

Remote Learning Packet

NB: Please keep all work produced this week. Details regarding how to turn in this work will be forthcoming.

April 27 - May 1, 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 27

Read NoS pp. 101-104 and complete the day's worksheet.

Tuesday, April 28

Read NoS pp. 104-105 and complete the day's worksheet.

Wednesday, April 29

Read NoS pp. 108-111 and complete the day's worksheet.

Thursday, April 30

Read NoS p. 115 and complete the day's worksheet.

Friday, May 1

Read NoS pp. 116-117 and complete the day's worksheet.

Statement of Academic Honesty

I affirm that the work completed from the packet is mine and that I completed it independently.

I affirm that, to the best of my knowledge, my child completed this work independently

Student Signature

Parent Signature

Name: _____

Section & Course: _____

Teacher: _____

Date: _____

Monday April 27: The Classical Elements and
Aristotle *On Generation and Corruption*
II.3

We have finished our study of the Pre-Socratics, but our quest to understand the ultimate material causes of the universe is far from over. Today we will be looking at how the Greeks who came after the Pre-Socratics understood it—most notably, Aristotle!

Today we will follow these steps:

1. Read the paragraph at the top of page 101 in the *Nature of Science* textbook.
2. Answer the questions related to that reading (#1-3)
3. Read Aristotle's *On Generation and Corruption Book II, Chapter 3*, on page 103-4 of your *Nature of Science* textbook.
4. Read and answer the questions (#4-14) which will guide us through this reading.
5. Answer a few final questions about the reading as a whole.
6. You will complete this worksheet on Google Classroom..

The Classical Elements – *Nature of Science* p. 101

1. How long after Empedocles did Aristotle live? _____ years.
2. What view had become widespread?
 - a. Water was the basic material element of all things.
 - b. Change is impossible.
 - c. Everything is composed of atoms and void.
 - d. There are four elements: Earth, Water, Air, and Fire.
3. Another element was added by Aristotle and others, called _____. It was the material that _____ were made of.

Directions: 1. Now let's turn to Aristotle. Remember to only continue here after you have

read the selection on Aristotle on pp. 103-104 of *Nature of Science* textbook. Did you read that yet (circle)?

YES NO

- 2. Read the five quotes from that reading, written below in *italics*.**
- 3. Read and answer the explanations and questions about that quote.**
- 4. Continue to the next quote and questions.**
- 5. Re-read the entire selection.**
- 6. Answer the final two questions about the passage**

Aristotle's *On Generation and Corruption* – II.3 – *Nature of Science* p. 103-4

Quote 1: *The elementary qualities are four, and any four terms can be combined in six couples. Contraries, however, refuse to be coupled: for it is impossible for the same thing to be hot and cold, or moist and dry. Hence it is evident that the couplings of the elementary qualities will be four: hot with dry and moist with hot, and again cold with dry and cold with moist.*

4. Aristotle's main idea here is **Elementary Qualities**. Do you remember the third category in Aristotle's Ten Categories? That's right—Quality! Here Aristotle is saying that not only are there elements that make up all the material in the universe, there are also *elementary qualities*. List the four elementary qualities:

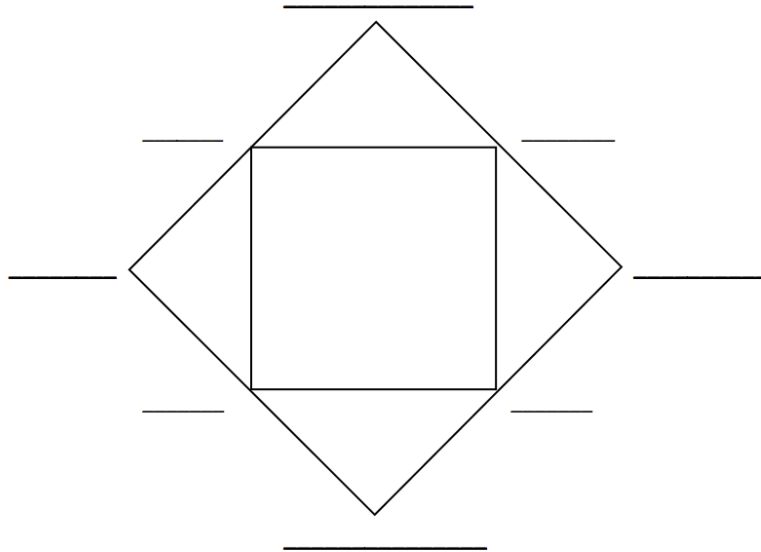
- 1) _____
- 2) _____
- 3) _____
- 4) _____

5. What are the four possible pairings (or "couplings") of elementary qualities?

<u>Pair 1:</u>		
<u>Pair 2:</u>		
<u>Pair 3:</u>		
<u>Pair 4:</u>		

Quote 2: “*And these four couples have attached themselves to the apparently simple bodies (Fire, Air, Water, and Earth)... For Fire is hot and dry, whereas Air is hot and moist (Air being a sort of aqueous vapor); and Water is cold and moist, while Earth is cold and dry...*

6. Look at the four couples (or pairs) that you just made in question #5. There are four of them. Aristotle says that each pair matches up perfectly with the four simple bodies (or elements). The way the elements are paired with qualities is displayed on a beautiful little chart on page 101 of your *Nature of Science* textbook. Copy that chart below:



7. Thus, every element has two elementary qualities:

Element	Elementary Quality 1	Elementary Quality 2
Fire		
Air		
Water		
Earth		

Quote 3: “For all who make the simple bodies elements postulate either one, or two, or three, or four. Now (i) those who assert there is one only, and then generate everything else by condensation and rarefaction, are in effect making their originative sources two... But (ii) those who postulate two from the start—as Parmenides postulated Fire and Earth—make the intermediates (e.g. Air and Water) blends of these. The same course is followed (iii) by those who advocate three... But (iv) some advocate four from the start, e.g. Empedocles: yet he too draws them together as to reduce them to the two, for he opposes all the others to Fire.”

