)

#### Procedure:

1. Begin the "Making Clay Atoms" PowerPoint.
2. Have each student form 6 red clay particles each with a diameter of 4 mm.
3. Have each student form 6 blue clay particles about as big as the reds.
4. Have each student form 6 green clay "specks" that they can barely see.
5. Have students put a red clay particle next to the word "Proton +", a blue one next to "Neutron", and a green one next to "Electron -".
6. Tell them to gently press the 6 red protons and 6 blue neutrons together into a cluster and set that on the dot in the center of the handout. Put 6 electrons around the nucleus- 2 on the first ring, 4 on the second.
7. Walk around the room and look for students who do not have this atom correctly made.
8. Fill in column 1 on the chart for carbon.
9. Tell students to add 1 red proton to the nucleus, then a blue and green also. Identify what it is (nitrogen) and fill in column 2.
10. Create 2 more atoms and fill in the information for them in their columns.