Estimating the Mass of Solids Mixed with Water

What do we need to measure when plants grow?

You will be doing an investigation of plant growth. Our goal will be to explain how plants grow by answering the Three Questions:

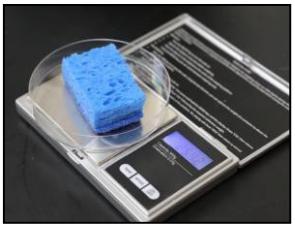
- **The Movement Question:** Where are atoms moving from and where are atoms going to when plants grow?
- **The Carbon Question:** What molecules are carbon atoms in and how are atoms rearranged into new molecules when plants grow?
- **The Energy Question:** How is energy changing from one form to another when plants grow?

In order to answer the Three Questions you will need to *measure* how much your plants are growing. But how can you measure plant growth?

This is a really hard question. When we talk about plants growing, we often mean that they grow taller or stronger, or they have more leaves. But measuring height and strength or counting leaves doesn't really help us answer the Three Questions. The "Connecting Atoms to Evidence" column of the Three Questions poster tells us what we really need to measure: ***When materials change mass, atoms are moving****.* So to answer the Movement Question, we need to measure the ***mass*** of a growing plant.

But measuring how a plant changes mass when it grows is hard, especially if we are interested in *carbon* atoms. If we are interested in carbon atoms, then we don't really want to measure water—H_2O. So let's think about what we REALLY want to measure when plants grow. Think about these situations:

- A dry sponge weighs 10 grams, but that same sponge weighs 85 grams when it is wet.
- If a girl drinks a half liter of water, she will weigh 500 grams more (about a pound) after drinking the water.
- If you add a half liter of water to a potted plant, then a balance will show that it weighs 500 grams more.



The sponge, the girl, and the potted plant didn't really *grow,* even though they added mass. Measuring plant growth can be hard because there's so much water in and around growing plants—water in the soil, water in the air, water in and moving through the plants. So what do we really mean by *grow,* and how could we measure growth?

Although we might say that the sponge, the girl and the plant are "solids," they are actually *mixtures* of solids and water. When we say that a plant or animal *grows,* we don't mean that it is just adding water. We mean that it is adding solid mass, or what scientists call *dry mass.*

How can we measure the dry mass of solids mixed with water?

In your investigations you will want to figure out where the **solid** matter in plants comes from. It's hard, though, because the soil and the plants and even the water are mixtures of water with different solid materials. *How can we figure out the mass of just the solids?*

There are two ways to do this:

1. Measure the mass of the solids before you make the mixture.
2. Measure the mass of the solids after you take the water out of the mixture.

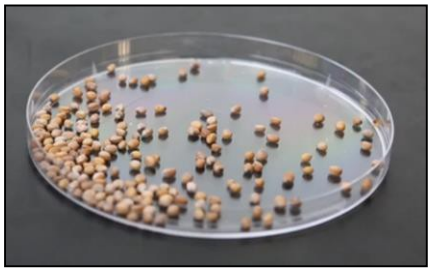
In your plant growth experiments, you will need to figure out the mass of the solids in four different solid-water mixtures:

- The plant gel crystals with water added
- The radish seeds that you plant
- The water with Ionic Grow fertilizer that you will use to water the plants
- The growing radish plants

You can use one of these methods above to figure out how much solid is in each of these mixtures. If you don't have time to do it yourself, we have already done these measurements, and we will report our results.

Gel crystals with water added. The gel crystals are made of a special material that absorbs many times its own weight in water. So when we put 1 gram of crystals in water and left them there for a few hours, we found that the hydrated gel (the crystals after they absorbed the water) weighed 70 grams! So we can use these numbers to figure out the percentage of water and solids in the hydrated crystals:

- Percentage of solid = (1 gram of solid ÷71 grams of mixture) x 100% = 1.4% solid
- Percentage of water = 100% - 1.4% = 98.6% water



Radish seeds. We put 10 grams of radish seeds in a 200 degree oven overnight to evaporate all the water from the seeds. After this they weighed 8.6 grams. So we can use these numbers to figure out the percentage of water and solids in the radish seeds:

- Percentage of solid = (8.6 grams of solid ÷10 grams of mixture) x 100% = 86% solid
- Percentage of water = 100% - 86% = 14% water

Water with Ionic Grow fertilizer. The water you use for the plants will have 4 teaspoons of Ionic Grow fertilizer added to each gallon of water. We evaporated the water from 4 teaspoons (17 grams) of Ionic Grow fertilizer and found that it had 0.6 grams of dry mass. A gallon of water weighs about 3,800 grams. So we can use these numbers to figure out the percentage of water and solids in the hydrated crystals:

- Percentage of solid = (0.6 gram of solid ÷3800 grams of mixture) x 100% = 0.02% solid
- Percentage of water = 100% - 0.02% = 99.8% water

Radish plants. We put a radish plant that weighed 10 grams in a 200 degree oven overnight to evaporate all the water from the plant. After this it weighed 0.7 grams. So we can use these numbers to figure out the percentage of water and solids in the radish plant:

- Percentage of solid = (0.7 grams of solid ÷10 grams of mixture) x 100% = 7% solid
- Percentage of water = 100% - 7% = 93% water

How can we use percentages to estimate the mass of solids in a mixture?

If you know the total mass of a solid-water mixture and the percent of the mixture that is solid, then you can make a pretty good estimate of the mass of the solid part of the mixture.

- (Total mass of the mixture x % solid) ÷100% = Mass of solid in the mixture

You can do this yourself when you plant your radish seeds, estimating how much solid mass there is in the hydrated crystals and radish seeds that you plant. You can also estimate how much solid (a tiny amount) is in the water you use to water your plants, and how much solid is in the gel and radish plants at the end of your investigation. Try it, and record the answers on your worksheets!

Too small to measure? The scales can measure very small amount of mass—as small as 0.01 grams. But some of the masses you estimate will be even smaller than that—such as 0.008 grams or 0.0035 grams. Since these masses are too small to measure, they are not enough different from 0 grams to include them in our calculations. Whenever an estimate is less than 0.01 grams, we will call it “too small to measure.”

Remember, we are measuring all of these solids because we are trying to come up with an explanation for how plants grow, and we need to calculate the mass of the dry plant before growth and later on during growth, as well as how many solids we’ve added into the system, in order to figure out where the plant’s mass is coming from.

How can you check the accuracy of your estimates?

Solid water mixtures don’t always have the same percentage of solid, so your gel or radish plants might have a slightly different percentage of solids from the ones we measured. But you can check to see how accurate your estimates are. If you have time, dry out the mixtures and measure the masses of the solids that are left. You can compare your results to the results of your classmates to see how close the estimates actually are!