Big and Small: How Big is Big, and How Small is Small?
Science Facts that are Stranger than Science Fiction . . .

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INTRODUCTION

While talking with a friend, he asked me the following question: how did Max Planck come up with such a small number? He was referring to 6.63×10^{-34} named after Planck as Planck's constant. I could not answer him because I didn't remember the facts related to that number. The more I thought about the question, the more I became interested in small as well as large numbers. Planck's constant is so small such that if we divide the Earth into pieces that small, each piece would be smaller than a grain of sand. I began to wonder about other numbers in science such as Avogadro's number, the electron mass and charge, the size and age of the universe and many more. When I was told about the Institute, I thought I could use the seminar to express my interest in numbers, big and small, and eventually relate that to the seminar title "The science of science fiction."

Fiction comes true

"Fly me to the moon, and let me play among the stars, and let me see what spring is like on Jupiter and Mars" (Howard). A fantasy song by Tony Bennett and the fantasy became a reality when we landed on the moon in 1969. What was fiction then is now reality, and what is fiction now, may become reality tomorrow.

Definition of Science Fiction

Before we go much further, I like to give four of the 52 definitions of science fiction. The following are compiled in Gökçe's website, which is listed in the bibliography below:

- According to Ray Bradbury, "Science fiction is really sociological studies of the future, things that the writer believes are going to happen by putting two and two together."
- According to Reginald Bretnor, "Science Fiction: fiction based on rational speculation regarding the human experience of science and its resultant technologies."
- Terry Carr defines science fiction as "the literature about the future, telling stories of the marvels we hope to see—or for our descendants to see—tomorrow, in the next century, or in the limitless duration of time."
- And finally, according to Donald A. Wollenheim "Science fiction is that branch of fantasy, which, while not true to present-day knowledge, is rendered plausible

> by the reader's recognition of the scientific possibilities of it being possible at some future date or at some uncertain point in the past."

From the above definitions, we see that although they are stated in different ways, they all agree on the meaning. To put it in my own way, science fiction is the way of imagining the future based on some strange science fact that we know of today.

What is that unit about?

After many years of teaching science and after talking with a friend (see the introduction), I began to have an interest in numbers, big and small, and their meanings. I used to read numbers, written in scientific notation, and attach little or no meaning to them. When I thought more about some of those numbers, I realized that some of these numbers are either so big or so small that they are beyond any one's imagination. On a time scale, we have time that goes from a nanosecond, 10^{-9} second or less, to billions and billions of years. On the mass scale, we deal with a mass of atomic or subatomic particles, to the mass of the universe. These numbers seem unreal and unbelievable to most people. These numbers also play a role in the strange facts in science that will be introduced next.

We hear about many strange science facts that boggle our minds such as black holes, or the size and age of our universe, or antimatter. This unit intends to introduce some of those facts and show how they are being used in science fiction. On the other hand, we will find out if there are viable science facts behind these fictions. We will also realize that many of the science facts are much harder to believe than many of the science fictions that we see in movies or on TV. We call this part of the unit "science facts that are stranger than science fiction."

We also live in a universe that is huge and complex and it is hard to think that we are alone. Therefore, aliens likely exist, and it is possible that they have made their visits to our planet undetected or at best detected by only few of us. UFOs and aliens seen by some and not by others may be true. We may have people among us with extraordinary powers that see what most of us cannot see.

Who are the students?

This unit is intended for senior high school students who have completed much of their science classes IPC, chemistry, and physics and who want to pursue a career in science. It is also intended for gifted and talented students. It is meant to teach them to ponder and think about what they have learned. It will also teach them to observe and inquire, to research and create. This unit can also be presented to other science students to bring out their interest and curiosity. The requirements can be different for different levels.

At the end of teaching this unit, I expect the students to have the ability to research topics of interest to them, look for unusual phenomenon, and observe strange and unusual patterns they encounter in their lives. The students will be able to examine what they read more thoroughly and very carefully.

