Build A Comet

Step 1: **Ask your audience Questions**, for example:

What is a comet?

What does a comet look like?

If you were going to draw a comet, what would your drawing look like?

If you were going to look for a comet, where would you look?

Space is big, so where in space would you look? Near the sun, or far away?

What is the farthest away planet in our solar system that you can think of?

What is it like there?

Use these questions to find out what level of background knowledge your audience already has about comets. If they don't know the answer to a question, try an easier, or more leading question (For example, if they don't know where comets might live, get them to name some planets, and talk about which planets you can find ocmets near).

The goal at the end of asking these questions is to get your audience to talk about the structure of comets (they look like they have long tails), and realize that comets mostly live very far out in our solar system, near Pluto and beyond, where it is very cold!

Now, line a bowl with a leakproof plastic bag, get your spoon, recipe, and ingredients ready, and let's make a comet!

Step 2: **What are Comets made out of?**

Every time your audience suggests a correct ingredient, have them help you add it to your comet bowl.

If your audience is stumped, start by telling them that comets formed at the same time everything else in the solar system did. They are the leftover materials that didn't make it into the sun, and didn't get to become part of a planet. However, they are still made out of many of the same materials you find in the planets. What sorts of things do you find on earth? (This can usually prompt your audience to mention **dirt** and **water**).

But what else do you add? We have to represent some of the other planets as well. What are some of the planets other than earth? Once your audience mentions a gas giant planet, ask them what that planet is like, and what it is made out of. Jupiter, for example, has lots of clouds in its atmosphere, but those clouds are not made out of water like ours. They are actually made out of **ammonia** (the stuff your parents use to clean the bathroom) or methane (that's cow farts, and we don't add that to our comet).

If you are dealing with older students, you can ask them what the sun is made out of. You can then discuss how hydrogen is the #1 element in our universe, and the #1 element in our solar system-- the Sun, which is the biggest thing in the solar system by far, is primarily made of hydrogen gas. Then ask them, what is **water** made out of? If you have high school students, then they should also know what **ammonia** is made out of-- nitrogen and THREE hydrogens. So, we are adding a lot of hydrogen to our comet.

For the second to last ingredient, I usually tell a story. Back in the day, (a few billion years ago) when the earth was forming, it was very hot and molten, and as a result, any water on it mostly evaporated. Luckily for us, as the earth cooled, it also went through a period of time where it was CONSTANTLY being hit by things-- asteroids, other planets, and most importantly comets. We think these comets were the main source of our **water**. So, if you go for a swim, or have a glass of water, you should thank a comet! But, that is not all! We also think that these comets may have also brought some of the ingredients necessary for life to start on our planet! What ingredients are necessary for your life? What did you eat for breakfast? (Try to get kids to mention sugar, it shouldn't be too hard!!) We have actually taken lots of pictures of comets and sent spacecraft to visit comets, and found out that comets have in them some complicate molecules, like **sugar**, that could help life on our planet get started!

Step 3: **Why doesn't this look like a comet? (The Dry Ice part)**

At this point, you should have a bowl of dirty looking water. You can tell your audience that you have added everything that goes into a comet. So, here is our comet! They will be disbelieving.

Now is a good time to go back to the first questions you asked, about what a comet looks like. You can ask the students:

> Does this look like a comet?
> What is wrong with it? (Where is its tail? Why isn't it round/hard?)
> How can we make this comet hard?

Remind your audience where they said you could find comets (near Pluto) and what it is like there (Cold!). So, as they will suggest, the best way to make our comet hard and realistic is to freeze it! However, we don't just have to get it as cold as our freezer, we have to get it as cold as space. What will we use to do this? Dry Ice!

SAFETY PRECAUTIONS

Dry Ice, or solid Carbon Dioxide, has a temperature of -109^{o} F. If it makes direct contact with your skin, it will cause severe frostbite. The remaining steps need to be performed with gloves (and goggles, if you are breaking the dry ice into smaller pieces). Any students who are helping you with the following steps need to wear gloves as well.

Add the dry ice to the bowl and stir. After about a scant minute of stirring. you need to lift the bag out of the bowl, and with the comet still inside of its bag, start pressing the comet together, like you would a snowball. The more pressure you apply, the more successful your comet will be. Having the dry ice broken into dime-sized chunks (but not powdered) will also increase the likelihood that your comet will be successful.

Step 4: **What to say while you make the comet**

While you are doing this, there are several things you can discuss

For older/chemistry audiences:

> Why is dry ice called dry ice? (It never becomes a liquid)
> What do you call it when a substances goes straight from being solid to a gas? (sublimation).
> Do you know any other substances that do this? (iodine)
> What is the opposite of sublimation? (When substance goes from a gas to a solid, it is called deposition, and this is the same process that makes snow and frost!)

For intermediate audiences:

> The dry ice is freezing our comet together. You can feel the vapor coming out of the bowl (it is ok to do this without gloves)-- it still feels cold, because just a moment ago this carbon dioxide had a temperature of -109 degrees!
>
> The dry ice is turning back into carbon dioxide. We are taking our comet from the cold of space, and bringing it close to the sun, and it is making a huge tail!
>
> Carbon dioxide gas is heavier than other gases in the air, so you can see it pouring out of the bowl, and running along the table and falling on the ground.
>
> However, carbon dioxide is actually an invisible gas, so what you are actually seeing is water vapor-- the water in the air has gotten cold and condensed, and turned into tiny droplets. We are actually making a cloud, right here on the table!

For audiences of any age:

> What we are doing right now is the same thing that happened as our solar system was forming, and making the sun, planets, asteroids and comets. The who solar system started as a big cloud of gas. That cloud collapsed, and got smaller, and packed closer and closer together. As this happened, most of the gas went into the center to make the sun. But the gas and dust grains that didn't also kept getting closer and closer together, until they started running into each other. Sometimes when to grains hit, they stick together and make a bigger grain. Those pieces collide again and get bigger, like a snowball. These rocks and snowballs hit other rocks and snowballs, and start building up bigger and bigger objects: meteoroids, asteroids, planetoids, and finally planets like the earth we are standing on. And the leftover pieces from this became the comets!

Step 5: **The Wrap-up**

Now that you have made a comet, the students can examine it. As long as there are no bright white pieces of dry ice exposed, it is safe for students to touch it. The surface will not be significantly colder than normal water ice (which has encased the pieces of dry ice).

You can describe how the size of this comet compares to real comets. Ask them how big they think a real comet is. The sizes of comets can vary from the size of their school, to the size of a college campus or city (The nucleus of Halley's comet is about 10 miles across, and the nucleus of comet Hale Bopp is thought to be about 40 miles across!).

A great culmination to this activity is to smash the comet. (Ask the students, for example, what happened to the dinosaurs).

ADDITIONAL SAFETY PRECAUTIONS

Smashing the comet will expose pieces of dry ice, which will cause severe frostbite if it makes direct contact with the skin. If you do choose to smash the comet, you must require that students udo not use their bare hands (for example, use a folded piece of paper towel) to pick up the comet pieces. You should also make sure that no pieces of dry ice remain behind where someone could accidentally come into contact with them.

Step 6: **Smash the comet**

With the students standing at a safe distance, have them give you a countdown, smash the comet, and then allow them to retrieve pieces.