The Force: Going Back to Basics

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Lo mas maravilloso es maravillarse.
—My brother, Felipe

INTRODUCTION

This unit is about everything in the universe. The topic seems broad, but the purpose is to explain to students the relation and the sequence of everything around us. This unit presents a structure based on the basic forces of the universe, which explain every scientific happening. The purpose is to introduce to students how every thing they see around and every movement on earth and beyond follows the same simple principles and are related to each other through only four forces generated during the Big Bang. This unit talks essentially about the forces of the universe and the laws that bind them.

In this introduction you will see first a background description that defines the terms that will be used and studied during the different lessons, then it describes the method and the sequence that will be followed to teach the concepts. For a fast overview of the lessons to be taught, you could look at the list presented in the subtitle "Procedure," at the end of this introduction. You will find after that the individual lessons proposed to teach the concepts.

My unit is called "The Force" because I would like to explore with my students the basic forces that make the universe a unit: quarks, movement of quarks, gravity, electromagnetism and strong and weak forces, the parts of the atom in full activity. I want them to understand "the power of motion" from which everything in the universe that we know is derived.

Then I would like them to understand compound forces: atoms, matter, systems, cycles, the derivation of physics, chemistry, biology, behavior, and measurement of time—the immense universe in its sequence and logic.

And wondering about all these wonders, the human conscience looking at the world, I would like to tell my students: "Now, go ahead, you look at the world. What do you wonder? " From this the discovery process and the scientific discussion will reveal all their meaning.

The most important part of these lessons is the final discovery process, the independent wondering and the finding of explanations by each student. The basic concepts will be taught, but the larger purpose is for students to establish a relation of

their recently acquired knowledge with the world that surrounds them and to awaken a curiosity and a view of things that really makes sense in their minds.

Science lessons, as they are portrayed in many elementary books, are independent topics that don't seem related to each other. The purpose of this unit is to establish the background for science learning, the basis from which all science lessons would have a logical sequence.

Many scientists had been wondering about the same universal connection. First they came up with the concept of the ether, later on they found the atom, and now they talk about quarks. They also keep going back in time, looking for the beginning of human kind, the beginning of earth, the beginning of the universe.

Fourth grade students don't know about all this wondering that has been going around human kind for centuries. They just know about their own wondering. They don't know the answers scientists have given to these questions.

I believe our job as teachers is to introduce students to these marvelous findings that have brought science to the place it is today, and then realize what else is for them still to discover. Even though it is important that they find on their own the marvels of science, we don't want them to invent the wheel again.

An important answer scientists have given to all this wondering is the theory of the Big Bang as an explanation of the beginning of the universe. Until now, most of the happenings in the universe could be logically explained through this event, that's why I have chosen it as the basis for this unit.

Background

The Big Bang

In 1927 a scientist called Georges Lemaître was looking at the stars and he realized a pattern in which stars seem to be slowly but steadily getting apart from each other. Like in a movie going in reverse, he imagined that if the space between stars was expanding, going backwards in time they should have been closer and closer and he proposed that something like an explosion should have caused such initial expansion. This explosion was later called the Big Bang.

The image of an explosion fit the patterns of stellar movements, and many other scientific realities. The theory of the Big Bang complies with Albert Einstein's formula $E=mc^2$. Energy is the same thing as matter multiplied by the constant of the square of the speed of light, which means that also matter is equal to energy divided by this constant. This means that you can obtain matter from energy, just as well as you obtain energy

from matter. Matter as we know it, was generated from energy that at some point of time, around fourteen billion years ago, exploded in the Big Bang.

Until now, both the theory of the Big Bang and Einstein's formula have been proved through several different circumstances. Nuclear bombs are made based on Einstein's formula, and the observation of stars and further away galaxies keep showing the pattern proposed in the theory of the Big Bang, even though there are still certain measurements about the rate of the expansion that still puzzle scientists. Until those specific questions are otherwise answered, the theory of the Big Bang and Einstein's theories will continue to have the most validity to explain the world around us.

From the Big Bang, a cloud of energy and matter appeared and its rapid expansion accompanied by local accretion generated atoms, molecules, stars, and our solar system. The movement of our solar system is a confirmation of this Big Bang.

The energy exploding during the Big Bang resulted in matter and four basic forces that determine the shape and sequence of the universe and are still present in every microscopic or macroscopic detail of the universe. These forces are electromagnetism, gravity, and strong and weak forces. Every happening in the universe is related to at least one of these forces.

The Four Forces

The purpose of this unit is to teach these basic concepts of science as the background to understand any other scientific reality. First, students will explore the concept of force itself. A force is what causes anything to happen. A force is a push or a pull. Any kind of movement is originated by a force, and there are only four forces in the universe: electromagnetism, gravity, and strong and weak forces. The video *All about Forces and Gravity*, developed by Schlessinger's Physical Science for Children series, is a good resource for exploring the concept of force as an acting presence for any happening. Some forces studied in the video, such as friction and water pressure, are the macroscopic evidence of the microscopic behavior of the electromagnetic force.

