Seasons, Water Waves, and Tides:
A Result of Interaction Between Celestial Bodies and Earth

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INTRODUCTION

I have always been intimidated by physics and math. So I was very surprised last year when I participated in the Climate and Weather Seminar that I could keep up with the basics behind the subject. It was very interesting to me, and I felt encouraged to delve further into the subject if it were possible. I am determined to learn more about the natural world around me and the laws of physics that explain things that happen around us. In other words, I want to understand more fully what keeps the planet earth from crashing into the sun, what makes the wind and water currents, and how exactly the moon affects the tides. When I learn more about these topics, I will be more certain of the response I give my elementary school students.

Stevens Elementary is a small Title 1 school in northwest Houston. Title 1 schools are those where the student population is considered to be disadvantaged and requires high quality education. These schools are committed to ensure that all children have a fair, equal, and significant opportunity to obtain a high quality education. The student population at Stevens is 95 % Hispanic, 3% African-American, and the remainder Anglo-Americans and Asians. The Hispanic students come from various parts of Central America and Mexico so that other than Spanish they share few cultural similarities. I teach first and second grade science in the bilingual program. It has been an interesting experience because children at this age are very inquisitive, alert, and bright.

RATIONALE

One day one of my little students asked me quite candidly why the Earth did not float away into deep space. I suddenly realized that I did not have a sufficient in-depth knowledge to simplify the explanation. Gravity alone did not explain it satisfactorily. If that were so, then why hadn't we smashed into the sun? I promised to look into the matter and give him an answer. But that was a promise that took longer to fulfill than I care to admit, for I had to do quite a bit of reading before I understood.

The same situation has occurred when I have discussed wind and water currents. Students have usually asked what wind is and how it makes the waves on a lake or at sea. If I am to help them learn about these and avoid misconceptions, I need to have a more in-depth knowledge about them. Finally, how exactly does the moon affect the tides? Houston is an international seaport subject to tidal changes along with some of the major bayous. Although my young students are not quite mature enough to understand the impact that the tides have on navigation, they do understand their effect on fishing because they often go out fishing or netting with their fathers very early in the morning. This unit will help them understand the reasons for the early fishing expeditions.

OBJECTIVES

Throughout the school year we will implement several objectives. As part of the curriculum one objective to be taught to second graders at the beginning of the school year is "Force and Motion"

TEKS Sci. 2.6A – B, Sci. 2.7A – C. It includes the ideas of push and pull as aspects of motion. Simple machines such as ramps, levers, and pivots are introduced and experimented with. "Properties and Patterns of Earth's Materials," TEKS Sci. 2.7D, deals with "Changes and Cycles in Objects in the Sky," and this is when the concepts of night and day, months, and seasons are introduced or reinforced. In Houston, concern over "Weather" is continually present throughout the year, especially with young students who might tend to show fear over news about the weather patterns, such as tornadoes, hurricanes, tropical storms and the resulting floods. Second grade curriculum does not include tides, but I cover the subject anyway because of our proximity to the Gulf of Mexico. Here the principal biome is a wetland compound consisting of estuaries, adjoining lagoons, and back bays subject to tidal systems.

UNIT BACKGROUND

Earth's orbit

We all know that earth turns on its axis once every twenty-four hours. That means that the orb itself takes about twenty-four hours to make a complete turn. A matter of international consensus was reached that Meridian Zero – better known as Greenwich – would determine the point from which the rotation would be measured. Each time the earth makes a complete rotation is referred to as a day. It takes the earth three hundred and sixty-five days plus six hours to make a complete orbit about the sun. That means that the earth is constantly at a different point of the solar system. The speed, however, changes slightly because of the earth's elliptical orbit. That means that when the earth is entering the aphelion's zone (farthest point from the Sun), it begins to slow down and then picks up speed again as it enters the perihelion (when the Earth is nearest to the Sun).

The mechanism by which the earth stays in orbit without risk of collision with the sun is a combination of inertia and the force of gravity. Gravity is the attractive force between any two masses, such as the earth and other celestial bodies, while "Inertia is that property of matter by virtue of which any physical body which helps it persists in its state of rest or of uniform motion until acted upon by some external force" (Funk & Wagnalls, 1980: 647). In the case of earth, the sun's pull inward creates the circular path, which is its orbit. The orbit of the earth is elliptic and the axis of its rotation is not perpendicular to the orbit, but tilted by a little more than 23º. The axial tilt is always in the same direction as the Earth orbits the sun the northern hemisphere will be tilted away from the sun during the winter causing, longer nights.

