Remote Learning Packet

NB: Please keep all work produced this week. You will be submitting this packet via Google Classroom. Some exercises may be directly completed on Google Classroom rather than on this packet.

April 20 - 24, 2020

Course: Nature of Science

Teacher(s): Mr. Brandolini (david.brandolini@greatheartsirving.org); Mr. Mooney (sean.mooney@greatheartsirving.org); Mr. Schuler (david.schuler@greatheartsirving.org)

Weekly Plan:

Monday, April 20

- ☐ Read Supplementary Reading on Anaxagoras
- ☐ Read p. 98 in *Nature of Science*
- ☐ Complete questions on Anaxagoras, preferably directly on Google Classroom

Tuesday, April 21

- ☐ Read Supplementary Reading on Democritus
- ☐ Read p. 100 in *Nature of Science*
- ☐ Complete questions on Democritus, preferably directly on Google Classroom

Wednesday, April 22

- ☐ Complete exercise comparing the Pre-Socratic natural scientists in this packet

Thursday, April 23

- ☐ Read Supplementary Reading on Mass & Weight
- ☐ Complete worksheet, preferably directly on Google Classroom

Friday, April 24

- ☐ Read Introduction to Volume
- ☐ Complete at-home Volume Measuring Exercise in this packet

Statement of Academic Honesty

I affirm that the work completed from the packet is mine and that I completed it independently.
Student Signature: _____

I affirm that, to the best of my knowledge, my child completed this work independently
Parent Signature: _____

Chapter Ten: Anaxagoras (This is the Reading for Monday April 20)

Parmenides and Empedocles

Recall the last two natural scientists we met: Parmenides and Empedocles. Here is what they said:

> Parmenides: Something cannot come-to-be from nothing. If something exists, then it must have *always* existed. Otherwise, it would have to go from non-existence to existence, which does not make any sense. Therefore, do not believe what your senses tell you—change and motion are impossible!
>
> Empedocles: Yes, you are right Parmenides: something cannot come-to-be from nothing. If something exists, it must have always existed. But our senses are not deceiving us: change and motion really *do* happen, just not in the way that we thought. When a new chicken comes into existence, for example, it is not a "new" creation—something coming from nothing—but rather a new *combination* of elements that have always existed and always will exist (i.e. earth, air, fire, and water).

A New Scientist to Challenge Parmenides

As you can see, Empedocles' main goal was to accept that Parmenides was *right* about the impossibility of something coming from nothing, but show that he was *wrong* about the impossibility of change. Today we will meet another natural scientist, who had that very same mission.

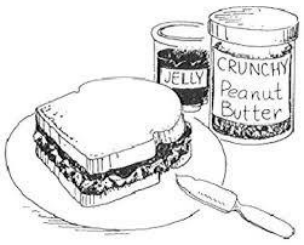
You might have thought we reached our limit of natural scientists whose name begins with "Anax-". Well, you were wrong—meet *Anaxagora*s (an-ax-AG-or-us)! He lived around the same time as Empedocles, and—as we said—shared a similar goal.

Nutrition

Like most Pre-Socratics, Anaxagoras came up with his best ideas when he was thinking about *change*. One type of change struck him as especially remarkable, and that was a type of change called *nutrition*: the process by which living things take in nourishment and grow.

Let's look at an example of nutrition that I know you'll be familiar with—your *own* nutrition!

Do you remember how small you used to be? Think about that shelf you couldn't reach, or that bike where you couldn't quite reach the pedals—and now you can! And, of course, you used to be even smaller than you can remember—we know from our study of embryology that, at the very beginning of your life, you used to be one tiny little cell. One tiny cell—and now look at you! Where did all the new material come from?



The answer is, of course, from the food that you have eaten! This is one reason your parents are always insisting that you eat your dinner—you need it in order to grow. But isn't it strange? Take a moment right now to look at your hand, your arm, your leg—all of that skin, flesh, and bone is actually made from peanut butter and jelly sandwiches and the like. Could it be true?

How do we explain this? Even if I look *really closely*, I do not see anything in a PB&J that looks anything like what my body is made of.

Anaxagoras' Solution

To see how Anaxagoras thought about nutrition, let's take a moment to consider the following imaginary scenario:

Imagine you find a very interesting machine where you could put paper into one end, and it churns it up and then spits out a metal paper clip on the other side. Your first question, after you got over your surprise, would probably be: "Where did the *metal* come from?" It would seem impossible for a metal paper clip to be made from a piece of paper, unless somehow there was metal *already in* the paper.