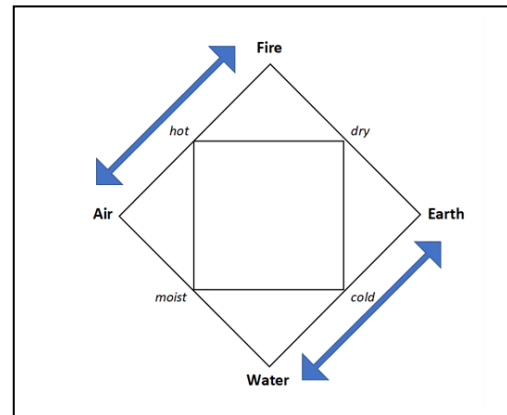
8. One of the marks of Aristotle’s wisdom is that he always looked back to the wisest thinkers of the past to see what they thought. Which Pre-Socratics is he thinking about? (Hint: One is not mentioned by name, but look for other clues to figure out who it is!).

_____, _____, and _____

Quote 4: “The simple bodies, since they are four, fall into two pairs which belong to the two regions, each to each: for Fire and Air are forms of the body moving towards the limit, while Earth and Water are forms of the body which moves towards the center.

9. Aristotle now shows us that, when you start pairing elements together in different ways, some remarkable patterns emerge.

The first such pattern comes when he pairs Fire with Air, and Earth with Water. (Notice these pairs are shown on the diagram to the right →)

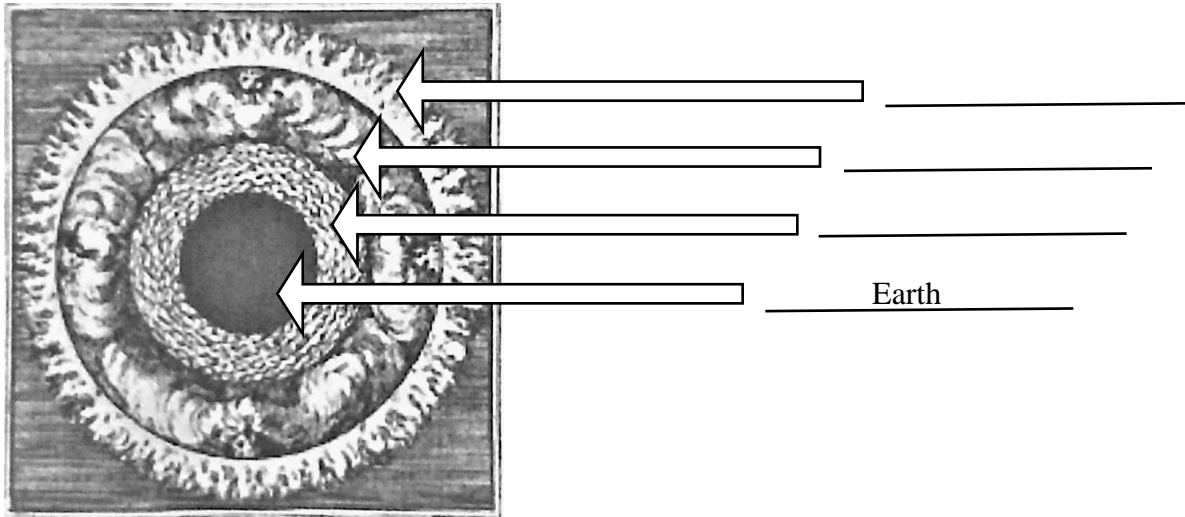


These pairs, he says, are similar because of their *natural places*. A natural place is the place that a thing tends to go by nature (e.g., all rocks by nature fall to the ground).

Look again at the quote from Aristotle (Quote 4) and fill in these two blanks.

- Fire and Air are related because they both move towards the _____.
- Earth and Water are related because they both move towards the _____.

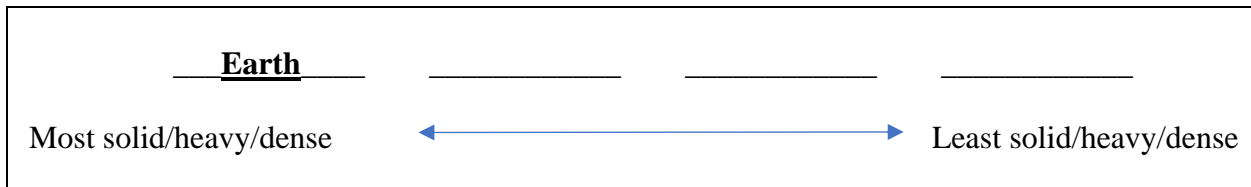
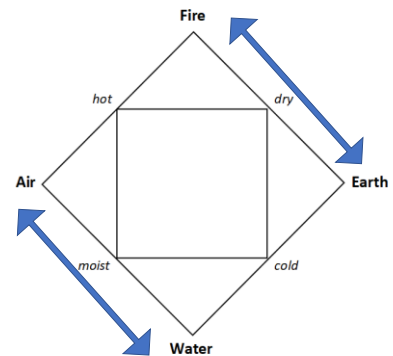
10. The diagram below is a model of how Aristotle and the ancient Greeks understood the cosmos. Each element has a natural place in the cosmos. See if you can figure out for each place the element that Aristotle said naturally goes there. I'll do one for you: the solid sphere in the middle is Earth.



Quote 5: “Fire and Earth, moreover, are extremes and purest: Water and Air, on the contrary are intermediates and more like blends.”