Some scientists have been trying to summarize the four basic forces in just one, but they haven't quite been able to do so. For now, we still have four basic forces: Electromagnetism, gravity, and strong and weak forces. All of them have to do with the shape of the atom and how its parts move. An atom is what matter is made of. An atom, formed by a nucleus and outer layers of electrons, looks a little bit like a solar system. The sun would be the nucleus and the planets the layers of electrons. Both the nucleus and the electrons around it are made out of quarks or little entities of energy.

The strong and weak forces happen in the nucleus of the atom. The strong force is what keeps the nucleus together. Acting on this force is what generates the greatest amount of energy. This can be done by either splitting nuclei or combining nuclei.

Breaking the nucleus is what atomic bombs are about whereas the sun's energy comes from a continuous combining of nuclei to form larger ones as occurs in a hydrogen bomb. The sun is, therefore, a continuous explosion of hydrogen bombs.

The weak force is the decay of energy—a change in the nucleus that makes an atom change into something different. Even though these forces are also present in each of our atoms and are so very powerful, they are balanced enough for us not to worry about them. It is good though, that they allow the nucleus of every atom to stay together as they are, so that matter could be as it is and as we know it.

The most interesting of the forces for our daily life is electromagnetism. Most evident scientific realities are caused by the electromagnetic force, from fire, electricity, and magnets, to the bonding of molecules that even make life possible. All our electronic gadgets and communication devices work by electromagnetism. A table stands up because of the electromagnetic force. Our bodies and all of our movements are caused by electromagnetism. Even our mind is a continuous work of electromagnetic forces.

Electromagnetism is most directly linked with the electrons around the atom. Electromagnetism can manifest itself in the movement of electrons in some matter, which causes movement of other electrons in other kind of matter. When we rub a balloon with wool or with our hair, we are robbing some electrons from the outer layers of the atoms of the balloon, which makes it electrically charged. The matter in the balloon is then trying to balance those missing electrons and will try to get them from somewhere else. So, if you put the balloon on the wall, it will attach itself to the wall to get the electrons it is missing. This is called static electricity.

A similar effect happens in the electricity we use for our machines, the only difference is that atoms are placed in line, like dominoes, and when one atom gets an electron from the next one, this one will get another one from the next one, and this one from the next one, and this one from the next one, and so on, which creates a path or a current. Permanent magnets work with the same principle, only that the electrons are somehow forced to stay in the same position, and they will attach all the time to the same kind of matter that complements the electrons they are missing.

The bonding of molecules is also electromagnetic. For instance, there is an atom missing some electron. Then it finds another similar atom and tries to get the electron it is missing from this second atom, but the second atom doesn't want to let it go, so they get together, the forces are balanced, the atoms are happy and they decide to stay attached forever. That is until some other electromagnetic force acts on them and scratch some of their electrons off, so the charged molecule looks for its missing electrons and finds it in some similar molecule and tries to get the missing electron from that molecule, but that molecule doesn't want to let it go, the forces are balanced and they stay together forming a more complex molecule. So, that's what a table or a chair is about. Each of their molecules is attached to the next one because of an electromagnetic force. The table will

stay as a table until a greater electromagnetic force, let's say contact with an atom that has been energized by heat from a fire, acts on it. Every single object around us, and our own bodies, are together and have their shapes because of electromagnetic forces. What make materials different are the different shapes and strengths of the electromagnetic bonds of its molecules.

Even the little that scientists know about our own mind is also electromagnetic. The information we receive through our senses is electromagnetic and the activity inside our mind is a myriad of electromagnetic exchanges.

The last of the four basic forces is gravity. Gravity is also an attraction of matter, but it works with quantity. A big mass of matter will attract a little mass of matter. The sun attracts the earth; the earth attracts us and attracts the moon. The moon, in turn, attracts the water of the oceans and forms tides.

Our daily measuring of time is the result of gravity and the movement of stellar bodies originally stemming from the Big Bang. The earth spins on its axis and that spinning is what makes our days. The earth stays orbiting the sun because of gravity that pulls it toward the sun, which balances the centripetal force originating from the motion of the Earth. This orbiting is what makes our years. A similar orbit of the moon around the earth is what basically makes our months.

The interaction of the different forces during billions of years has generated compounding of matter. One simple atom became a more complex atom thanks to the action of strong and weak forces; atoms attached to each other with the help of the electromagnetic force and because of gravity and they formed molecules; molecules got together in bigger and bigger chunks of matter that, because of gravity and angular momentum, generated galaxies and in one of them, our solar system. After millions of years, some of these molecules, with just the right energy received from the sun, enough water in a planet called Earth, and in that amount of water was a proper environment for complex molecules called DNA to form. DNA molecules are ordered in specific ways that allow them to repeat themselves which was the generation of life on earth. Our universe is the result of the compounding of matter and the basic forces of the universe.

To wrap up the block of basic concepts, Newton's laws of motion will be discussed, because these laws affect all the movements generated by the basic four forces and therefore the movement of any complex machine or living thing. Even though these laws don't work for some situations in the complete universe, they will be accurate for what 4^{th} grade students could experiment.