Kind of a strange example, to be sure—but I hope you see the connection! Anaxagoras saw nutrition and growth, and he thought something very similar:

> *Where did the flesh and blood come from? It seems impossible for flesh and blood to be made from food, unless somehow there was flesh and blood in the food to begin with.*

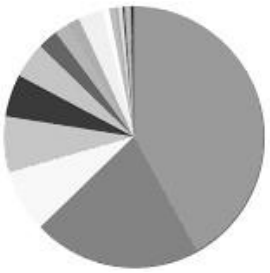
And that is just what he concluded: in all food—a piece of bread, for example—there were actually little bits of all the materials that you need to make up your body, such as skin, muscle, bone, hair, and so on. We only do not see all of these things because they are so very small.

Everything in Everything – "portions" and "seeds"

And, says Anaxagoras, this is not only true of bread or peanut butter and jelly! It is true about *everything*! Every single material that you look at has a little bit of every other kind of material in it.

Here's how it works. Everything in the universe is made of tiny little packets of material called *"seeds."* Every seed contained little bits—called *"portions"*—of every single kind of material in the universe. Literally, *any* kind of material you can think of—water, salt, oil, wood, metal, flesh, blood, and so on—is contained in infinitely small little portions in the seed. Also, every quality and its opposite—wet and dry, hot and cold, bright and dark—was also contained in small portions in every seed. The appearance of a particular seed is based on which material and which qualities are most abundant in that seed.

Take a look at the skin on your hand. Since it is material, Anaxagoras would say that it is composed of tiny little "seeds"—too small to see individually. And each of these "seeds" contains within it every kind of material in the whole universe. That's right—water, metal, sand, wood—you name it! It is all contained in every little part (or "seed") of your skin. The reason that these "seeds" look like skin is that, although they contain every kind of material, they contain more skin in them than anything else.



This is a seed of hair, because its largest portion is hair material.

You might think of each seed like a little pie chart, like the one depicted on the right. There are infinitely many different materials and opposites, but only very small portions of them. The portion that is the largest determines what the seed looks like. If, for example, the largest portion in this seed was hair, then it would appear to be hair.

Infinite Elements – A Solution to Parmenides

This is why Anaxagoras said "*all things were in the whole*," and "*in everything there is a portion of everything*." He means that in every little bit of matter (a "seed"), there are infinitely many little portions of every kind of substance that exists.

This theory helped explain how change is possible without breaking Parmenides' rule. Parmenides said that something cannot come from nothing—if something exists now, it must have *always* existed. In Anaxagoras' theory, all the materials in the universe *already* existed in the little seeds, and have always existed, unchanged, from the beginning. When it *appears* to us that something new has come to be, what has really happened is that the already-existing portions have been mixed together in a new way, or have been separated apart. That is why he said:

> *"The Greeks are wrong to accept coming to be and perishing, for nothing comes to be, nor does it perish, but they are mixed together from things that are and they are separated apart."*

When we say that a new apple has come to be, for example, it has not *actually* come to be, as if from nothing. It's just that the apple material, which *already existed* in every other kind of material, was separated out from those things and came together to form an apple.

This answers many of our questions from earlier, in chapter two. How did the grass turn into a cow? The grass must have actually contained—in small, unnoticeable portions—the flesh and hair that we see when we look at a cow. When the cow at the grass, its digestive system took out all the flesh, bone, and hair portions that it needed, and let the rest of the portions go back to the grass.

"Mind"

In some sense, then, Anaxagoras' theory of seeds, each containing portions of everything, explains how change is possible. There is a problem here though. Although it explains how one material can appear to change into another material, it does not explain why it happens in any kind of <u>orderly</u> way.

Think back to the machine that turned paper into a paperclip. Anaxagoras would explain that the paper contained portions of metal in it. But even accepting this as true, how would you explain that it became a paper clip instead of a misshapen scrap of metal?

Similarly, even if grass really contains flesh and bone in it, how do you explain the fact that the flesh and blood is organized into a beautiful, living, breathing cow?

That is, *how do you explain that change happens in an <u>orderly</u> way*? Why is there <u>order</u> in the universe? Anaxagoras had an explanation for this as well. He knew that, wherever there is *order*, there must be something *intelligent* that put it in order[1]. For this reason, he says that all change and everything in the universe is governed by *Mind*.

[1] Your room, for example, does not become clean and organized randomly on its own. (Yes, unfortunately.) It takes an intelligent person to come in and put things in order.