This unit is divided into two parts. The first part deals with the extremes in numbers and how far apart they can be. How big is big and how small is small? It deals also with the strange and weird things in science, science facts that are stranger than fiction. Science fiction characters, stories, movies etc that are based on hard to believe science facts such as black holes, mass and energy equivalence, antimatter, and how much a billion light-years is, as well as the age and size of the universe. The students have a lot to choose from. They can make their own science fiction characters or science fiction stories based on the information they read and gather.

BIG AND SMALL, THE POWERS OF TEN

How big is big and how small is small? Is 6.02×10^{23} big? How about 6.63×10^{-34}, is this small enough?

Before I begin this section I would like to ask the following question. If I give you a billion dollars, but I ask you to count it first dollar by dollar, would you accept the offer? Most people will say yes. If one starts counting now, and assuming that each number takes one second to count, it will take more than 33 years to count a billion without sleep and time out to eat. Of course, this is impossible to do. Now we know that Bill Gates can in no way count his billions.

If we even think about our own mortality, we hope to live to about 80 years, and that is 80x365 or 29,200 days, and that in turn is 700,800 hours, or about 2.53×10^{9} seconds. In other words, we live only 2.53 billion seconds. Our heart beats a little more than that during our lifetime. This is considerably small compared to the numbers we are sometimes dealing with in science.

Avogadro's Number and Planck's Constant

A number like 6.02×10^{23} is very big. This number is called Avogadro's number. It is the number of atoms or molecules in one-gram mole of a substance i.e. one gram of hydrogen gas contains this number in hydrogen atoms. More accurately, two grams of hydrogen gas contain this number of hydrogen molecules, since hydrogen does not exist in nature in the atomic form. If we divide this number in dollars among all the people on Earth, everyone, man, woman, and child will get 10^{14} dollar, a very large amount of money. On the other hand, the number 9.11×10^{-31} is very small. This number represents the mass of an electron in kilograms. If we use this information, we can calculate the number of electrons in one gram at about 10^{27} electrons, a very large number too.

Another very large number is the nuclear density (black-hole density). The radius of the nucleus is given by the relationship $r = r_o A^{1/3}$ where $r_o = 1.5 \times 10^{-15}$ m, and A is the atomic mass. The volume of a nucleus (sphere) is given by $4/3\ \pi\ r^3$ and for the hydrogen nucleus (A=1) this becomes 1.05975×10^{-44} m^3. The mass of the proton (the nucleus of hydrogen) is 6.7×10^{-24} kg. Therefore, the density of the hydrogen nucleus, or the nuclear density is 6.32×10^{20} kg/m^3, a very large amount indeed. One cubic centimeter of nuclear material has a mass of 6.7×10^{14} kg. No crane in this world can lift such mass. If we were to use nuclear material only, the Earth could be condensed into a ball that fits inside a six-block radius of downtown Houston.

On the other hand, a number like 6.63×10^{-34} is very small. It is called Planck's constant after a German scientist who first derived it. That number is so small that it is hard to believe that such a number would have a meaning. That is why Planck's first report was not immediately accepted. In fact, Planck himself didn't think that his derivation of that number would survive for any length of time. He thought that someone would come up with a better explanation for cavity radiation than his. However, it was destined to profoundly influence the new physics emerging with the 20th century. The following presentation will explain Planck's constant in easy to follow terms:

> Planck's constant represents the concept of "slop" as applied to the universe as a logical system. The term mechanical slop is the amount of free play in a mechanical device which is engineered into its design to facilitate workability, e.g. if you have a cylindrical sleeve (four inches inside diameter) and a rod (four inches outside diameter) which is to fit into the sleeve, you have a mechanically impossible situation. You will not be able to insert the rod unless there is some slop gap. Too much slop, the rod wobbles, too little and it doesn't go in. If the universe were entirely deterministic (no slop), it couldn't go; if it were totally indeterminate (infinite slop), there would be no logic to it. (*Planck's Constant*)

As we see, we are dealing with extremes on both sides. We are looking into the atom and at the same time looking into space. While the atom is so small, the universe is so large and we have much interest in both. Where do we humans fit into this? It depends whether we are looking into a microscope or through a telescope.