11. Aristotle next looks at another two pairs (shown on the right): Fire and Earth, and Air and Water.

These pairs are related based on whether they are extremes or intermediates on scale that goes from the most solid, heavy, dense material to the least. Place the elements where they belong on this scale (I did **Earth** for you already!).



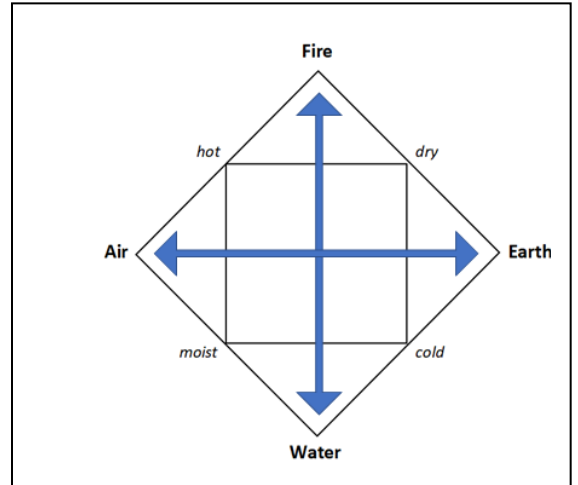
12. Thus, Fire and Earth are related because they are *extremes* on this scale.

Air and Water are related because they are _____ on the scale.

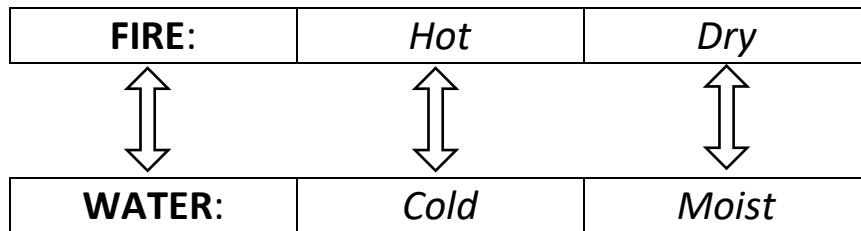
Quote 6: “And, further, the members of either pair are contrary to those of the other, Water being contrary to Fire and Earth to Air, for the qualities constituting Water and Earth are contrary to those that constitute Fire and Air...

13. Next, Aristotle looks at the pairs that are on opposite corners of the square. He says that these pairs are contraries (or, opposites). Which elements does he say are contraries?

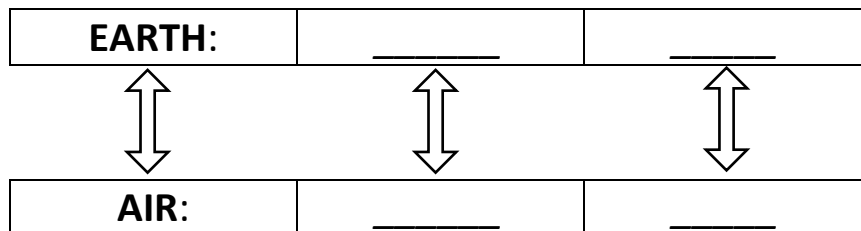
- c. Fire and Earth; and Air and Water.
- d. Fire and Air; and Earth and Water
- e. Earth and Water; and Earth and Air
- f. Water and Fire; and Earth and Air



14. The reason we can know that these elements are truly contrary, or opposite, to each other is that *both* of their *elementary qualities* are contraries. Let’s look at how this works for Fire and Water.



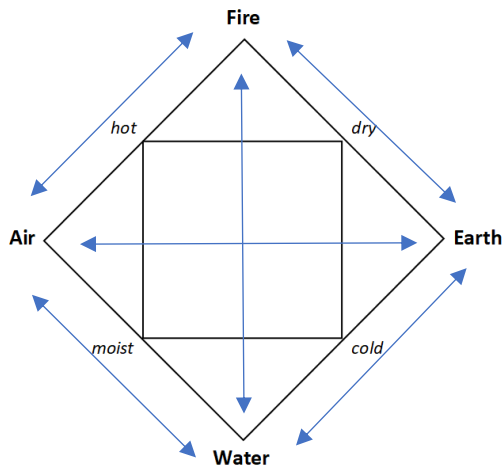
The arrows point to contraries. Fire and Water are contraries because *both of their qualities are contraries*. Show how the same is true of Earth and Air:



We have now come to the end of the reading! Good job. Now for a few final questions that sum up the whole reading!

Final questions:

Consider once more the chart that we have been working with. This chart illustrates the perfect order that Aristotle saw in the four elements and their qualities. One of the beautiful things about this chart is that really there are only three rules that govern the relationships between elements.



The three rules:

Any pair of *qualities* on opposite corners of the inner square are contraries.

Any pair of *elements* on opposite corners of the square are contraries because both qualities are contraries.

Any elements on corners that are closer to each other are related in some special way.

For the following pairs, circle what is true about them (contraries or related):

- 1) Fire and Water are: contraries or related in a special way
- 2) Air and Earth are contraries or related in a special way
- 3) Water and Earth are contraries or related in a special way
- 4) Water and Air are contraries or related in a special way
- 5) Fire and Air are contraries or related in a special way
- 6) Fire and Earth are contraries or related in a special way

Name: _____

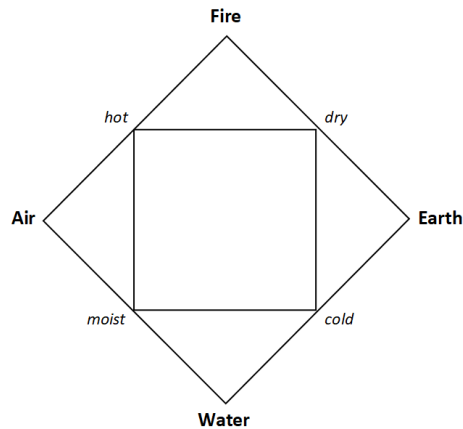
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Tuesday April 28: Aristotle's *On Generation and Corruption*
Book II, Chapters 4 and 5

Yesterday we learned from Aristotle all the ways in which the four elements and the four elementary qualities were related. This understanding was summarized in a beautiful diagram:



As we move forward with Aristotle today, it will be very important that you remember this chart and keep it fresh in your mind. Today, Aristotle uses this understanding of the relationships of the elements and the elementary qualities to understand the nature of *change*, and, as you'll see, the real truth about the so-called "elements."