About this Mind, he says:

> *"The rest have a portion of everything, but Mind is unlimited and self-ruled and is mixed with no thing, but is alone and by itself . . . For it is the finest of all things and the purest, and it has judgment about everything and the greatest power. And Mind rules all things that possess life . . . And Mind knew all things that are being mixed together and separated off and separated apart. And Mind set in order all things, whatever kinds of things were to be—whatever were and all that are now and whatever will be—and also this rotation in which now are rotating the stars and the sun and the moon . . .*

Like Empedocles' *Love* and *Strife*, it seems to be some kind of force or god-like power, that is separate from the materials of the world, but that causes them to change in the way that they do. It is different from Empedocles' Love and Strife, however, because, by calling it *Mind,* he is emphasizing the *order* and *intelligence* of this power.

Conclusion

Thus, nothing new ever really comes to be, because all of the materials have always been present in everything—"everything is in everything" as he says—from the very beginning. This is how Anaxagoras both upholds Parmenides' rule—that something cannot come to be from nothing—while explaining how change really does happen. He then goes even further, to explain why change results in an orderly universe, by saying that there is an intelligent and powerful being—called *Mind*—that is everywhere in the universe and oversees every change and is in charge of everything.

And so concludes our *second* attempt to explain how change is possible in spite of the fact that, as Parmenides tells us, something cannot come from nothing. In our next chapter, we will read of a third such attempt, by a brilliant natural scientist named Democritus.

Name: _____
Section & Course: _____
Teacher: _____
Date: _____

Anaxagoras – Worksheet for Monday April 20

****Remember to complete it online at the Google Classroom rather than on this sheet, if possible****

Anaxagoras – p. 98 in *Nature of Science*; pp. 2-5 in Supplementary Reading

1. Anaxagoras, like Empedocles, had the mission of
    a. Proving things come to be from nothing
    b. Proving Parmenides was right in his ideas
    c. Proving Parmendies was wrong about the impossibility of change
    d. Proving change was impossible

2. Like most Pre-Socratics, Anaxagoras thought carefully (and came up with his best ideas) about _____.

3. Anaxagoras thought carefully about a specific type of change called:
    a. Motion
    b. Nutrition
    c. Action
    d. Fire
    e. Rarefaction
    f. None of the above

4. Copy the definition of the term that was the answer to question 3:
    _____
    _____

5. A key claim of Anaxagoras' is that "everything is in everything". He says everything in the universe is made of tiny little packets of material called _____. These packets contain little bits, "portions", of every single kind of material in the universe.

6. If every material in the universe is in everything, what determines that something is a hair rather than something else like grass or jelly?
    a. "Mind"
    b. Whatever portion is a majority
    c. Whatever makes logical sense
    d. Random chance
    e. Whatever is the largest portion of that seed

7. A key problem with Anaxagoras' theory of how change is possible is that it does not explain how change happens in a/an _____ way.
    a. Healthy
    b. Helpful
    c. Direct
    d. Transformative
    e. None of the above

8. Anaxagoras actually does have a solution to this key problem (from question 7). He says that the order is provided by
    a. Mind
    b. Matter
    c. The Four Elements
    d. Love
    e. Strife

9. According to Anaxagoras, new things constantly come to be.
    a. True b. False

10. How does Anaxagoras' theory fit with Parmenides' rule that something cannot come from nothing? In other words, how does Anaxagoras' theory allow for things such as new-born chickens and growing children without saying that these things came from nothing?

_____

_____

_____

_____

11. How does Anaxagroas' theory show that change *is* real and possible? (Note: Remember, this disproves Parmenides, which was a goal of Anaxagoras'.)

_____

_____

_____

_____

Chapter Eleven: Democritus

Two Solutions to Parmenides

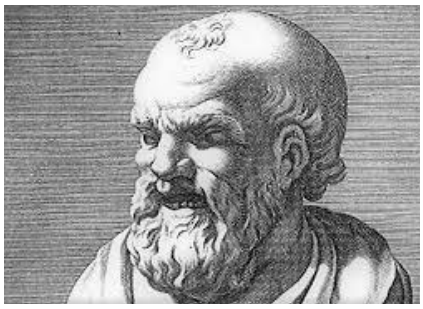
The efforts of our last two thinkers were directed towards explaining how change is possible despite the fact that something cannot come to be from nothing.

> Empedocles said that the only things that truly exist are the four elements—earth, air, fire, and water—and that they have always existed, and always will exist, and will never change. When we see things that *appear* to be changing—such as a plant growing up out of the ground—we are just witnessing the four elements coming together in new combinations.
>
> Anaxagoras said that every substance that exists right now has *always existed*, but that much of it is hidden in invisibly small portions in everything else. When we see things that appear to be changing—such as a new chicken being born and growing into an adult—we are really just witnessing the portions of chicken flesh and chicken bone and chicken feathers that already existed—and have *always* existed—in invisibly small portions in the chicken's food, being separated off and becoming visible in the living chicken.