The magnitudes of these big and small numbers are masked by the use of scientific notation. We became accustomed to this notation such that we do not stop and think how big or small these quantities are. If we write these numbers in a standard way, we can get a better feel of their magnitudes. However, they will be very hard and cumbersome to read, as well as subject to making a lot of mistakes.

The *Powers of Ten* web site demonstrates the effects of moving from a very large number (distance) to a very small number (distance). It gives a view of the Milky Way at 10 million light years from Earth, then moves through space towards the Earth in successive orders of magnitude until you reach a tall oak tree just outside the buildings of the National High Magnetic Field Laboratory in Tallahassee. After that, it begins to move from the actual size of a leaf into a microscopic world that includes leaf cell walls, the cell nucleus, chromatin, DNA and finally into the subatomic universe of electrons and protons.

SCIENCE FACTS STRANGER THAN SCIENCE FICTION

The Age of the Universe

According to the Big Bang theory, the universe was created 12 to 15 billion years ago. These are big numbers, and it makes no difference whether this is 12, 15, or 100 billion years, or 100 million years, the whole thing is beyond most people's imagination. However, these numbers have importance to scientists, especially those in astronomy. If we choose the estimate to be 12 billion years, and we try to put that time on a more compressed and easy to follow scale of one year, then every billion years would correspond to one month. On this compressed scale, some notable events are:

January 1, 12 am	Big Bang occurs
Early February	Our Milky Way Galaxy forms
August 12 (approx)	The Earth and Sun are formed
September 28 (approx)	First life arises on the Earth
December 13	First animal appears on the Earth
December 25	Dinosaurs now walk the Earth
December 30, 12:33 am	Dinosaurs wiped out by asteroid's collision
December 31, 9:00 pm	First humanoid life appears
December 31, 11:59 pm	*Homo Sapiens* first appear
December 31, 11:59 pm +30 s	Agriculture developed
December 31, 11:59 pm +47 s	Pyramids built
December 31, 11:59 pm +59 s	Shakespeare writes plays

The universe is so old that all human history occupies only the last 13 seconds or so of the year (Wright).

The Size of the Universe

It is preferable to assume that the universe is infinite in size. A finite universe would have an edge, and what would be beyond that?

The universe could be finite and have no edge or end, it could be a wraparound, like the Earth, having no edge. The Earth's surface is curved, it wraps around and closes in on itself. There is only a finite amount of area yet there is no end or edge. If we start at one point in Earth and keep moving in straight line, we will end coming back to the same point. The universe may be a curved three-dimensional space that wraps around and closes on itself. If you set out in a spacecraft heading one direction, you might end back at the same spot from the opposite direction.

The entire universe, or just what we were able to detect of it until now, is roughly 25 billion light-years across. That’s 147,000,000,000,000,000,000,000 miles. Our solar system, from the Sun to Pluto is .00063 light-years across or 3,720,000,000 miles. That makes our solar system 39,500,000,000,000 times smaller than the whole visible universe. To put that into a more meaningful perspective, if the surface of the Earth represents the entire visible universe, the solar system on that scale would be one-millionth of a meter wide, the size of a single, small bacteria, and if that bacteria is the whole solar system, imagine how much smaller the Earth and people are on that scale.

A universe this size is very likely to have planets that can support life on it. It is highly possible to have other beings in this universe besides us. We may, and very likely may not, be able to contact this other form of life. Such contact will only happen by coincidence, and not by our methods of search.

The universe is also full of stars, arranged in enormous groups called galaxies. Our Sun is one star among 100 billion stars in the Milky Way Galaxy. There are about 100 billion galaxies in the universe, each with a comparable number of stars. With some simple calculation, we can figure out the total number of stars in the universe:
(100 billion stars/galaxy) X (100 billion galaxies)=(100×10^9) X $(100 \times 10^9) = 10^{22}$
How many is that? The number of stars in the universe is more than the number of grains of sand on all the beaches of the entire Earth! More stars than grains of sand! Unbelievable (Lochner, Delsemme)!

