NAME______________________________________ **CLASS**___________ **DATE**______________

DIRECTIONS: READ AND ANNOTATE THE ARTICLE BELOW AND ANSWER THE QUESTIONS AT THE END.

THE SHOULDERS OF GIANTS BY ROBERT CHESBRO

It is always there, but invisible. It holds you down, but you can't touch it. You'll never know a world without it, and you will never escape it. It is gravity. But for something so significant, do we really know what gravity is?

Legend tells us that the idea of gravity came to a man by the name of Isaac Newton in the 17th Century when he was bonked on the head by an apple. True or not, what is remarkable is that Newton basically reduced all observable phenomena to four key "laws" that still hold true today--everything made of anything follows these laws, and these laws cannot be broken.

One of these laws is the Universal Law of Gravitation, and it explains the nature of gravity with such precision that we have used it to send humans to the moon, orbit earth, explore Mars and the moons of other planets, as well as understand how stars and galaxies are born and how they die.

How many things around you are made of "stuff"? A book, a cell phone, air you breathe, trees, a falling leaf, the earth, the moon, stars, you, and everything in between. Anything made of matter has mass, and mass is a measurement of the amount of matter in an object. In our universe anything made of matter will attract anything else with matter.

This means that everything right in front of you is pulling on everything else. So, why doesn't it all lump together in a big pile? Because there is something nearby that has more mass than everything else--the Earth! The Earth has about one million billion billion times more matter than anything else around, so it wins; and everything gets pulled toward *it*.

If you think of it through this lens of perception and then drop a tennis ball, you may see the effect of gravity in a new light--the object is not falling *down*; it is falling toward the *center* of the Earth where gravity is strongest…and the ground just gets in the way.

What's more, if all things with mass attract, then isn't the tennis ball also pulling on the Earth with a force? The answer is yes, and the Earth does in fact move toward the ball, but not enough to measure.

This force of attraction is what we call weight, and things have weight because they have mass. This means that the ball has weight on the Earth, but the Earth also has the same weight *on the ball*! You have weight because your mass and the Earth's mass are attracted. If you put a scale between yourself and the Earth, it will measure that force; but the force is different depending where you are.

Newton's Universal Law states that two factors affect weight: mass of objects and the distance between them. This means that weight can change. If two masses attract due to gravity, they will attract with less of a force if the mass of either or both is reduced. Because your mass is attracted to the Earth's mass this means that if you eat less, get a haircut, or even clip your fingernails, the Earth pulls on you with less force because you have less mass and your weight decreases as a result! Unfortunately, the change is so small that even the most precise instruments cannot record it.

The idea works both ways too. If you reduce Earth's mass, the force of attraction between you and Earth will diminish; therefore, you get lighter every time a space shuttle or unmanned probe is sent into space!

Going to a planet or moon with a different mass than Earth's would also change your weight; although your mass always stays the same, you're always the same amount of stuff.

People often mistakenly believe that astronauts bouncing around on the moon are weightless. Although their weights are considerably less than when on Earth, they still have a force attracting them to the Moon; otherwise they would drift into space. The Moon's mass is about 1/6 that of Earth's, which means the attractive force between it and you would be 1/6 as much as on Earth. You would weigh six times less!

To put this in a more interesting way, a basketball hoop is 10-feet high. Michael Jordan, assuming he was not burdened by the extra mass of a space suit, could slam dunk a basketball in a hoop that was 60-feet tall using the same leg strength! If he were to try a slam dunk on Jupiter, he would have great difficulty getting off the ground because Jupiter's incredible mass would be crushing … and there's no ground at all, just compressed liquidy gas. This means that your weight would change if you voyaged from one planet to another.

If changing the mass of objects doesn't interest you, then you have more options if you want to conduct weight-loss experiments. Newton proved that the distance between objects affects the force of attraction between them. This means the farther away those masses are, the more weakly they are attracted. In this sense, gravity is like cell phone reception--the closer you are to the tower, the stronger the signal is.

So, this means that all you have to do is increase the distance between you and the center of the Earth and you'll lose weight! The next time you climb a mountain or fly on a plane, you have lost weight, but again, not enough to measure. You could even stand on your chair. When people ask what you're doing, you can tell them you're testing Newton's Universal Law of Gravitation and conducting a weight-loss exercise!

Gravity is the mysterious force that holds our universe together and literally keeps our feet on the ground. Isaac Newton claimed that his insights came from the good fortune of standing on the shoulders of giants having benefited from the insights of the scientists that came before him. Perhaps there's a young Isaac Newton in your class at school, or maybe it's even you. Whatever the case, we can all learn from the world around us and stand on the shoulders of giants, and lose a little weight in the process.

Cool Fact #1: Your Weight on Other Worlds

Weight is a measurement of the attractive force between two objects, and it depends on the mass of the two objects and the distance between them. Check out how much a 100-pound person (on Earth) would weigh in elsewhere in the universe….

Earth: 100lbs.

Mercury:	37.8 lbs.	Saturn:	106.4 lbs.
Venus:	90.7 lbs	Uranus:	88.9 lbs.
The Moon:	16.6 lbs	Neptune:	112.5 lbs.
Mars:	37.7 lbs.	Pluto:	6.7 lbs.
Jupiter:	236.4 lbs.	The Sun:	2,707.2 lbs.

A White Dwarf: 130,000,000 lbs.

A white dwarf is a small star with a mass equal to that of our sun, but with a volume the size of Earth

Neutron Star: 14,000,000,000,000 lbs.

A neutron star is an extremely hot star resulting from the collapse or explosion of a larger star. It is made up of sub-atomic particles called neutrons.

Cool Fact #2: Slam Dunk Contest!

A standard NBA basketball hoop is 10-feet from the floor of the court. Check out how high hoops could be for an out-of-this-world slam dunk contest!

Mercury: 27 ft.	Jupiter: 4. 2 ft
Venus: 11ft.	Saturn: 9 ft
Earth: 10 ft*	Uranus: 11 ft
The Moon: 60 ft	Neptune: 9 ft
Mars: 27 ft.	Pluto: 149 ft

Complete this Document Name: ____________________________

The links below can be found on my website: contonascience.weebly.com

Don't forget to fill out the Participation Form and the Learning Survey!!!

1. Your weight on other worlds: http://www.exploratorium.edu/ronh/weight/
    a. Describe what the site is about:

2. Build Your Own Solar System: http://www.exploratorium.edu/ronh/solar_system/index.html
    a. Describe what the site is about:

3. Your Age on Other Worlds: http://www.exploratorium.edu/ronh/age/index.html
    a. Describe what the site is about:

3 things of interest from the reading—restate them

1.
2.
3.

2 things you learned from any of the web links above

1.
2.

1 symbol that shows—with color-coding:

a. How mass affects gravitational force (weight)
b. How distance between masses affects gravitational force (weight)