Thus, both natural scientists agreed that certain substances had always existed, unchanged, since the beginning of the universe.

They disagreed, however, on what those substances were like, Empedocles saying that there were *only four* elements—earth, air, fire, and water—and Anaxagoras saying that there were *infinitely many* elements—wood, metal, sand, flesh, blood, hair, and so on—as many as there are substances that we see in the universe.

Democritus



After Anaxagoras, came a brilliant philosopher and natural scientist named Democritus (deh-MOCK-rit-us). Like Anaxagoras and Empedocles before him, he

> *agreed that certain elements have always existed,*

but

> *disagreed about what those elements are like.*

As you'll see, he had an ingenious idea about what these elements were like and how they accounted for everything we experience in the world.

Two Elements

Democritus says that there are *only two elements*—two things from which everything else in the universe is made. He called them "The Full" and "The Empty." The *Full* he describes as full, solid material. The *Empty*, as you might expect, is not full and solid, but entirely empty. That is, The Empty is nothingness itself—empty space, really.

Everything is made of these two things. The piece of paper you are reading from right now, for example, is made of solid material (The Full) and empty space (The Empty).

To understand how Democritus understood these two things going together, picture a Styrofoam ball. The Styrofoam is clearly made of some kind of solid stuff, but it has lots of empty space in it too. If you were to squeeze it, you could condense it into a smaller ball by filling in further all the empty space between the material.

In some ways, this should remind us of Anaximenes, who talked about the rare and the dense. Density and rarity, in Democritus' theory, is the result of how much of The Empty there is amidst The Full.

With these things in mind, let's look at the first passage from your textbook:

> *"Leucippus and his associate Democritus declare the full and the empty [void] to be the elements, calling the former "what is" and the other "what is not." Of these the one, "what is," is full and solid, the other, "what is not," is empty and rare . . .*

As you'll notice, in this passage, there are given two more names that Democritus used for The Full and The Empty, namely "What is" and "What is not."

But Why Does Every Substance Looks Different?

At this point, you may be saying to yourself, "I can see how everything is made of stuff and empty space…but the *same* stuff? *Everything*? If everything is made of the same stuff, what is that stuff, and why doesn't everything look the same?"

These are great questions, and I am glad you asked them! Democritus asked himself these very same questions, and these were his answers:

Atoms

He said that the material that everything is made of (that is, The Full, or "What Is") is a bunch of very small particles of matter—so small that they are invisible to the human eye—that have no qualities themselves, except for being full and solid, and having a particular shape (e.g smooth or pointy, or hooked).

They have **no** color, **no** hardness or softness, **no** odor or flavor, **no** anything! In some ways, these little pieces of matter should remind us of Anaximander's *indefinite*.

Futhermore, these little bits of matter were *unchangeable*. The way they are now is the way they have always been and always will be. (This satisfies Parmenides' requirement that something cannot come from nothing!) Since they cannot change, they cannot be broken apart or divided, because dividing would be a kind of change. Therefore, Democritus called these little bits of matter by the Greek word that means *undividable*:

ἄτομος

Or, in English letters, *atomos*—that is, **atoms**!

Shape, Arrangement, and Position

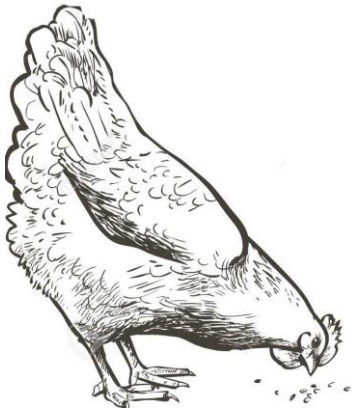
Thus, says Democritus, everything is made of atoms and empty space, which he called void. Atoms and Void—that's all it is. And these atoms have no real qualities themselves.

When the atoms come together in void, however, they create things that *do* have qualities. The qualities of the substances that we experience are all based on three things about the atoms:

1) the **Shape** of each individual atom,
2) the **Arrangement** of the atoms when they are combined
3) and the **Position** of each atom

For example, why is water wet, and fluid, and clear, while a rock is solid, and hard, and rough? If they are both just made of the same two ingredients—atoms and void—how can they be so different? Democritus says that differences between these substances has something to do with the shape of the atoms involved, how they are arranged relative to each other, and how they are positioned. For example, maybe the atoms in water have a smooth shape, and the atoms in rock have jagged or pointy edges. And maybe the atoms in water are arranged in a more spread-out fashion, whereas the atoms of a rock are more tightly packed together.