Today we will follow these steps:

1. Read Chapter 4 from Aristotle's *On Generation and Corruption*.
2. Read and answer the quotes and questions which will guide us through this selection.
3. Re-read Chapter 4 and answer the remaining questions.
4. You will complete this worksheet on Google Classroom.

Directions: 1. Remember to only continue here after you have read Aristotle’s Chapter 4 on pp. 104-105 of the *Nature of Science* textbook. Did you read that yet?

YES NO

- 2. Read each of the five quotes below, written in *italics*.**
- 3. Read and the explanations and answer the questions about that quote.**
- 4. Continue to the next quote and questions.**
- 5. Re-read the entire selection.**
- 6. Answer the final three questions about the passage**

Aristotle’s *On Generation and Corruption*, Book II Chapters 4 (and 5)
Nature of Science pp. 104-105

Quote 1: “*It has been established before that the coming-to-be of the simple bodies is reciprocal. ... Consequently, we must explain (i) what is the manner of their reciprocal transformation, and (ii) whether every one of them can come to be out of every one—or whether some can do so, but not others.*”

1. This paragraph introduces the main idea of chapter four: **reciprocal transformation**. Aristotle uses this term to mean the transformation into each other of the four elements. That is, how water can transform into air, or how earth can transform into fire, and so on. “But wait,” you say, as a good student of the Pre-Socratics. “Empedocles said that the four elements were eternal and *unchanging*—they cannot change into each other!” That’s right—Aristotle is proving that Empedocles was wrong about this.

“Reciprocal transformation” means ____.

- a) the transforming of a fraction by flipping it over
 - b) the transformation of food into the body, in nutrition
 - c) the transformation of Empedocles’ ideas into Aristotle’s ideas
 - d) transformation of the four elements into each other
2. What is the difference between Aristotle’s view of the four elements, and Empedocles’ view?
 - a) Empedocles says that the four elements *can* change, Aristotle says that the four elements *cannot* change.
 - b) Aristotle says that there are really eight elements, Empedocles says that there are four elements.
 - c) Aristotle says that the four elements *can* change, Empedocles says that the four elements *cannot* change.
 - d) Empedocles says that water and fire are not contraries, but Aristotle says that they are.

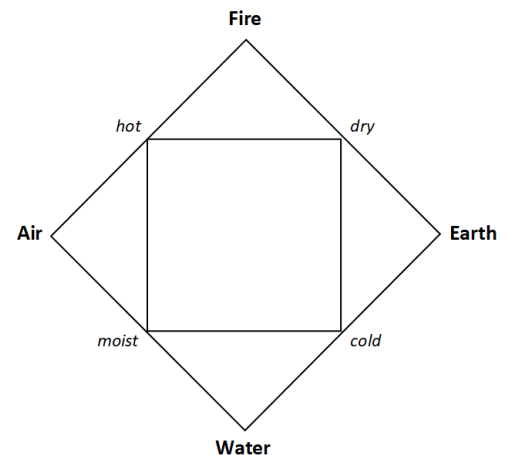
Quote 2: *“Now it is evident that all of them are by nature such as to change into one another: for coming-to-be is a change into contraries and out of contraries, and the elements all involve a contrariety in their mutual relations because their distinctive qualities are contrary.”*

3. Aristotle affirms again what he said about reciprocal transformation in the first paragraph, saying here that it is evident that “all of them are by nature such as to _____.”
4. This quote also tells us one of Aristotle’s most important ideas about change. He says that “coming-to-be” is a particular kind of change “into contraries and out of contraries.” When change happens, it is always from one contrary to another. If you try to say anything different, it sounds like nonsense (as you’ll see below!). What are some examples of changes into and out of contraries? Circle all that apply.
 - a) Something changes from hot to cold.
 - b) Something changes from full to empty.
 - c) Something changes from dark to light.
 - d) Something changes from smooth to heavy.
 - e) Something changes from cold to white.

Quote 3: *“For in some of them both qualities are contraries—e.g. in Fire and Water, the first of these being dry and hot, and the second moist and cold: while in others one of the qualities (though only one) is contrary—e.g. in Air and Water, the first being moist and hot, and the second moist and cold. It is evident, therefore, if we consider them in general, that every one is by nature such as to come-to-be out of every one...”*

5. Aristotle is pointing out that every element is contrary to every other element in either one or both of its qualities. Let’s try it out! Refer to the diagram and put a check mark in the correct column for each pair of elements:

Pair of Elements	Opposed in one of its qualities	Opposed in both of its qualities
Fire and Water		
Fire and Air		
Fire and Earth		
Earth and Air		
Earth and Water		
Water and Air		



Quote 4: *“Thus the process of conversion will be quick (a) between those which have interchangeable complementary factors, but slow (b) between those which have none. The reason is that it is easier for a single thing to change than for many. Air, e.g. will result from Fire if a single quality changes: for Fire, as we saw, is hot and dry while Air is hot and moist, so that there will be Air if the dry be overcome by the moist...”*

Think about your answers in the table on #6 above. Aristotle is saying that the “process of conversion” (that is, the change from one element into another) will be quick if they are opposed in only one quality, but slow if they are opposed in both. For example, he says, the transformation of Fire into Air will be quick. Only one quality needs to change. Both Fire and Air are already hot, so the only thing that needs to happen for Fire to become Air is that...