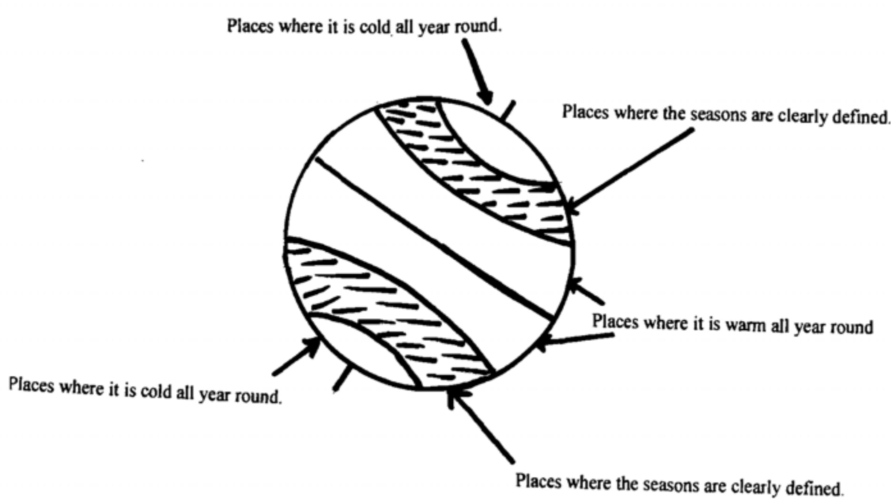

Figure 1. Regardless of the position of Earth in its orbit, some places show little or no seasonal changes because of the axial tilt and the amount of direct or dispersed sunlight that reaches them. [All illustrations are original drawings by Francisca Sorensen.]

In summer the northern hemisphere is tilted toward the sun. The longest day occurs in midsummer and is called summer solstice. When the Earth is between the northern winter and northern summer, both hemispheres get nearly the same amount of sunshine. The length of day and night time on earth will be nearly the same. Spring and autumn begin on an equinox: the same duration of night and day. After that the days will be increasingly longer in spring and shorter in autumn.

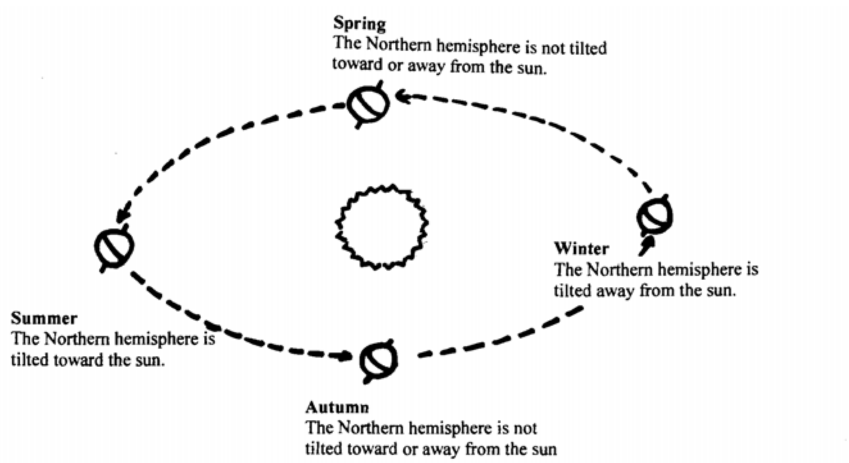

Figure 2: Position of Earth at different locations during its orbit around the sun. Seasons are directly related to the axial tilt which is always facing the same direction.

Water Waves

During the earth's orbit, different locations are exposed to different amounts of solar radiation that sets in motion other mechanisms that sustain life. Among these mechanisms are the wind, the water cycle, and the resulting climate changes: all ample enough subjects on their own to merit specific attention. Here, I will discuss wind and the way in which it transfers energy through air and water.