What Change Really Is



Change, then, says Democritus, is simply the recombination of the eternally-existing atoms into new arrangements and positions.

Let's go back to our chicken example from the last chapter. It is not that the chicken's food must have contained little portions of flesh and feathers and such—no, no, no! It is that everything is made of atoms. The atoms in the chicken's food have a certain arrangement and position, but then, when the chicken eats and digests the food, the atoms from the food arrange themselves into flesh, and bone, and feathers, and beak, and so on.

Change *does* exist, and it does *not* involve something coming from nothing. It is just little atoms, that have always existed, taking on new arrangements and positions.

The little atoms, says Democritus, just move around the void, and when they bump into each other, they sometimes get "entangled," and the result is that a new compound—a new material with recognizable qualities—is formed.

The Importance of Void

This theory of atoms, you might say, sounds like a very solid theory.[2] But what about *void*? Why does Democritus bother to mention the empty space between them?

[2] Pun intended.

In fact, Void is extremely important to the theory. Void is actually what makes change *possible*. If *everything* were solid and unchangeable matter, then nothing could change or even move. The atoms would not be able to separate from each other and reattach to form new things—because they would have nowhere to go!

Imagine for a moment a little cluster of atoms, coming together to form some substance, say a drop of water.

Now if this little speck of water were going to change into something else, the atoms would have to separate and reattach to other things in new ways. You might imagine that the atoms, as they separate, would shoot off into the surrounding air or something. But remember—air is a substance too and is thus also made of atoms! If there were no *truly empty space*—space with no atoms in it at all—the atoms of water would be packed in and unable to budge. That is why *Void* is so important—it gives the atoms the space they need to move around and recombine.

Conclusion

Thus, Democritus explained everything in the universe by The Full and The Empty, "What Is" and "What Is Not," Atoms and Void. It is quite a remarkable and insightful theory! His ideas were to influence scientific thought for a long time after him—indeed, these ideas still influence us now!

Although he had such a brilliant theory, and although he is the last Pre-Socratic natural scientist that we will study, let's not make the mistake of thinking that Democritus had "gotten it right." No, indeed, there were still some problems with his theory—many of which Aristotle later pointed out—and indeed many, many new things about the natural material world that yet remained to be discovered. In the remainder of our Chemistry unit, we will continue to see how our understanding of the material world around us has transformed and improved, with the contributions of many more natural scientists.

Name: _____
Section & Course: _____
Teacher: _____
Date: _____

Democritus – Worksheet for Tuesday April 21
****Remember to complete it online at the Google Classroom rather than on this sheet, if possible****
Democritus – p. 100 in *Nature of Science*; pp. 9-12 in Supplementary Reading

1. A review question before going to Democritus: What did Empedocles and Anaxagoras *disagree* about?
    a. Empedocles said there were only four fundamental substances; Anaxagoras said they were infinite
    b. Empedocles said there were an infinite number of fundamental substances; Empedocles said there were only four
    c. Empedocles said change was impossible, but Anaxagoras said change was possible
    d. Empedocles said change was possible, but Anaxagoras said change was impossible

2. Our new Pre-Socratic, Democritus, agreed with Empedocles and Anaxagoras that certain elements had _____ existed but disagreed about _____ those elements are like.

3. How many elements did Democritus say existed?
    a. Zero
    b. One
    c. Two
    d. Three
    e. Four
    f. Infinite
    g. Unknown

4. What did Democritus call his elements?
    The _____ and the _____

5. Which Pre-Socratic, who spoke about density and rarity, should Democritus remind us of?
    _____

6. Earlier (question 4), you listed what Democritus called his elements. What is another way of naming these elements?
    a. Dense and Rare
    b. Atoms and Void
    c. Hooked and Smooth
    d. Fire and Water
    e. None of the above

7. When atoms, which do not have any qualities (such as color, odor, etc.), come together they do create things that have qualities (amazing!). These qualities are all based on which of the following factors? Choose the THREE correct answers.
    a. The texture of the atoms
    b. The arrangement of the atoms when they are combined
    c. The number of atoms that combine
    d. The shape of the individual atom
    e. The size of each individual atom
    f. The position of each atom
    g. The weight of the object

8. Which of the following is true about atoms, according to Democritus? Atoms are…
    a. Heavy
    b. Multi-colored
    c. Eternal
    d. Flexible
    e. Constantly Changing

9. Void makes _____ possible.

10. Democritus says change exists. Explain how change happens according to Democritus. Your response must include the following words:
    -Void -Atoms -Rearrangement/Recombination -Shape -Arrangement -Position

_____

_____

_____

_____

Name: _____
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Pre-Socratic Review (worksheet for Wednesday April 22 – it cannot be completed on Google Classroom)

Now that we have finished reading about each Pre-Socratic natural scientist individually, let's take some time to review all of them together. For these questions, please refer to all the supplementary readings from the packets that you have done on the Pre-Socratics so far (Chapters 3-11) and pp. 90-100 in *Nature of Science*. Fill out the following table by answering the questions for each natural scientist. Some have been done for you.