- a) the hot of Fire needs to change to cold
- b) the Air needs to change to Water
- c) the hot of Fire needs to change to dry
- d) the dry of Fire needs to change to moist

6. Aristotle then goes on to outline several more similar changes. Let’s follow the pattern along with him and describe these changes. In order to do this well, you must be looking at the diagram of the elements and their qualities (unless you already have it perfectly memorized). I filled out the first one for you.

Fire will become Air if the dry of the Fire changes to moist.

Air will become Water if the _____ of the Air changes to _____.

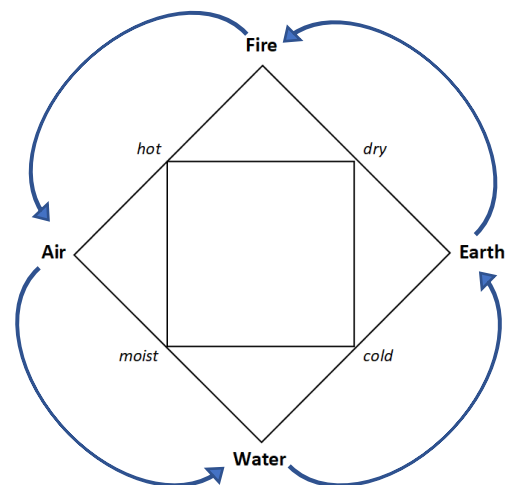
Water will become Earth if the _____ of the Water changes to _____.

Earth will become Fire if the _____ of the Air changes to _____.

Do you see how every transformation is possible? We went from Fire to Air, from Air to Water, from Water to Earth, and from Earth back to Fire!

As you can see, the transformations can be shown as a cycle where, one-by-one, it goes through changes in the contrary qualities and thus passes through all four elements!

... But do you see the problem? If “it” goes from Fire to Air, and Air to Water, and Water to Earth, and Earth to Fire—what is the “it” that undergoes those transformations?



Quote 5: ...*Since the elements are transformed into one another, it is impossible for any one of them...to be an originative source of the rest.*

...*Since, then, there is nothing—at least, nothing perceptible—prior to these, they must be all.*

Aristotle's conclusion is both shocking and brilliant. First of all, since the four elements can change into one another, *there must be something else that they are all made of*. But secondly, he says, neither is there some other body besides these four that everything comes from (sorry Anaximander, no "indefinite").

The reality is that there *is* something beyond the elements—it is matter *without form*—but, since nothing can *actually* exist without form, this something cannot exist independently.

Understanding this "something without form"—Aristotle calls it "Prime Matter"—is very philosophically tricky, and we will not get into it here. There are just two things I'd like for you to take away from it right now. First, (1) that Aristotle was correct about the existence of Prime Matter and that it is the thing that underlies and constitutes all material in the universe. But secondly, (2) since we can never experience Prime Matter directly, we should continue to focus our scientific efforts on understanding the material elements that we do experience. That is, although Aristotle knew that he had arrived at certain truth about the existence of Prime Matter, he was still seeking—and is encouraging us to seek—greater understanding about the smallest material elements of the natural world. We will continue this quest in the coming days.

7. Aristotle says that the four elements can be transformed into each other. This is called:
 - a) mutual destruction
 - b) reciprocal transformation
 - c) balanced strife

8. Since they can all turn into each other,
 - a) there must be something *else* that underlies these changes.
 - b) everything must just be air
 - c) everything must just be water
 - d) everything must just be fire

9. True or False: This underlying thing, called "Prime Matter," has no form, and so it cannot *actually* exist as a perceptible body without a specific form.

10. True or False: Even though it is certain that everything is made out of Prime Matter, Aristotle still encourages us to search for a better understanding of the smallest material elements that make up the natural world.

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Wednesday April 29: Lucretius, *De Rerum Natura*, pp. 108-111

Today we are reading several selections from *De Rerum Natura* (On the Nature of Things) from the Roman philosopher, Lucretius. Originally written as a long poem, it has been simplified in our textbook to be more easily read. He wrote this text in the first-century B.C. several hundred years after Aristotle, and much of his ideas will sound familiar as he responds to both Aristotle and the Pre-Socratics. Lucretius is especially interesting because of this distance in time: for him, the Pre-Socratics were already several hundred years old, so his perspective on them, in one sense, is a bit similar to our own so many centuries later. It will be interesting to unpack how he responds to the great thinkers that came before him!

Today we will follow these steps:

1. Read the first four selections from Lucretius' *De Rerum Natura* on pp. 108-111 of the *Nature of Science* textbook. Don't forget to pay attention to the definitions of the bolded words in the sidebar!
2. Read and answer the questions which will guide us through these selections.
3. Re-read *NoS* pp. 108-111 and answer the remaining questions.
4. You will complete this worksheet on Google Classroom.

Nothing Can Come to Be out of Nothing, pg. 108

Quote 1: *[The poem's] first principle will take as its starting point for us as follows: nothing ever comes to be from nothing through divine intervention... For if things came to be from nothing, every kind of thing could be born from all things, and nothing would need a seed. Men might sprout from the sea and the scaly race of fishes from the earth, and birds might hatch from the sky.*

1. Lucretius' first principle is that all things in material existence must have come from some other thing of the same kind, or **seed**, that existed beforehand. This first principle should remind us of which Pre-Socratic?