These laws are also true for microscopic forms, but are evident to us in the compounding of forces and machines that we use each day or the machine that our body is. We see the force of our hand pushing an object, not the electromagnetic forces inside our molecules and through our nervous system that causes such pushing. Newton's laws

will be evident to students on a macroscopic level, but it is important that they understand that what we see is the compounding of the four basic forces of nature acting on matter.

Newton's Laws of Motion

Once the concept of the basic forces has been understood, students should learn Newton's laws and how they are true for everything that happens around us. These rules will establish the basis for what could or couldn't be possible in real life. The basic forces of the universe and Newton's laws of motion will be the argument for students to judge the scientific truth or scientific possibility of what they see around them, especially in movies and television for our specific field of study, but also later on in life to understand and judge the world around them and to develop their own scientific theories or inventions.

Newton's laws of motion define the movement of particles, or the motion of all objects in the universe. The first one is inertia, which states "an object will stay as it is, either static or moving, unless some external force acts on it." This explains why a chair stays where it is put, an automobile continues to move unless you step on the brakes or hit something, and an object on top of a paper tends to stay where it is, even if the paper is rapidly removed from underneath. The nuclei of our atoms just stay where they are, and things mostly maintain their shape. Stars in the universe keep expanding, the earth keeps going forever around the sun.

The second law says that "the amount of force needed to move a particle or an object is proportional to its mass and acceleration wanted, or the change in momentum per change in time." A bigger push on an object will make it move faster; a bigger object will be harder to move. The force of a person's push needs to be greater than the forces acting on an object to be able to move it. The forces acting on an object at any moment could be gravity from the earth, the force of friction from the floor, and air pressure. Friction and air pressure are forces derived from the electromagnetic force that keep their molecules together. A table stays as it is because it will need a bigger force than the force of the bonding of its own molecules to change it.

The third law of motion is called action-reaction, and states "an amount of force applied will generate a reaction of the same amount." Even when we push an object we feel a little rebound in our own body. This rebound is more obviously perceived in the rowing of a boat or the shooting of a gun. The person rows and the boat advances as a reaction. The person shoots and the gun goes back to the person's shoulder as a reaction.

This unit is all about force: the four forces of the universe and the laws that rule the motion originated by such forces—the same forces that are inside us and make us one with the universe.

Our human nature has developed after billions of years of these forces acting against each other and generating complex forms that keep building and developing in more

complex forms each time. Life is the result of the complexity of molecules interacting with each other. Humankind is a further step in such development.

Our job as scientists is to look at that universe and wonder. Stand in front the universe and awe. Wow! We've come this far. This is a wonderful world. Having understood the thread that makes us one with the universe, students could begin their own wonder of wondering. They could select any detail of the universe and relate it to these basic concepts and understand more about it.

Scientific Fallacies in Film

For the purposes of this unit, we will select passages from movies to analyze their scientific reality. Once these specific basic concepts have been revised and discussed, the unit will go to a discovery stage in which students will research about independent scientific events taken from science fiction movies, and will relate them to the basic notions mentioned before.

Science fiction includes not only the movies and literature related to space traveling, but also stories of fantasy such as Cinderella, Peter Pan and Harry Potter. In every movie there are some parts that are true, scientifically true, and others that are fiction. The purpose of the work that follows is to argue why any specific scene from a movie is scientifically true or could be scientifically possible.

For instance, Peter Pan flies, but sometimes he also jumps to extraordinary high altitudes. Could this be possible? Well, there are fleas, which by their nature jump an altitude more than a hundred times their size. If they can, why not Peter Pan? The clue here is "their nature." Fleas are all legs and little bodies. Is Peter Pan's nature similar to that of a flea or a grasshopper? Even though Peter Pan's legs seem a little bit long for his body, the proportion is not quite enough to allow him to jump such distances.

Another option could be to study the gravity acting on Peter Pan, which is the force that the jump should overcome. Maybe if gravity was not as big as it is on earth, maybe Peter Pan would be able to jump with less effort. Something like that happens on the moon when the astronauts have been there. They just jump around because the moon is smaller than earth and therefore the force of gravity is less on the moon than it is on earth. But, if gravity were less in Peter Pan's planet, it would affect the rest of the crew as well. That means that Captain Hook and all the other characters should have been able to jump proportionally as high as Peter Pan does, and they don't seem to have that capability.

Could a pumpkin become a carriage? How could the broom of Harry Potter fly? What is wrong with the possibility of Superman flying? How are all those images generated to create the illusion that they are really happening? Students need to realize the importance of the physical laws that rule our universe, a certain necessary sequence for things to

happen. The discovery learning process and the analysis of science fiction movies will be the method and the framework to discuss the basic principles of science.

THE UNIT

The structure of this unit is based on initial demonstrations, discovery learning and individual choice for project development. It means generating early discussions, demonstrating the basic forces and laws, and organizing individual or group projects that explore and confirm such laws in the real world. It is important for students to be able to select their own options, the scene that interests them so that they can have ownership of their project. The structure has been established but the final choice for development of projects is theirs.