Questions:	Is there *one* material that everything is made of, or *more than one*?	What were those fundamental materials (or elements)?	Were there any non-material principles or causes that had some effect on the material world?	How is change explained?
Thales (Chapter 3, Wed., April 8)	**Thales thought that there was <u>only one</u> material that everything was made of.**	**Thales thought that everything was made of water.**	**No.**	**Thales did not attempt to explain change. He simply said that everything somehow came to be from water.**
Anaximander (Chapter 4, Thurs., April 9)			**Anaximander said that the material world was affected by the war between opposites.**	

Anaximenes (Chapter 5, Mon., April 13)			**There were two non-material principles that affected the material and those were: rarity and density.**	
Pythagoras (Chapter 6, Tues., April 14)	N/A	N/A		
Heraclitus (Chapter 7, Wed., April 15)				
Parmenides (Chapter 8, Thurs., April 16)	N/A	N/A	N/A	

Empedocles (Chapter 9, Fri., April 17)				
Anaxagoras (Chapter 10, Mon., April 20)				
Democritus (Chapter 11, Tues., April 21)				

(Worksheet continues on the next page)

1. Who was your favorite Pre-Socratic and why? (a) Briefly summarize what he thought, and (b) why you think it was a good theory.

   Chosen Pre-Socratic: _____

   a. Summary of his thought:

_____

_____

_____

_____

_____

_____

   b. Why are this scientist's arguments and understanding of the universe good?

_____

_____

_____

_____

Mass v. Weight (This is the reading for Thursday April 23)

Recall what you read in your science packet on the second week "back" after spring break. You were sitting at home, presumably in your uniform just for the sake of good routine and because you missed your beloved cotton polo shirt, of course (So soft! So many memories!). When you opened to the science section of the 6th grade packet, you may have been surprised to learn that we had transitioned from Biology to Chemistry!

Certainly, you had heard of Chemistry, but you may have not known what it studied. Chemistry focuses on the **material cause of substances, both living and non-living** (as opposed to biology, which focuses on the formal cause of living substances). Broadly speaking, chemistry studies **matter**.

We then spent a couple weeks exploring the first natural scientists, the Pre-Socratics, who were seeking to understand what was the ultimate substance that made up things in the universe. For the rest of this week, we will go back to the reading on Introduction to Chemistry (pp. 89-90 in the *Nature of Science* textbook) and develop some key points that were touched upon there.

If you recall, there was a list of the **Properties** (or Characteristics) **of Matter**. If we are going to study matter effectively, we need to know what key and foundational questions to ask about matter. For example, if we ask "How hot is the matter"? we are asking about the **property** of Temperature. If we ask, "How tightly packed is the matter?" we are asking about the **property** of Density. Today we are going to look at two properties and compare them. The two properties are **Mass** and **Weight**. Before we begin, though, you need to take 5 minutes on a "pre-test" (don't worry about grades for accuracy) to see what you know. This will help you focus on what you are about to study and help you correct any misconceptions. So please follow these instructions:

- Do not use the textbook, any previous readings, or any other resources during the ungraded pre-test
- Spend a solid 45 seconds (or longer) really thinking about each of the seven questions
- Write your answer to each question on this sheet or a separate piece of paper
- Then, continue reading and following along with this section

Pre-Test

1. Are mass and weight the same thing?

2. Can your **weight** change depending on where you are located?

3. Can your **mass** change depending on where you are located?

4. What determines your **mass**? (e.g. "My height determines my mass"; "My weight determines my mass", etc.)

5. What determines your **weight**?

6. When we measure **mass**, what, if anything, are we measuring?

7. When we measure **weight**, what, if anything, are we measuring?

As with so many things, beginning with an etymology can really break open a word and help us to understand it. Here are the etymologies for mass and weight, respectively:

Word	**Root**	**English Translation of the Root**
Mass	Massa (Latin)	Kneaded dough, lump
Weight	Gewiht (Old English)	Weighing, downward force of a body, heaviness

As you will hopefully see as we continue in this reading, these etymologies do indeed reveal something of the concepts these words represent.