One billion-light-year

One billion-light-year is a measure of the distance traveled by light in a billion years’ time. Light travels at the speed of 3×10^8 m/s. One billion years is equivalent to $365 \times 24 \times 60 \times 60 \times 10^9$ seconds. Therefore, the distance traveled by light in a billion years is 9.46×10^{17} m or 9.46×10^{14} km, a very large distance indeed. Compared to the distance between the Earth and the Sun, this is 6.32×10^6 times larger. A light that has traveled that much distance must have come from a star that is very far away. That gives us an idea about how big our universe is. In fact, we observe light that has traveled many times more than the distance above, billions and billions of light years as the late Carl Sagan used to say on the Johnny Carson show.

Mass and Energy, $E= mc^2$

Why can’t we accelerate something to go faster than the speed of light? As something is moving with respect to another object, we say that the moving object has a certain amount of energy due to its motion and that energy can be used to do work. Einstein argued the only way we can ensure that it cannot be accelerated indefinitely is if there is a universal equivalence between mass and energy. The more energy an object has, the heavier it gets and the larger the force needed to accelerate it further. As the object speed gets closer to the speed of light, an infinite force is needed to speed it up to the speed of light: it never happens!

There is more to the equivalence of mass and energy. It also implies that an object of mass m has energy, just by virtue of its existence. The specific formula is **$E=mc^2$**. This formula plays an important role in nuclear reactions, mass defect, binding energies, in atom bombs etc.

To get an idea of how powerful this formula is, suppose we have a 6g sheet of paper, and we only transform ½ of it completely into energy according to the above formula, the energy released is so big that it can turn on a 100 W light bulb for about 86,000 years, or turn on a hair-dryer for about 4,000 years.

Fission and fusion are nuclear processes that use this formula to calculate the energy released in both cases. In both cases, a certain amount of mass is converted into energy according to the above formula. The bigger the amount of mass converted, the more energy we get. In fact, mass-energy conversion is one of the methods being considered seriously by scientists for a future energy source.

The splitting of a heavy nucleus into nuclei of intermediate mass is called fission. In the case of uranium 235, a slow neutron causes the uranium nucleus to split into barium 138 and krypton 95 and 3 more slow neutrons. A mass defect of 0.3 amu is converted into energy. This means that the masses of the products are 0.3 amu less than the reactants. Since amu = 931 Mev, the reaction will lead to an energy release of 0.3x931=300 Mev. The new 3 slow neutrons cause three other Uranium 235 to split, and an additional 3x300 Mev are produced. This chain reaction will continue leading to more and more energy. The process will continue until the desired amount is reached, where a process to slow down the reaction is introduced.

In fusion, two small nuclei are made to combine to produce a bigger nucleus. A mass-defect will also occur in this situation and is converted into energy the same way as above (Wudka).

Antimatter

The history of antimatter began in 1928 with a young scientist named Paul Dirac (Wudka) who generated a strange mathematical equation that suggests the existence of a particle of equal but opposite charge to the electron to exist in nature. Of course, such a particle was known already – namely the proton. However, Dirac's equation suggested that the particle should have the same mass as the electron, whereas the proton is almost two thousand times heavier. This discrepancy between observation and the "naïve" interpretation of the mathematical formula remained a puzzle for four years until the

American physicist Carl Anderson discovered, among the cosmic rays bombarding the Earth, a new particle whose mass was identical to the electron’s but whose charge was opposite – that is, positive. This “anti-electron” soon became known as the positron. The search for the constituents of antimatter, antiparticles, continued and it has been a major scientific and technical evolution for over 70 years.

Antimatter is the same as matter but made up of antiprotons and positrons. An antiproton is a negatively charged proton instead of the positively charged one we are accustomed to. A positron is a positively charged electron instead of the negatively charged electron we know of. Our world could very well be the antimatter world, while the opposite of it is the matter world. It does not matter which way it is, all we know is that these two exist. Since we are more comfortable with the idea that our world is made of matter, then the opposite of that will be an antimatter world.