The unit could be expanded to a writing exercise for students to create their own science fiction stories that include believable scientific facts. The literary elements of the specific selected movies could be analyzed and the structure of the writing task organized so that students could write their own scenes or stories using such structure. Their stories could have a problem, a hero, a logic sequence, and a fantastic element that defies the laws of nature.

After this introduction, 14 individual lessons are portrayed. Each lesson of this unit touches a basic concept. Even though it does not venture very deeply into each topic, it gives a broad knowledge that could be correlated in sequential lessons and the projects to be developed at the end of the unit. The purpose is to give students basis for future discovery.

The unit has been developed as a sequence of hands-on, interactive, easy demonstration lessons through which students will explore the basic scientific concepts of the force that are the core of this unit. It also includes some lessons related to centripetal force, angular momentum, convection, compounding of forces, time, systems, and cycles. One-hour lessons are dedicated to each of these concepts for a total of 14 lessons that give an overview to the forces that unify the universe.

Procedure

The sequence begins with a simple lesson of wondering. Students go out to wonder about the world around them. Why does the sun shine? Why do birds fly? Why do leaves fall? Wondering is the basis of any scientific discovery. From this observation of the world around them, students should realize that there are forces that act on objects and make them interact. Students will generate possible answers to their questions and probably the word “force” will be in some of their answers. This first lesson will be a resource for possible project topics and as a rubric on how all their questions could be at least partly answered with the behavior of the basic four forces of the universe and Newton’s laws of motion.

The second lesson will be used to discuss the term of Force. Students will then learn about the four basic forces defined by scientists, forces that act on everything around us and are the cause of every scientific happening. Several class sessions will be dedicated to study of each of these forces.

In order to understand the generation of such basic forces, the theory of the Big Bang will be studied. Since matter was generated during the Big Bang, together with the basic forces, in subsequent lessons the concept of matter will also be studied and the basic components of the atom.

To understand the relation of microscopic elements to the macroscopic realities that we encounter on a daily basis, compounding of forces and generation of systems will be studied. We will study the relation between the forces in an atom, a molecule, an element, a compound, to the generation of DNA, the cell, to the formation of complex life forms. The world is what it is today because of the multiple paths and connections, billions of years of trials and errors and forces interacting with each other.

Once the structure and the sequence have been defined, each individual basic force could be studied. One session will be devoted to each of the basic four forces: electromagnetism, gravity and strong and weak forces. From the study of gravity, the measurement of time will also be studied, because it is also basic for the sequence of events, and gravity will be a proper introduction to Isaac Newton and the laws that he stated.

The rules defined by Newton have proved to be true for every movement in earth. Students should learn such rules and relate them to their own observation of the world around them. Students should understand that, once the compounding of forces has created a specific system, the system would only work if its essential parts were present.

To deepen into the rigidity of a system and Newton's laws, students will study movie scenes to analyze their scientific veracity. Experiments should be designed and presented to the classroom for discussion. The sequence of the titles of the lessons follows:

Lesson 1 – What do you wonder?
Lesson 2 – What is a force?
Lesson 3 – The Big Bang.
Lesson 4 – Matter
Lesson 5 – Atoms
Lesson 6 – Compound forces. Fields of Science
Lesson 7 – Electromagnetism. What holds molecules together?
Lesson 8 – Gravity and Angular Momentum.
Lesson 9 – What is Time?
Lesson 10 – Newton

Lesson 11 – Systems and Cycles
Lesson 12 – Watching movies
Lesson 13 – The discovery process
Lesson 14 – The scientific discussion

Later Note for Literature Lovers

Wow! Science is a Wow! W.O.W. The Wonder of Wondering. The purpose of any school class should be to transmit that Wow to students as Walt Whitman pictured in his poem "Beginning my studies":

> BEGINNING my studies, the first step pleas'd me so much,
> The mere fact, consciousness—these forms—**the power of motion**,
> The least insect or animal—the senses—eyesight—love;
> The first step, I say, aw'd me and pleas'd me so much,
> I have hardly gone, and hardly wish'd to go, any farther,
> But stop and loiter all the time, to sing it in ecstatic songs.

The feeling I would like to instill in my students is this Wow! of science, the first step in consciousness that makes them "sing it in ecstatic songs."

LESSON PLANS

Lesson 1: What do you Wonder?

Objectives
Students will conceive questions related to the world around them and how it functions. They will also infer possible answers, propose hypotheses and appraise peers and own answers to proposed questions.

Time Required
One 60-minute period

Materials
Paper and pencil
Outdoor location

Procedure
The first lesson will be a generation of ideas. Students will go outside with their notebooks to jot down anything they wonder that they would like to find out about the world. Why does the sun shine? Would a bullet shot up into the sky kill you on the way down?

After some time is devoted to this activity, a discussion will be generated to study the questions and try to guess some answers. This is the base of any scientific work: just be able to wonder. The first encounter with "problem" and "hypothesis" of the scientific process will be experienced in this informal setting, and the terms will be used for this activity to place students in a scientific attitude.