When we watch water at the seashore, each wave looks like a mass of traveling water that crests and troughs on its way to the edge of the beach. It is easy to think that the waves are water coming in to the shore until one realizes that they seem to dissipate on the shore. If it were water coming, would it not accumulate? In reality the water is not traveling anywhere. The water molecules move back and forth where they are simply hitting one another as they transfer energy.

Water itself does not actually move along, it just moves back and forth about a point such as to bunch up and create each crest; spread out to create each trough, and return to their starting points once the wave has left (Bloomfield 291; Russell 2).

Surface water moves in a circular motion as a wave passes. Close to the surface it moves in large circles in the direction of the wave. Below those circles are smaller circles which also rotate in the same sense. Lower still the circles, although very small, repeat the action. Beneath the wave, at roughly half its wave length, the water is calm without a whisper of the activity. It is important to recognize that depth in surface wave because in shallower water the dynamics of the wave will be different.

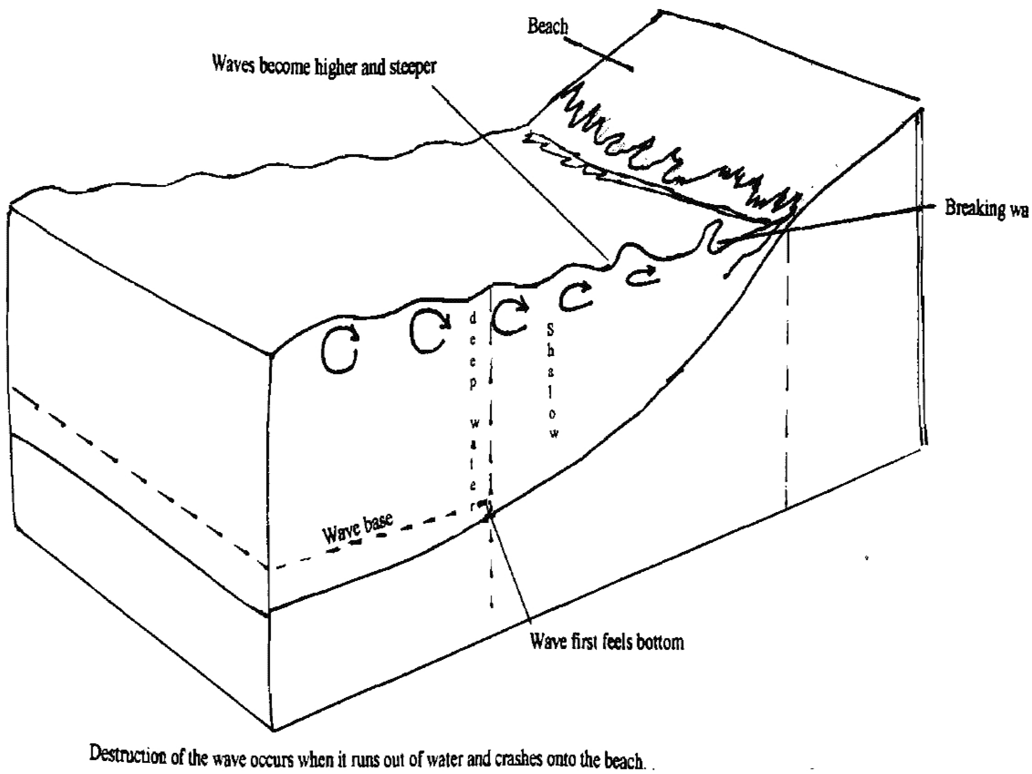

Figure 3: Point where water wave begins to encounter seabed.

At the point where the water begins to encounter the seabed and the water is shallower than half of the wavelength of the wave, the seabed will distort the water's circular motion making it elliptical (deviate from the circle). The new shape causes the waves to slow down and bump into each other forcing their crests to bunch up, grow taller, and steeper than in open sea. As the crests enter very shallow water there isn't sufficient water in front of them it to construct their forward side. They become incomplete and begin to 'break' (Bloomfield 295). In other words, the wave becomes higher, steeper, and more turbulent. If the surface where the waves reach is relatively flat and smooth like a beach, they will simply dissipate. But if the surface is vertical, the wave will crest and break against it and send particles of water back toward its source. A vertical and rocky surface will create larger a greater amount of turbulence.