At the Fermi National Accelerator Laboratory just outside Chicago, or Fermilab for short, antiprotons are made, and it is the largest repository of antiprotons (Krauss). Since matter and antimatter combine to annihilate each other and produce energy, it is important to contain the antiprotons produced in Fermilab. Since protons circulate under the influence of a magnetic field, antiprotons will also circulate under the influence of a magnetic field but in the opposite direction, and therefore can be confined by a magnetic field.

Antiprotons can fuel starships by combining them with protons to produce energy. Antimatter containment is fundamental to starship operation, since the failure to do so will lead to catastrophic results. The containment of antimatter aboard starships is plausible, and in fact uses the same principle that allows Fermilab to store antiprotons for long periods. Antiprotons and positrons are electrically charged particles and can be made to accelerate through an electric field and then enter a magnetic field of an appropriate strength to travel in a circular path almost indefinitely.

Antiprotons must be produced at a much higher rate to be successful as a starship fuel. At the present rate, it will take many years to produce enough antiprotons to fuel a ship to the escape velocity. A proton and an antiproton will annihilate each other and produce a photon whose energy can be calculated from the mass energy formula $E = mc^2$ Since the mass of the proton is $1.67x10^{-27}$ kg, and the speed of light is $3x10^8$ m/s, the energy released from this process is about $2(1.5x10^{-10})$ j, since we have two equal masses. Since 1ev = $1.6x10^{-19}$ j, this becomes $1.9x10^9$ eV, a small amount of energy.
Fermilab produces antiprotons through the medium-energy collision of protons with a lithium target. Every now and then these collisions will produce an antiproton, which is then directed into the storage ring. When operating at an average efficiency, Fermilab produces about 50 billion antiprotons an hour. If all these antiprotons converted into energy, this would result in a power generation of about 1/1000 of a watt! Put another way, you would need about 100,000 Fermilab antiproton sources to power a single lightbulb! Since the total annual cost of running the antiproton source at Fermilab is $48

million, it would cost at present time more than the annual budget of the U.S. government to light up your living room in this way. A much more effective means of producing antimatter is needed before we could ever think of using matter-antimatter as a source of energy.

It is believed that after the big bang, the number of protons created were more than the number of anti-protons by 1 in 10 billion. Scientists arrived to this conclusion by comparing the number of cosmic rays in the universe to the number of protons (Mondardini).

Black Holes

Loosely speaking, a black hole is a region of space that has so much mass concentrated in it that there is no way for a nearby object to escape its gravitational pull. If we are standing on the surface of a planet, and throw an object upward, it will return. However, if we throw hard enough, we may make it escape the planet's gravity. The speed with which we throw an object for it to just barely escape the planet's gravity is called "escape velocity." For the Earth, it is 11.2 km/s (about 25,000 mph), while the Moon's is only 2.4 km/s (about 5,300 mph). For a black hole, the escape velocity is greater than the speed of light. Since nothing can go faster than the speed of light, nothing can escape the gravitational field of a black hole. A beam of light would be pulled back and would be unable to escape, thereby making the object "black."

The idea of a mass concentration so dense that even light would be trapped goes all the way back to Laplace in the 18th century. Immediately after Einstein developed general relativity, Karl Schwarzschild discovered a mathematical solution to the equations of the theory that described such an object. Much later, in the 1930's, Oppenheimer, Volkoff, and Snyder thought about the possibility that such objects might actually exist. These researchers showed that when a sufficiently massive star runs out of fuel, it becomes unable to support itself against its own gravitational pull, and should collapse into a black hole.