- a. Anaximander
- b. Heraclitus
- c. Democritus
- d. Anaxagoras

2. Lucretius wants to try to find an explanation for how different things come to be without relying on divine intervention as an explanation; in other words, he says that "we are after the

_____ from which each _____ is _____."

3. What words does the sidebar use to explain what Lucretius means by “seed”?

Nothing Can Be Destroyed into Nothing, pg. 108

Quote 2: *[N]ature dissolves each thing back into its particles and does not destroy things into nothing. For if anything were mortal in all its parts, each thing would perish by being snatched suddenly from before our eyes.*

4. Here, Lucretius is emphasizing that we never observe something completely vanishing out of existence: we always see things crumble into smaller or particles (think of something breaking apart, or wood burning into ash). This idea is very similar to Anaxagora’s principle of

- Mixture and Separation
- Love and Strife
- Body and Soul
- Ousia* and *Morphe*

Quote 3: *... since each thing is composed out of eternal seed, until a force is present that hammers apart the thing with a blow or penetrates within through empty spaces and dissolves it, nature does not allow destruction of anything to be seen.*

5. Lucretius is further explaining why nothing truly vanishes from existence. What does the sidebar say he means by the term “eternal seed”? What could be another name for such a thing?

Bodies and Void, pp. 109-110

Quote 4: *... there exists intangible space, void, and emptiness. If void did not exist, there is no way things would be able to move. For that which is the natural role of body, to roll in the way and obstruct, would be present at all times for all things.*

No questions here; just take a moment and really think about this one: how could *anything* move from one place to another if something was in its way? One could say that the other object is just getting pushed out of the way, but then where does *it* move to? Lucretius is pointing out if there was not empty space for anything to occupy, it would be impossible to move at all, since everything would be solid. The very fact that we can move proves that there is such a thing as empty space!

6. Later on in this page, Lucretius says that “*The nature of the universe, then, as it is in itself, is made up of two things; for there are _____ and _____.*”

next page →

Quote 5 (pp. 109-110): *...unless a thing has void in it, it cannot be crushed, broken, or split by being cut in two ... Moreover, unless a minimum exists, all the tiniest bodies will be made up of an infinite number of parts, since in that case the half of a half will always have a half, nor will there be anything to set a limit ... you must also admit that the atoms are solid and eternal.*

7. What allows for a thing to be crushed or broken into pieces?
- a. the void (empty space) outside the thing
 - b. the void (empty space) within the thing
 - c. parts of the body vanishing out of existence
 - d. a build-up of too much “body” within a thing

8. Based off of the last question, what do you suppose Lucretius means when he says that atoms are “solid and eternal”? Does an atom have empty void inside itself? Could it this smallest part be split into smaller parts?

Critique of the Pre-Socratic Natural Philosophers, pp. 110-111

9. According to Lucretius, the Pre-Socratic philosophers are mistaken to focus so much on change: he argues instead that *“First beginnings ought never to do this [change] in any way. For something*

_____ *must necessarily remain, so that all things not be*
_____ *to nothing.”*

10. List all of the Pre-Socratics that Lucretius mentions in his critique. In the very top paragraph on page 111, what mistake does he believe was made by the last Pre-Socratic he mentions?

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Thursday April 30: Isaac Newton's *Opticks*
From Query 31

"If I have seen further, it is by standing upon the shoulders of giants." -Sir Isaac Newton

Today we are jumping ahead about 1700 years in the history of scientific thought (quite a leap!) to hear the thoughts on ultimate principles of one of the true geniuses of scientific inquiry: Sir Isaac Newton. This is the same Newton (born in Lincolnshire, England in 1643) of the famous "Laws of Motion", as well as the story of the apple tree and theories of gravity. Today, though, we will focus on his understanding of the fundamental material principles of the universe, which he also considered as the Pre-Socratics had done before him. His quotation at the top of this paragraph is a grand example of the humility of a scientist (and, indeed, any student); he clearly recognizes that any of his gains in understanding are due to learning from those who came before. Newton added his own voice to the conversation on seeking to understand the ultimate material make-up of the universe.

Today we will follow these steps:

1. Read the selection from Newton's *Opticks* on p. 115 of the *Nature of Science* textbook. Don't forget to pay attention to the definitions of the bolded words in the sidebar!
 2. Read and answer the questions which will guide us through this short selection.
 3. Re-read Newton's *Opticks* and answer the remaining questions.
 4. You will complete this worksheet on Google Classroom.
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Directions: 1. Remember to only continue here after you have read the selection on Newton on p. 115 of the *Nature of Science* textbook. Did you read that yet (circle)? YES NO

2. Read the five quotes below from the selection written in *italics*.
3. Read and answer the explanations and questions about that quote
4. Continue to the next quote and questions
5. Re-read the entire selection
6. Answer the final three questions about the passage

Isaac Newton's *Optics* – From Query 31 – *Nature of Science* p. 115

Quote 1: *...All these things being consider'd, it seems probable (likely) to me, that God in the Beginning form'd Matter in solid, massy, hard, impenetrable Particles...*

1. We see above that Newton thinks that matter was created right at the beginning of time. He says matter was created by God as "Particles". This understanding of matter as "Particles"—or little parts—should remind us of which of the following Pre-Socratics?
 - a. Thales
 - b. Anaxagoras
 - c. Anaximenes
 - d. Democritus
 - e. Pythagoras
2. He says these Particles are _____, massy, _____, and impenetrable.
3. Copy down what **impenetrable** means from the sidebar on p. 115 of *Nature of Science*

Quote 2: *"[The Particles are]...of such Sizes and Figures, and with such other Properties, and in such Proportion to Space, as most conduced to the End for which he form'd them; and that these primitive Particles being Solids, are incomparably harder than any porous Bodies compounded of them..."*

4. When Newton says that God made these Particles in such a precise way that they worked toward "the End for which he form'd them", Newton is talking about which of the Four Causes?

The _____ cause

5. Newton also indicates that there are different sizes and shapes of these particles. Again, this sounds like a Pre-Socratic philosopher we know! After centuries and centuries, a man from England still has ideas that sound like the earliest scientists – Incredible! Newton also emphasizes that the Particles are
- Liquid
 - Porous (full of wholes)
 - Solid
 - Gas

Quote 3: “[*The Particles are*]...even so very hard, as never to wear or break in pieces; no ordinary Power being able to divide what God himself made one in the first Creation.”