Evaluation
Students should produce length appropriate lists in their science journals. No judgment should be given to their questions. A classification exercise could be done for the teacher to identify student's main interests, or possibilities for development in future lessons and projects.

Lesson 2: Forces

Objective
Students will summarize the concepts presented in the video *All about Forces and Gravity*.

Resources
Video *All about Forces and Gravity* developed by Schlessinger's Physical Science for Children series.

- <http://www.batesville.k12.in.us/Physics/PhyNet/Mechanics/Newton1/what_is_a_force_really.htm>
- <http://www.csupomona.edu/~ddutto/ci/modules/Landing_module/tutorials/What%20is%20Force.htm>

Time Required
One 60-minute period

Materials
Video: *All about Forces and Gravity*, developed by Schlessinger's Physical Science for Children series.
Any object from the classroom that can be moved.

Procedure
A force is a push or a pull. This simple concept is clearly demonstrated in the video *All about Forces and Gravity* developed by Schlessinger's Physical Science for Children series. Several kinds of forces are explored, such as water pressure, which is shown through buckets of water on top of a diver. Air pressure, friction, and gravity are also observed and an easy experiment with paper clips and tissue paper parachutes is shown to prove the equilibrium of forces.

Evaluation
Students should identify the forces that affect any object in the classroom that could be moving or could be still. If time allows, the experiment shown in the video would be replicated in class.

Lesson 3: At the Beginning

Objective
Students will associate the theory of the Big Bang with the movement that results from the model provided (balloon with confetti).

Resources
<http://www.damtp.cam.ac.uk/user/gr/public/bb_home.html>

Time Required:
One 60-minute period

Materials
Balloon
Confetti
Overhead picture or poster of the universe with a view of the myriad of galaxies

Procedure
At the beginning there was nothing, and it suddenly exploded. A balloon full of confetti will be exploded in the middle of the class to clarify the point. The Big Bang is the explanation for the beginning of the universe. A lecture will be given about the Big Bang and the forces and matter generated in such explosion. Time will be allocated if a religious discussion generates. Such discussion would be appropriate to demonstrate respect for each other's beliefs and limit the scope of the class to the scientific theory.

The Big Bang generated matter and forces. Matter is everything that exists, that takes a place in space—tiny atoms that gather together into more complex forms. The forces are characteristics that define matter, and essentially make matter move. The four basic forces are Gravity, Electromagnetism, Strong and Weak forces, that make matter move and which will be visited in future lessons. A picture of the galaxies will be shown to students to observe the similarities between the bag of confetti and the real view of the universe.

Evaluation
Students will draw and color their vision of the Big Bang and will reflect in their science journals their thoughts about the topic.

Lesson 4: Matter

Objective
Students will examine and describe a substance provided, will differentiate its basic characteristics and will propose hypotheses about the bonding of molecules.

Resources
<http://www.nyu.edu/pages/mathmol/textbook/whatismatter.html>

Time Required
Two 60-minute periods

Materials
One box of starch per group
Water
Food coloring
Butcher paper
Markers
One wide container per group, such a plastic shoe box

Procedure
Matter as such could be studied with the "Oobleck" experiment developed by GEMS, in which students study an "unknown" green substance from "another planet." This substance is just starch with water and food coloring. The unit for the experiment is designed by the authors to last a week, but I have found that two periods of class are good enough to cover the material.

After the fun of touching and describing the substance, students will be asked what the substance has in common with other things in the universe or with us. Shy does the substance stay together? What makes it move? This will bring us to the study of the atom and the forces of the universe.

Evaluation
The list of descriptive words generated by the groups and the content of individual science journals would be assessed. Hypothesis for the bonding of matter should be included in the journal.

Lesson 5: Atoms

Objective
Students will design and arrange an atom model.

Resources
<http://www.fearofphysics.com/Atom/atom1.html>

Time Required
One 60-minute period

Materials
White posters
Colored punched paper
Pencils and glue

Procedure
Models of different atoms will be created by each student, one element per student, to observe the activity of the electrons, the similarities with the solar system and the complexity of the elements that make the universe and the periodic table.

There are plenty of resources on the Internet to find lessons to demonstrate the atom, but models with colored hole puncher pieces might be enough.

The levels of energy will be explained as similar to the solar system. One element will be assigned to each student or pair of students to be drawn. Each student will be provided with a card that identifies the number of energy levels and the number of electrons (or "planets") in each level. Students should generate a model of the assigned atom according to the information provided in the card.

Evaluation
Models created should be accurate with the energy levels of the elements they represent, according with the information provided by the teacher.

Lesson 6: Fields of Science—Compound Forces

Objective
Students will discriminate between the different fields of science and their objectives.

Resources
<http://www.wikipedia.org/wiki/Science>

Time Required
One 60-minute period

Materials
Six or 12 blank puzzles

Procedure
The compound relation of the forces and matter generated during the Big Bang is what makes everything in the universe. Its manipulation by human hand is what originates all advances in useful products, from a toothbrush to computers and TV. The study of these basic forces is the main purpose of physics.