The horizon of a black hole has some very strange geometrical properties. To a far away observer, the horizon seems to be a nice, static spherical surface. But once we get closer to the horizon, we realize that it is moving outward at the speed of light. This explains why it is easy to cross the horizon from outside to inside but never vice versa. To cross the horizon from inside to outside, you have to be traveling faster than the speed of light, and that is not possible. Therefore, you can't escape the black hole. Once you are inside the horizon, spacetime is distorted so much that the coordinates describing radial distance and time switch roles. That is "r," the radial coordinate becomes a time-like coordinate, "t," and vice versa. As a consequence of this, you can't stop yourself from moving to smaller and smaller values of r, just as under ordinary circumstances you can't avoid moving towards the future (that is, towards larger and larger values of t). Eventually, you are bound to hit the singularity at $r=0$. You may try to avoid it by firing your rockets, but it's futile: no matter where you go, you can't avoid your future. Trying to avoid the center of a black hole is like trying to avoid tomorrow.

How big is a black hole? This can be answered by how massive it is or much space it occupies. However, a more massive black hole will occupy a bigger volume. We expect a black hole to weigh about as much as a massive star. A typical mass of a black hole would be about 10 times the mass of the Sun, or about 10^{31} kg. A black hole with the same as the Sun, would have a radius of 3 km. So, a typical 10 solar mass black hole would have a radius of 10 km, and a million solar mass black hole would have a radius of 3 thousand km.

If you fall in a black hole, what will happen? You will be able to see images of far away objects distorted in strange ways, since the black hole gravity bends light. However, no one can see you since light can't escape the hole. What will happen to you is that you will be moving fast towards the center and depending on the size of the hole, you will eventually hit the center (the singularity) sooner or later.

Is there a white hole? Solutions to the equations of general relativity suggest as we have black holes, we can also have white hole. Since a black hole is a region of space from which nothing escapes, a white hole is a region of space into which nothing can fall, just as a black hole can only suck things in, a white hole can only spit things out.

What is a wormhole? So far we have been talking about black holes that are not rotating and have no electric charge. If we consider black holes that rotate and/or have charge, things get more complicated. In particular, it is possible to fall into such a black hole and not hit the singularity. In effect, the interior of a charged or rotating black hole can "join up" with a corresponding white hole in such a way that one can fall into the black hole and pop out of the white hole. This combination of black and white holes is called a wormhole.

Is it possible for the Sun to become a black hole? It is highly unlikely that will happen soon. However, if the Sun becomes a black hole, the Earth will lose one of the essential factors supporting life on it. The Earth will lose the energy from the Sun and will freeze. The Sun's rays are also important for photosynthesis and the survival of green plants on Earth and so plants will not grow. However, our solar system will continue to go in its orbital motion as usual but in the dark since the Sun is replaced by a black hole of the same mass.

Are there evidences that black holes exist? Indirect evidences, just like those connected with the electron. Scientists have observed light reacting to black holes in the manner predicted as above (Bunn).

The Sun's Radiation Energy

The Sun puts out too much energy. The Sun's energy output ($3.86\text{x}10^{33}$ ergs/s or $3.86\text{x}10^{18}$megawatts) is produced by nuclear fusion reactions (Bunn). Each second $7.00\text{x}10^{8}$ tons of hydrogen are converted to about $6.95\text{x}10^{8}$ tons of helium and the difference of $5\text{x}10^{6}$ tons are converted into energy according to the formula $\mathbf{E=mc^2}$ which amounts to $3.86\text{x}10^{18}$ megawatts of energy as mentioned above, in the form of gamma rays. As it travels out toward the surface, the energy is continuously absorbed and re-emitted at lower and lower temperatures such that by the time it reaches the surface, it is primarily visible light. For the last 20% of the way to the surface the energy is carried more by convection rather than by radiation.

If the Sun puts out such huge amount of energy, what will a star 10 or 100 times the Sun's size do? This makes us wonder about what is going on out there in our universe. What we are able to see in our solar system represents very little of what goes on in our universe.