Let's take up mass first:

Mass

How many of the Ten Categories of Being can you name from memory? The Ten Categories are a foundational concept for this course (and indeed for many aspects of natural science!). The category that Mass is most closely tied to is **quantity**, for it is interested in the question, "**How much** matter is there in a particular body?" In the earlier reading on the Introduction to Chemistry, we defined mass as follows:

Mass: The quantity or amount of matter in a body

So when we ask "What is my mass?" we are asking "What is the quantity of matter that makes up my body?" At the end of the reading, we will consider important questions about mass's relationship to weight, as well as whether your current location affects your mass or not.

Weight

When it comes to the Ten Categories of Being, it is a bit more difficult to determine which category weight applies to. Think about it and consider it as we hear more about weight here. In our initial reading, we defined it like this:

Weight: The heaviness or lightness of a body; the downward tendency exhibited by a body

I want you to consider three different options for which Category of Being weight is most associated with: Quality, Action, and Passion. Let's take each in turn.

Weight as a Quality:

As you can see right in the definition of Weight, it is listed as the "heaviness or lightness" of a body. This point immediately brings to mind weight as a quality. For example: "The heavy box was difficult to carry." Here the box has the quality of "heaviness". But this aspect of weight is not the whole story.

Weight as Action or Passion:

It may be odd to think of weight as an "action" or a "passion". (Remember: Passion is receiving action, such as "I was hit by the ball.") Aren't things just simply heavy, light, or somewhere in between? Objects do not appear to be performing any action or receiving any action (which is what passion relates to) when we consider their weight. In fact, ordinarily in everyday life, we only consider the weight of something when it is standing still on a scale! But here is where we can dive deeper into the concept of weight. Weight is actually a **force**. When we think of weight as a force, it becomes clearer how it could be associated with categories of Action or Passion. Forces *act* or other things *receive* the actions of forces. A critical component of this force known as weight is **gravity**. When you multiply a body's mass by the gravitational force in its current location, you get the weight of that body. Without any gravitational force, you would be weightless!

Your weight will be much less on Pluto than on Earth because of Pluto's weaker gravitational pull. Your mass, however, will be the same no matter which planet you are on (or from…).

And if weight is a force, that means it can change. For example, a 140-pound man on earth will only weigh about 9 pounds on Pluto! Why is that? It is because gravity is so much weaker on the dwarf planet Pluto than it is on earth. When it comes to weight, location is everything.

But what about mass? Can it change? Well, yes, but not based on location. Your mass changes all the time as you eat, grow, and workout. The amount of matter does not change, however, based on whether you are on Earth, Pluto, or the Moon. Your weight will be different in each of these locations, but not your mass.

Mass and Weight Compared

Hopefully this clears up the common confusion that mass and weight are the same thing; they are quite different. Mass is a measurement of the quantity of matter, whereas weight is a measurement of a force acting on mass. Weight needs mass to exist, whereas mass will remain whether there is strong, weak, or no gravity. The relationship between gravity, mass, and weight will be explored more carefully in Physics, but for now, make sure you understand the difference between mass and weight.

In order to strengthen your understanding, please use the key listed on the next page to go back and correct your answers to the pre-test. Then, continue on to the following page to

complete the worksheet for today's reading. Place a check next to correct answers and scratch out and correct incorrect answers.

Pre-test Answers:

<table>
<tr><td>1. No</td><td>2. Yes</td><td>3. No</td><td colspan="2">4. The amount of matter in my body determines my mass</td></tr>
<tr><td>5. The force of gravity in my current location multiplied by my mass determines my weight</td><td colspan="3">6. When we measure the mass of something, we are measuring the amount—or quantity—of matter in a particular object/body</td><td>7. This is a bit tricky. We are used to measuring our weight on a scale. But what are we measuring? What we are measuring is the force being exerted on our body's mass.</td></tr>
</table>

Name: _____
Section & Course: _____
Teacher: _____
Date: _____

Mass v. Weight

(This is the worksheet for Thursday April 23; remember to complete it online at the Google Classroom rather than on this sheet, if possible)

1.
    a. I went back to my pre-test and used the key to correct my answers: YES NO
    b. I put check marks next to what I got correct: YES NO
    c. I scratched out ***and*** wrote in the correct answer for what I got incorrect: YES NO

2. What are two key differences between **biology** and **chemistry**? Circle the *two* correct answers.
    a. Biology focuses on the final cause and chemistry focuses on the efficient cause.
    b. Biology focuses on the material cause and chemistry focuses on the formal cause.
    c. Biology focuses on the formal cause and chemistry focuses on the material cause.
    d. Biology focuses on living things only and chemistry focuses on both living and non-living things
    e. Biology focuses on living things only and chemistry focuses on non-living things only
    f. Biology focuses on both living and non-living things and chemistry focuses only on non-living things