Quarks form atoms; atoms form matter. Atoms have different characteristics and are called elements. These elements and the way they change and combine with each other are studied in chemistry. Life is also formed from these atoms. Atoms get together with other atoms and form molecules, and cells are made of molecules organized in a certain specific way. Molecules interact and combine with each other to form sugars, sugars form cells, cells form tissues, tissues form organs, organs make systems and systems make life forms. The study of these complex living structures is called biology.

The most complex form of living things are humans, who are able to reason and be conscious about themselves and the world around them. This complexity gives humans and living things certain behaviors that are studied in several different fields such as medicine, psychology, sociology, etc.

A couple of pieces of a blank puzzle will be given to each student to decorate. Maybe it could be decorated with colors defining the parts of an atom or the parts of a cell. Students will have to find and complete the puzzles. There should be at least 5 or 6 complete puzzles at the end. A box will be formed with all the puzzles. The purpose of this activity is to demonstrate how a simple particle gets together with other particles to form something else much more complex. The puzzle piece is a cell, a complete puzzle is a tissue, and the box is an organ.

If available, a complex model, such as the Eiffel tower, will be shown to students to discover how the human being is part of a complex evolution that has happened for millions of years, and is only a very small portion in such development of the universe, just as Earth is a minimum part of the huge universe, a “pale blue dot.”

Evaluation
Students will construct boxes from singular pieces and will paraphrase in their journals the concepts studied in the lesson.

Lesson 7: Electromagnetism

Objective
Students will evidence the effects of electromagnetic charges in their own bodies, and will explain the force that cause this charges.

Resources
<http://www.exploratorium.edu/snacks/charge_carry.html>
Any science textbook chapter dedicated to circuits, current, and electricity.

Time Required
One 60-minute period

Materials
Balloon
Aluminum pie container
Foam plates and cups
Wool

Procedure
Electromagnetism is the movement of electrons in some matters, which causes movement of other electrons in other kind of matter. Electricity is the current of charges along a path in a material. Magnetism is the alignment of charges in a material.

Students' bodies will be used to demonstrate movements of particles, electrons and planets. Some of them will spin around each other and will be "trapped" by a member (electron) of another group.

Electromagnetism will be demonstrated through simple experiments, such as rubbing a balloon on somebody's hair and then "gluing" it to the wall. There is a nice experiment that produces sparks and is clearly explained in the "Science Snacks" web site of Exploratorium <http://www.exploratorium.edu/snacks/charge_carry.html>. I ask my students who wants me to electrocute them and all of them raise their hands. Of course it is just a little zap, but kids have a blast. Kids play along with imagination.

It would be important to note that electromagnetism is much more than permanent magnets or electricity. Electromagnetism is also what holds molecules together. The movement of electrons in these processes could be shown through drawings or a power point presentation.

Evaluation
Students will paraphrase in their journals the concepts studied in the lesson, including the terms electromagnetism, charge, positive, negative, electricity, current, circuit.

Lesson 8: Gravity and Angular Momentum

Objective
Students will explain the effect of gravity and angular momentum in the orbits of the planets and the shape of the galaxies.

Resources
<http://www.theory.caltech.edu/people/patricia/gravtop.html>

Time Required
One 60-minute period

Materials
Ball attached to a string
Bucket with water
Video or pictures of a skater spinning, a twister, a bicycle rider, and a galaxy
Wheeled chair
Masses to be held by person in the chair

Procedure
Gravity means that a big body of mass will attract a small body of mass, like earth attracts us and the sun attracts earth. The centrifugal force will be explained through the use of a soft ball attached to a string, spinning around and letting it go, and through the use of a basket that contains some objects that wouldn't fall if you turn them upside down with your hand.

Angular momentum would be explained with a wheeled chair and a person holding two masses in their hands. The chair will be put to spin, while the person holds arms outwards. The person will then bring arms together which will make the chair spin faster. This movement will be related to ice skaters, the beginning of the solar system, the galaxies, and twisters.

The beginning of the solar system will also be related to a bicycle wheel through a muddy path. The back of the rider will receive the mud in a linear path. This explains the shape of the galaxies and the formation of planets as extra mud that went out from the initial spinning of atoms from the sun after the Big Bang. This will also explain why galaxies have a disk form.

Evaluation
Students will paraphrase in their journals the concepts studied in the lesson, including the terms centripetal force, gravity, and angular momentum.

Lesson 9: What is Time?

Objective
Students will represent the movements in the solar system and recognize the patterns that allow time measurement.

Resources
<http://www.wikipedia.org/wiki/Time>

Time Required:
One 60-minute period

Materials
Lamp
Different size balls to be earth and the moon

Procedure
After the Big Bang, the stellar bodies formed by action of the gravitational force. The solar system started this way. Gravitational force is what makes planets orbit around the sun, and this movement is what we know as time. Time is the change that occurs in stellar bodies while they move because of the forces created by the Big Bang. A day is the movement of earth on its axis. A month is the movement of the moon around the earth. A year is the movement of earth around the sun.