The amount of the Sun's energy that reaches the Earth is only a small fraction of the total Sun's energy. This amount is just enough to provide us with our needs. In fact it is the right amount such that any more or less would be harmful to our lives. To calculate the amount of energy that reaches us from the Sun, we proceed as follows. The intensity of the sun at a distance d from it is given by $\mathbf{I} = (\mathbf{P}/4\pi d^2)$ where $\mathbf{P}$ is the energy output of the sun. At the Earth's location, d would be the average Sun-Earth distance of $1.496\text{x}10^{11}$ m. The amount received by the Earth is given by $\mathbf{I}$ times the cross-sectional area $\mathbf{A}$ of the Earth (πR^2), where R is the radius of the Earth, $6.37\text{x}10^{6}$ m. The amount of energy reaching the Earth from the Sun is therefore $\mathbf{IA}$ or $\mathbf{P}_E = (\mathbf{P}/4\pi d^2)\,\pi R^2 = \mathbf{P}\,(R/2d)^2$. If we use the above values of P, d and R we get $\mathbf{P}_E = 3.86\text{x}10^{18}\,(6.37\text{x}10^{6}/2\text{x}1.496\text{x}10^{11})^2$ megawatts=$1.75\text{x}10^{9}$ megawatts.

From the above calculations we see that the amount of energy reaching the Earth from the Sun is less than one half of one billionth of the Sun's output. A very small portion indeed, and yet it is the right amount for us to survive on the face of the Earth. Some of this energy is used to warm up the Earth. Other parts are radiated back to the outer space. A radiative balance must exist according to the principle of conservation of energy (Fox, et al.). According to this principle, energy received from the Sun must be equal the energy used and re-emitted by the Earth (Arnett).

SCIENCE FICTION FLIP-FLOPS

Watching a science fiction movie, you get to a point in the film where you say, "Oh no that can't happen!" Some of the most common flip-flops are:

- Sound where there is no medium to transmit the sound.
- Fire where there is no oxygen.

- High gravity on small asteroids where there should be little or no gravity at all.
- Cases where the principle of conservation of momentum is broken.
- Walking inside space ships like walking on Earth.

Fictional Characters, and How Plausible Can They Be?

This part deals with science fiction characters such as Superman and Spiderman. How realistic are these characters? Does science support these possibilities? Is it possible to be Superman? Is it possible to be a Spiderman?

Superman

If you come from the planet Krypton like Superman did, you may have Superman qualities on Earth. If the planet Krypton were more massive than the Earth, people on that planet would be more muscular than the people on Earth and therefore would be strong. They will also be able to walk on Earth (more or less like jumping and flying), due to a lower gravity on Earth than they were experiencing on Krypton. In short they will have superhuman characteristics.

However, if you came to Earth from the planet Krypton when you were only a child (as Superman did), and you grow up among humans, you would probably have no extra powers than humans. You may be a little more stronger but not super-strong.

Spiderman

Spiderman, a recently released movie, takes an ordinary human being and through a bite by a spider becomes a superhero. His genes change and he becomes strong with perfect vision, and becomes capable of casting a web like a spider. Becoming strong is a little too much to see through a bite from a spider, since the spider is not a strong creature. However, being able to cast a web like a spider is somewhat feasible, since his genes made the necessary transformation to do so. However again, one might be able to say that the venom from the spider could cause a human to undergo both types of transformations, strong and able to cast a web.

Creating New Science Fiction Characters

Here, the students are asked to develop their own science fiction characters from their own science background. They may use a character to represent an element of the periodic table such as the Sodiumman whose characteristics are the properties of the element sodium, very reactive, cant live in an oxygen environment. Can breathe nitrogen, and get energy from oxygen. Live only in an environment where oxygen represents his food source.

The fictional character may be from here (Earth) or from another planet. These characters must be scientifically plausible and have human like characteristics such as sleeping, eating, walking, communicating, and thinking. The fictional can be a normal person who makes the transformation only when needed, e.g. the incredible Hulk, Spiderman, or the invisible-man.

The fictional character may be able to something other human beings can’t do, e.g. turn dust into gold, or charcoal into diamond, or be able to disappear and reappear in other places, live under water, and so on.