6. No person or power on earth is able to do what to the Particles?
- Split
 - Grow
 - Invent
 - Change
 - All of the above
7. Are these Particles eternal (no beginning and no end)?
- The Particles had a beginning but will not end.
 - The Particles have always existed but will someday decay and cease to exist
 - The Particles had a beginning and will someday decay and cease to exist
 - The Particles have always existed and will always continue to exist.

Quote 4: “*While the Particles continue entire, they may compose Bodies of one and the same Nature and Texture in all Ages: But should they wear away, or break in pieces, the Nature of Things depending on them, would be changed... And therefore, that Nature may be lasting, the Changes of corporeal Things are to be placed only in the various Separation and new Associations and Motions of these permanent Particles...*”

8. Be careful as you read the above quote. Newton is saying the Particles will *never* wear away or break into pieces. Take water for example. If the pieces start to wear away, eventually it would change the very _____ of Water.
- Idea
 - Nature
 - Change
 - Heart

(worksheet continues on the next page)

9. This is critical: Newton just like the Pre-Socratics, was very concerned about the nature of _____ and whether or not it could happen. The worry that Parmenides began continues!
- Final causes
 - Water
 - Fire
 - The Four Elements
 - Change
10. For Newton, the reason we notice change in the world is because the Particles _____
- Come together and combine in new ways to form other substances
 - Decay and change into other kinds of Particles
 - Grow and expand
 - Shrink and Contract

Quote 5: “...*compound Bodies being apt to break, not in the midst of solid Particles, but where those Particles are laid together, and only touch in a few Points.*”

11. When Newton says, “compound Bodies being apt to break”, he is recognizing what we see all the time: Things made up of a lot of matter (like grass, trees, houses, our own bodies) “break” or fall apart or decay. We know this by experience: grass withers in the heat, tree branches come crashing down during a storm, our bodies can be wounded or weakened. But Newton said the Particles that make these things up cannot be split or broken! So how can these breakdowns happen? Take a look at the same image you saw when you read about Democritus:



Imagine this is a clump of Particles that make up a tree branch. Then, the lightning strikes! The branch cracks and crashes to the ground with half the “Particles” you see here still attached to the tree and the other half on the forest floor. Since the Particles themselves cannot be split, where did the breaks happen that separated half the Particles from one another?

He says the breaks happen _____

- At weak spots where the particles meet
- Only on the surface of the Particles
- That these “breaks” are just tricks of our senses and do not really occur
- At the points where the Particles are closely linked and fitted together.

(worksheet continues on the next page)

We have now come to the end of the reading! Good job. Please go ahead and re-read Newton's words on p. 115, which are copied in full below. Why am I re-reading? Good question. These primary sources can be difficult to understand, but now that you have worked through it, you can now see it in whole so you have a better understanding and can really grapple with it. You may walk away with new insights! It's important we read these thinkers' words directly, but it can be hard and takes us (including teachers!) multiple attempts to get it.

Afterwards, complete the final three questions about Newton that are written out below.

Isaac Newton's *Optics* – From Query 31 – *Nature of Science* p. 115

...All these things being consider'd, it seems probable (likely) to me, that God in the Beginning form'd Matter in solid, massy, hard, impenetrable Particles, of such Sizes and Figures, and with such other Properties, and in such Proportion to Space, as most conduced to the End for which he form'd them; and that these primitive Particles being Solids, are incomparably harder than any porous Bodies compounded of them; even so very hard, as never to wear or break in pieces; no ordinary Power being able to divide what God himself made one in the first Creation. While the Particles continue entire, they may compose Bodies of one and the same Nature and Texture in all Ages: But should they wear away, or break in pieces, the Nature of Things depending on them, would be changed. Water and Earth, composed of old worn Particles and Fragments of Particles, would not be of the same Nature and Texture now, with Water and Earth composed of entire Particles in the Beginning. And therefore, that Nature may be lasting, the Changes of corporeal Things are to be placed only in the various Separation and new Associations and Motions of these permanent Particles; compound Bodies being apt to break, not in the midst of solid Particles, but where those Particles are laid together, and only touch in a few Points.

Final questions (there are three):

1. Explain how Newton reminds of Democritus. Identify **two specific ideas** from Democritus that are echoed in Newton. Please remember to respond in complete sentences.

2. An important difference between Newton and many pagan Greeks is that Newton recognized that _____
 - a. The ultimate substances (Particles) were created by God who was outside the creation; the ultimate substances are not eternal
 - b. There was only one ultimate substance: Particles
 - c. All the Particles were identical
 - d. Change was impossible

3. A key point that may come up again as we study more natural scientists is whether or not the nature of the Particles is stable (they do not change) and why we might think the nature is stable is because substances which are made of particles, such as Water, have the same Nature everywhere we go and have always (as far as we know) had that nature. If the Particles forming Water could change, what would happen to the Nature of water at different times and in different places?

Name: _____

Section & Course: _____

Teacher: _____

Date: _____

Friday May 1: Isaac Newton's "Rules of Philosophizing"
from *Principia Mathematica*

Welcome to the month of May! God willing, we will soon be playing with abandon again!

Yesterday, as you recall, we leaped ahead in time to the late 17th century and read a brief selection from Isaac Newton on his ideas on the ultimate principles of matter. Today we are going to continue with Newton and look more carefully at his ideas about the "Particles" (as he calls them) that make up the bodies of material things. Again, you should hear echoes of earlier thinkers, especially Democritus.