Students will be used to represent the movements in the solar system that make days, months and years, in order to understand the recognizable patterns that make time.

Evaluation
Students will accurately represent the difference of movements that make a day, a month and a year.

Lesson 10: Newton

Objective
Students will apply Newton's laws to identify the difference of force needed to move two selected objects. Students will paraphrase Newton's laws and will give examples that confirm them.

Resources
<http://id.mind.net/~zona/mstm/physics/mechanics/forces/newton/newton.html>

Time Required
One 60-minute period

Materials
Small bucket
Water
Different size balls or objects
Heavy object
Piece of paper

Procedure
There are laws that define the movement of particles, or the motion of all objects in the universe. These are called Newton's laws of motion. The first one is inertia, which says that an object will stay as it is, either static or moving, unless some external force acts on it. Pulling rapidly a piece of paper from underneath objects could be done to demonstrate such law. A bucket with some water could also be gyrated with the arm for the astonishment of kids that watch how the water doesn't fall.

The second law says that the amount of force needed to move a particle or an object is proportional to its mass and the acceleration wanted, or the change on momentum per change in time. The third one is action-reaction, which states that an amount of force applied will generate a reaction of the same amount. The video *Newton in a Bottle* will be used to discuss such laws. The web site *Newton's Laws* by Zona Land, developed by Edward A. Zobel, <http://id.mind.net/~zona/mstm/physics/mechanics/forces/newton/newton.html> will also be presented. It defines and has a basic demonstration of each of Newton's laws.

Evaluation
At this point a written test could be given to assess the vocabulary knowledge, including matter, Big Bang, force, inertia, Newton's laws, air pressure, water pressure, atom, energy levels.

Lesson 11: Systems and Cycles

Objective
Students will accurately discriminate what could and could not be a system and a cycle.

Time Required
One 60-minute period

Materials
Cards – one deck per group
Simple machine
Complex machine that includes the simple machine shown before

Procedure
The complexity of the universe will be reinforced in this lesson. The boxes made during lesson 6 will be used to review how the universe has been developing into more complex and sophisticated structures. A simple machine will be compared to a complex machine. A sequence model, such a domino line, will be used to exemplify cause and effect situations. An Eiffel tower model will be shown to exemplify how our place in the universe has come after billions of years of derivations of the basic forces of the universe. Student will understand that complex systems may not work if some parts are removed,

and will predict and draw conclusions about what will happen if a part of a system is removed.

Different groups of students could build card towers, which will collapse if one is removed. This understanding will be the basis to analyze fiction movies, and to identify their flaws related to the reality of the systems around.

Evaluation
Students will paraphrase in their journals the concepts studied in the lesson, including the terms system, cycle, simple machine, complex machine, cause, effect, removed parts. Students will also infer what would happen if a specific part of a specific system, pointed out by the teacher, is missing.

Lesson 12: Watching movies

Objective
Students will select a scene from a movie and infer the flaws that make the scene not possible in real life.

Time Required
One 60-minute period

Materials
Any appropriate movie: fiction, fantasy or science fiction

Procedure
So far, and no matter their complexity, everything that happens in the universe could be related to basic forces and principles—not necessarily as simple as it sounds, but as a compound relation of these forces. The student's job will be to select a scene from any movie (which will be our universe) and relate it to these basic realities. How these forces make some things work and why some of the scenes shown in the movies are not possible in reality, because of contradictions to these basic forces and laws. I will ask them how they know, and what it would need to really happen.

They will need to prove how come it doesn't happen in reality. Students will need to decide on a piece of a movie before trying to look for information or an experiment to conduct. This way they will not fall in the temptation of just repeating an already made experiment just as they do just to comply with a science fair requirement.

Evaluation
Students will select a movie clip and will give a hypothesis about the scientific validity of the scene shown in the clip, and how it was made.

Lesson 13: The Discovery Process

Objective
Students will design an experiment to prove or disprove the accuracy of a movie scene.

Time Required
Four 60-minute periods

Materials
As needed according to students projects

Procedure
The structure of the class will be a discovery process. Students will select whatever piece of information they are attracted to and will follow their scientific intuition from there. I will suggest them to follow through to relate their selected evidence to the two basic forces, and Newton's motion laws that are the center of our investigation. With the use of discovery learning, my students will learn the scientific method and put it to practice through their own personalized search for knowledge.

If they have trouble finding out the fallacies of science fiction movies, I will point out some to them, but it would be their job to prove why. Once they have seen the clips of the movies, each group or individual will need to select a piece to prove or disprove.

Students should begin by formulating a sentence of the issue they are going to prove. "I think Superman jumping to the top of a building is perfectly possible in certain circumstances, and I am going to prove it." That is going to be their hypothesis. They will need to relate their hypothesis to a physical principle, research to find other scientific data that could support their hypothesis and conduct an experiment to describe or proof their statement. They need to try their experiment several times and provide clear instructions for other students to conduct the same experiment.