3. Which Category of Being does Mass most relate to?
    a. Substance
    b. Quantity
    c. Quality
    d. Force
    e. Action
    f. Passion

4. Which *three* Categories of Being does weight potentially relate to? List them:
    a. _____
    b. _____
    c. _____

5. What is the formula for determining weight?

   _____ x _____ = Weight

6. Weight is a
   a. Force
   b. Balance
   c. Material
   d. Number
   e. Constant

7. Mass changes based on location.
   a. True b. False

8. What is the difference between Mass and Weight?

_____

_____

_____

_____

9. Why does the weight of an object change based on the object's location?

_____

_____

Volume

(This is the reading for Friday April 24)

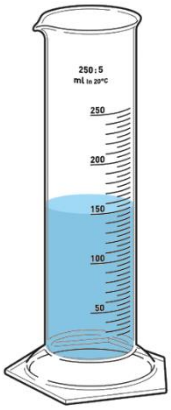
The *Nature of Science* defines volume as "the amount of space a body occupies in three dimensions." This is most commonly measured as the product of an object's length, width, and height. For example, if a block of wood were to have a length of 3 centimeters, a width of 3 centimeters, and a height of 12 centimeters, then the volume would be calculated as such:

Volume of a block of wood = 3 cm × 3 cm × 12 cm = **108 cm^3**

"**cm^3**" means *cubic centimeters* and is the unit for measuring the volume of a solid. For liquids, however, we tend to use the liter (L) and the milliliter (mL); fortunately for us, one milliliter exactly equals one cubic centimeter, so the two are directly transferable (meaning 1 L technically equals 1000 cm^3!).

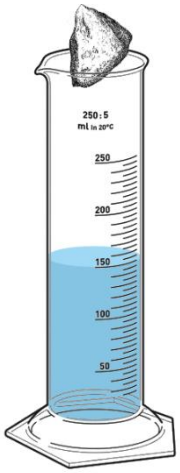
Calculating base × width × height is simple enough for a perfectly rectangular block, but what about when you are measuring something more organic or irregular? The solution is simple. Say you wanted to find out the volume of a specific chunk of rock:

1. Fill a graduated cylinder with water:



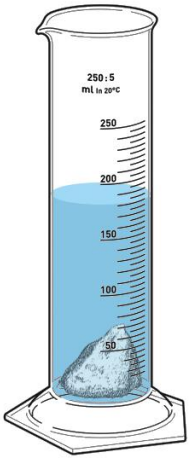
2. Drop an object into the cylinder:

→



3. See the water level change!

→



The volume of the rock causes it to push, or *displace*, the water upwards, resulting in a higher water level than before the rock was dropped in. Now, all that's left is to subtract the starting volume of water from the new total. It's probably difficult to see in the pictures, but the starting water was 150 mL, and the final result was 180 mL.

Thus, 180 - 150 = 30, so the rock must have a volume of 30 mL, right?

Wrong!

It's actually 30 cm^3, since the rock is not a liquid.

At any rate, today you will be trying this out in your own homes! Since most of us don't have graduated cylinders lying around at home, you can use a clear measuring cup as an alternative. The smaller and narrower the cup, the easier it will be to notice and measure changes in volume; having a measuring cup with metric measurements (so, liters and milliliters) is important as well.

_____
_____
_____
_____

Packet Week 4 Friday Volume Measuring Exercise

What you need:

1. A measuring cup that can hold at least 20mL of water--the more precisely labelled, the better
2. A small rock
3. A quarter
4. Two small objects of your choice

*In this exercise, we will practice identifying the volume of an object through **water displacement**. For each object, you will...*

1. Make sure you have your measuring container filled to *at least* 20mL. (If the shape of your container is very wide, you can fill it further, but fill it to a multiple of ten.)
2. Drop the object into the container. Observe where the water level is now and note it down as the New Total Volume.
3. Subtract your starting volume from the new volume you recorded in step 2: this difference tells you the exact volume of your object! Note this down. **Remember that solids use the unit cubic centimeters (cm^3) instead of milliliters (mL) when measuring volume.**
4. Remove the object, make sure you have exactly the same amount of water that you started with (refill if necessary), and repeat steps 1-3 for each object.

Note that for the test of your own choice, the object must be small and dense enough to stay completely under the water, to ensure that you are seeing the entire object's volume displacing the water.

Object	**1. Initial Water Volume**	**2. New Total Volume**	**3. Volume of the Object**
Small rock			
Quarter			
Student Choice #1:			
Student Choice #2:			