As you read, though, it is also very important to stay alert to some concerning points Newton is making. Remember that Chemistry is more concerned with the Material Cause rather than the Formal Cause. That's fine, but we must never forget about the Formal Cause. Do you remember which cause is more important? Right, it's the Formal Cause. Do you also remember that many modern thinkers have lost sight of the Formal Cause, causing them (pun intended!) to make some fundamental errors about reality? As you read, see if you can spot where Newton loses track of the Formal Cause and makes some key errors.

Today we will follow these steps:

1. Read the selection from Newton's "Rules of Philosophizing" on pp. 116-117 of the *Nature of Science* textbook. Don't forget to pay attention to the definitions of the bolded words in the sidebar!
 2. Read and answer the quotes and questions which will guide us through this short selection.
 3. Re-read Newton's "Rules of Philosophizing" and answer the remaining questions.
 4. You will complete this worksheet on Google Classroom.
-

Directions: 1. Remember to only continue here after you have read the selection on Newton on pp. 116-117 of the *Nature of Science* textbook. Did you read that yet (circle)?

YES NO

- 2. Read the three quotes below from the selection written in *italics*.**
- 3. Read and answer the explanations and questions about that quote**
- 4. Continue to the next quote and questions**
- 5. Re-read the entire selection**
- 6. Answer the final three questions about the passage**

Isaac Newton's "Rules of Philosophizing" from *Principia Mathematica*
Nature of Science pp. 116-117

Quote 1: "*The qualities of bodies that do not suffer intensification and remission, and that pertain to all bodies upon which experiments can be carried out, are to be taken as qualities of bodies universally... For the qualities of bodies are apprehended (grasped) only through experience...*"

1. Think back in your memory, back to a time when you could give hugs to your neighbors and shake people's hands—right around October 2019. Do you remember studying about particulars and universals, induction and deduction? If you're struggling you can hop over to **pp. 27-28** of *Nature of Science* for a quick refresher. As we've discussed before, many of the fundamental principles we studied earlier in the year are continuing to play a role as we learn new topics. What's fascinating is to see in Quote #1 Newton intentionally using some of these concepts. Not only does he mention qualities being apprehended (or grasped) through the senses (as Aristotle taught us!), but he is also making an argument based on using **which kind of reasoning**? Hint: He is looking at numerous particular cases and then reasoning these cases apply to things in a universal way. He is moving from particulars to universals.
 - a. Induction
 - b. Deduction
 - c. Knowledge of the Cause
 - d. Knowledge of the Fact
2. Review question (related to this Newton quote)! All knowledge begins in the _____.

(worksheet continues on the next page)

Quote 2: *“We experience many bodies to be hard. Hardness of the whole, moreover, arises from hardness of the parts...”*

3. OK – here is where a serious problem jumps out. Do you remember our discussions about significant philosophical errors many modern thinkers make? Newton, unfortunately, has made one of these errors. When he says that “Hardness of the whole... arises from hardness of the parts...”, he is reversing the correct order! Does a human being – as a whole being—have a mind because some of our parts have minds? No. Newton is losing sight of which cause? (Hint: He has trouble seeing that whole things have natures which guide the parts.)
 - a. Material Cause
 - b. Formal Cause
 - c. Efficient Cause
 - d. Final Cause

4. Newton made a mistake that Aristotle had already answered correctly centuries earlier. Despite what we may think or hope, natural science does **not** always progress and advance but sometimes tragically moves backward to earlier errors. It’s happened many times in history, including in our own time. This fact is another reason we want to be sure we know a large part of the scientific conversation so we can help correct modern mistakes. For example, Newton, to some extent, is in the group of people who want to reduce understanding of things to their smallest parts and to think of things in a way that overemphasizes their smallest parts at the expense of the whole and of Form. What is the name for this common error?
 - a. Atomism
 - b. Materialism
 - c. Relativism
 - d. Inductionism

Quote 3: *“...all the least parts of all bodies are extended and hard and impenetrable and movable and endowed with forces of inertia...”*

5. Newton had some ideas that were wrong, but this does not change the fact that he was a genius and came to very thoughtful and interesting insights into the nature of what he called Particles – the things he says make up all matter at the smallest level. Reference the quote above in order to list the **five** things he says are qualities of all Particles.
 - a. _____
 - b. _____
 - c. _____
 - d. _____
 - e. _____

6. Newton’s ideas are clearly related to Democritus from so many centuries earlier. In some ways Newton said very similar things to Democritus about the nature of these Particles, but in other ways he differed. You may want to look at p. 9 of the Week 4 packet to review what Democritus said about what he called “Atoms”. This information will help you compare and contrast Newton and Democritus. Let’s begin with a similarity: **What was one similar belief Newton and Democritus had?**
- a. The Particles had a beginning but will not end
 - b. The Particles have particular odors, though these odors differ
 - c. The Particles are hard
 - d. The Particles will not change
7. What was one different belief Newton and Democritus had?
- a. Democritus said atoms have no hardness but Newton said they are hard
 - b. Democritus said atoms change but Newton said they do not
 - c. Democritus said atoms were made by God but Newton said they were eternal
 - d. Democritus said atoms are impenetrable but Newton said they are penetrable

We have now come to the end of the reading! Good job. Please go ahead and re-read Newton’s words on p. 116-117 in the textbook.

Afterwards, complete the final two questions about Newton that are written out below.

Final questions (there are two):

1. Explain how Newton demonstrates that science can actually regress (get worse) rather than progress?

(worksheet continues on the next page)

2. I know we have talked about Newton's mistakes, but it is important to recognize and respect his genius. His genius extended into other areas, as well, such as Calculus, which he invented! The truth is, though, that we must be careful about some of Newton's ideas because we could accidentally follow his errors, specifically that he may have been rejecting the _____ Cause and paying too close attention to the parts and losing sight of the reality of the _____.
- Material; Whole
 - Efficient; Form
 - Formal; Whole
 - Final; Being