The students will use scientific inquiry methods, such as planning and implementing descriptive investigations, formulating testable hypotheses, and selecting and using equipment and technology. They will also collect information, analyze and interpret the information to construct reasonable explanations from direct and indirect evidence, construct simple graphs, tables, maps, and charts to organize, examine, and evaluate information, represent the natural world using models, and communicate valid conclusions. This part of the unit will need several days for research, experiment building, and writing of instructions. Resources should be available for research and concept clarification.

Evaluation

A rubric will be given to evaluate the projects on basis of scientific rigor, and presentation of results.

Lesson 14: The Scientific Discussion

Objective
Students will critique peers' projects on the basis of scientific accuracy and rigor to follow the scientific process.

Time Required
Three 60-minute periods

Materials:
Butcher paper
Evaluation rubric

Procedure
Each group of students will present their proofs to the scientific community (class). The experiment will be conducted in class, but by other students who will just follow the written instructions. After the work is presented and the experiment conducted, the scientific community will discuss the results and present new questions to challenge the presenter. The scientific community could decide to conduct further experiments to solve the challenges. With this activity, the students will ask well-defined questions and communicate valid conclusions.

Evaluation
The questions and comments presented to the exhibitors will be assessed, as well as the adequate completion of the evaluation rubrics.

ANNOTATED BIBLIOGRAPHY

All About Forces and Gravity. Physical Science for Children series. Schlessinger, 2001.
A clear video directed to young learners. Includes visual explanations and experiments to clarify the concept of Force in an amusing format that will keep the interest of the students.

Heinmets, Hillary and Nicole. *Parents Guide to Newton in a Bottle*. 2002. Newton in a Bottle. 25 Mar. 2003. <http://www.newtoninabottle.com/downloads/parent_s_guide_r2.0_online.pdf>.
This site has literature to go with the video *Newton in a Bottle*, for different ages, from pre-school to elementary grades and a guide for parents and teachers about the concepts included.

Levin, Janna. *How the Universe Got Its Spots*. Weidenfeld & Nicholson, 2002.
This book, written by a gifted cosmologist, touches most subjects of this unit, including ideas of Newton, Einstein, and the Big Bang. It is directed to an adult audience, but could be the basis for teachers to immerse in the controversies related to the explanations of the universe, before teaching the basic universal concepts that are the object of this unit.

Tinker, Robert F. *The Promise of Technology*. 1991. The Concord Consortium, Inc. 23 Mar. 2003. <http://archive.concord.org/publications/sci4kids.html>.
This site is a proposal that gives reasoning behind discovery learning. It talks about the difference about knowing many facts and being able to answer standardized tests, and really knowing and being able to explain everyday facts with scientific concepts. It supports the approach of projects for students to work through and discover for themselves the science around them.

Supplemental Web Sites

The following web sites have down to earth definitions of different scientific topics covered in this unit. They were not used for my research, but could be useful for further clarification of concepts and students research.

Dayley, Matt and Keith Holbert. *Electromagnetism*. 2002. Arizona State University. 27 Mar. 2003. <http://www.eas.asu.edu/~holbert/wise/electromagnetism.htm>.

Dreher, John. *What is a Magnetic Field and How Does it Work?* 1997. Washington University Medical School. 5 May 2003. <http://www.madsci.org/posts/archives/mar97/859291596.Ph.r.html>.

Hinshaw, Dorothy. *What is Fire*. 1998. Houghton Mifflin Company. 3 Apr. 2003. <http://www.k12.wa.us/webcontestjudge/F107/what_is_fire_.html>.

Momentum Machine. 1999. Exploratorium. 12 Apr. 2003. <http://www.exploratorium.edu/snacks/momentum_machine.html>.
Exploratorium has different simple and clear experiments to explain scientific concepts, organized under a common structure called "snacks." The one selected in this case is related to Angular Momentum. But the site has a complete selection of options.

O'Donnel, Mark. *Newton Laws*. 2001. All World Knowledge. 25 Mar. 2003. <http://www.allworldknowledge.com/newton/index.html>.

Patterson, Joseph. "Sun." *KIDS Discover Magazine.* New York.

This is a magnificent magazine with superb pictures, information and graphics about the sun. The first two pages of this magazine have all the basic information for students to understand at this point.

Scientific Services Group. *Basic Forces*. 1997. TRIUMF, Canada. 26 Mar. 2003. <http://www.triumf.ca/welcome/forces.html>.

What is a magnetic field? 1997-2002. Center for Integrating Research and Learning. 3 May 2003. <http://education.magnet.fsu.edu/faq/FAQ2.html>.

What is Electricity. Energy Information Administration. 3 Apr. 2003. <http://www.eia.doe.gov/kids/electricity.html>.

What is Energy. Energy Information Administration. 3 Apr. 2003. <http://www.eia.doe.gov/kids/whatsenergy.html>.

What is Radioactivity. 1998. Centre de Calcul Recherche et Réseau Jussieu. 5 Apr. 2003. <http://www.ccr.jussieu.fr/radioactivite/english/what_is_radioactivity.htm>.