Conclusion

Is it possible to make a connection between the above different topics? Yes, extreme numbers are hard to imagine and therefore make strange science facts. Strange science facts are sometimes the basis for strange science fiction. While we have touched only a few of these facts, there remains many more such as Heisenberg’s uncertainty principle, the theory of relativity, wave-particle duality of light, supernova and many more. This paper is only meant to open the student’s eyes to the new world of science. It is the purpose of this paper to bring out their interest and continue their investigations with some guidance from their teachers.

Teachers also need to know a host of topics and be willing to learn more as they work along with their students.

LESSON PLANS

Three lesson plans can be easily drawn out of this unit. More lesson plans can be made depending upon the level of students. The first lesson deals with big and small. The second lesson can be built around strange science facts. The third lesson has to do with creating a fictional character and a story that goes with it.

Lesson One: Big and Small

Student Objectives

Comprehend, analyze, interpret, and evaluate scientific data. The student will be asked to pick an object of certain importance in science and research it independently during class and on their own time. As an example, the electron; how it was discovered; its mass, and how it has been determined; its charge and how it has been measured.

Activities

This lesson can be considered a research project to find small and big numbers of certain importance in science such as the electron mass and charge, proton mass and charge, the size and the mass of the Sun, the size and mass of Mars and more. Some of these numbers can be found at the end of science books in appendices under constants.

The students are then divided into small groups depending upon the size of the class. They brainstorm their results of their search and talk about them and exchange ideas. Each student then picks a value to research and writes more about it in details. Some may choose big numbers like the speed of light, or Avogadro's number, and others may choose small numbers like the mass and charge of the electron. Every student is to give a reason for his own pick. Students are then asked to make a presentation of their work to class and answer questions.

Lesson Two: Science Facts that are Stranger than Fiction

Student objectives

Observe, analyze, interpret, synthesize, and evaluate science facts presented to him/her. Look for unusual and strange phenomenon, patterns, that can only be explained by science. As an example, two people stand on the shore while two ships arrive. Both ships blow their horns. Why does one person hear the sound very loudly and the other doesn't?

Activities

Students are asked to research phenomenon of interest to them on the web, in magazines, and periodicals. The students then get together in groups and brainstorm their findings.

Each student is then asked to choose a topic to research in details on his or her own independently in class and on their own time. Students are then asked to make a presentation to the whole class and answer questions.

Lesson Three: Fictional Characters

Student Objectives

Develop, synthesize, create, and evaluate fictional characters of their own making. Each character will have a story built around it. As an example, the Iron-man, a man who is supposed to be as strong as iron. He, most of the time is an ordinary person, but turns into an iron-man at times of need when he fights evil. The story can evolve around good versus evil.

Activities

Students are divided into groups – the size of each depends upon the size of the class. They discuss among themselves what characters they are thinking about and how they envision each character. They exchange ideas and get support from each other.

Each student chooses a character and builds his story around it. He or she can do that independently in class and on his or her own time. The student is then asked to make a presentation to the whole class and answer questions.

How Much Time Should be Spent on these Lessons?

The above three lessons are not the kind that can be done in one period. They can in fact be divided into different segments and stages. The kind of student who would be doing this work is a student who is familiar with a lot of concepts in science. He knows about physical constants, and what they mean.

If we divide the above three segments into an ordinary class size lesson, we would get a minimum of five each. In total we will need 15 class periods to complete the above lessons. As an example, one can divide the first lesson on big and small into 5 sub-lessons.

Sub-lesson 1

The first thing to do is to present the idea of each lesson. Introduce students to big and small numbers and give examples. This presentation may take a whole period.

Sub-lesson 2

The next period is to ask the students to spot some large and small numbers. Distribute literature that has some of these numbers. Let them discover some of these numbers on their own

Sub-lesson 3

The third period is to ask the students to get in groups to discuss the numbers they chose, exchange information among themselves and try to explain to the best of their ability the meanings of the numbers they choose.

Sub-lesson 4

The fourth period is to ask them to write independently about the numbers they chose and give enough background information about them.

Sub-lesson 5

Each student makes a 5-10 min presentation and answers questions.

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