We see that waves are really a way to transfer energy without moving the water itself. And we need to see how that energy gets there in the first place. I have experimented with water to learn more about the way that energy is transferred in it. I have noticed that water is very sensitive and will react to the slightest touch. The mere touch of an object on its surface will create radiating miniscule waves called ripples. Many objects at one time will cause many ripples which seem to dissipate at the edges of the testing pan. When an object strikes the water harshly the ripples are larger and of longer duration. It is when I blow on the water that ripples reach a greater dimension and frequency. These findings are consistent with the scientific knowledge that formation of waves in water is caused by wind.

Because Earth has various land and water formations it absorbs the sun's radiation unevenly. Some parts of the earth, such as the tropical latitudes of the Pacific and Atlantic Oceans are exposed to solar radiation all year round making them warm. Other places, such as the extreme northern and southern latitudes receive the radiation in a more dispersed manner causing their climates to be colder. The warm air rises over the tropical latitudes permitting cooler atmospheric air to replace it. The interaction between the warm air and the cool air create movement in the atmosphere commonly known as wind. Over the oceans wind touches the surface with lesser or greater force creating waves of different magnitudes.

At the beach the energy becomes sound and heat. There are other smaller wind patterns such as those between the landmass and sea which develop from the differential heating and cooling of the surface of the land and the water. The temperature difference between the land and sea surfaces will determine the amount of pressure across the land-sea boundary with the higher pressure being located over the sea. Strength and direction of large scale wind patterns, roughness of the terrain and, curvature of the coast will influence the gradient of pressure as will be the moisture conditions over land (Heidorn).

The air over land warms faster than that over the sea surface because solar energy heats the surface of the earth, which in turn, heats the lowest layers of the atmosphere. At sea the radiant energy received is rapidly dispersed by a concatenation of winds, waves, currents and the capacity of the water to absorb great quantities of heat with only slight alteration of its temperature. When the pressure of the cooler air over the water is high enough it will move inland in the form of a sea breeze and displace the rising warm air of the landmass. The strength of the sea breeze depends upon the difference between the temperature of the water and the adjacent coastal area. At night, the land cools more quickly than the water resulting in a reversal of wind flow from land to water (Heidorn; "Wind").

When the air is very light, it merely causes ripples without crests on the surface of the water. But, as wind speeds increase the ripples increase in size to form, first wavelets and later waves. Small wavelets or ripples will appear as soon as a breeze of 2 mph flows across the water surface. Whitecaps begin to form on top of waves when winds reach 15 mph. During violent storms the waves will be exceptionally high and capable of great destruction.

Experiment

In order to understand wave more clearly I conducted a few experiments. I needed to see for myself that waves transfer energy rather than water itself. To this effect I placed a 36 cm x 28 cm x 3 cm transparent plastic pan on a lit overhead. Next I placed foam slopes against the walls of the pan simulating beaches. When they were firmly in place I added two liters of water (2 cm deep) into the pan and squeezed the foam a number of times until each piece was soaked and stable at the bottom. I wondered if the water would be reflected or absorbed at the beach.

When the water settled, I very gently touched the surface of the water with a bead at the end of a two pronged wave source. Immediately as the bead touched the water a circle of ripples formed with other concentric ones following. The ripples appeared to dissipate at the foam walls in the pan. I tried striking the water more harshly thinking it might be a matter of force. The reaction was the same reaction. I had expected the ripples to bounce off the wall and return toward the source of the activity. I next touched the water with an item called a "Multipoint Wave source" which looks rather like a wide toothed comb. As the points of the teeth touched the water a ripple formed from each tooth point. Since the wave source was close to the back wall the ripples toward the front arched and rapidly interlaced with those from the other teeth constantly pulsating away from the sources of disturbance. Again the waves dissipated at the foam slopes.

What would happen if I blew lightly on the water trying to emulate the wind? Ripples in concentric circles still formed where my breath touched the water only they seemed to dissipate. I saw no evidence of reflection, so I placed a pumpkin seed in the water and tried all the above once more. The seed just bobbed in the water amid the ripples, but did not go anywhere. It seemed that there was no displacement of water, and that the waves were simply energy traveling through. Was the energy itself reflecting? How could that be proven?

We have all seen how a wave strikes the rocks and millions of drops burst and fall all around them. Many fall back into the water. Wouldn't they make backward pulses? If so, how turbulent would the encounter of the pulses be? I removed the foam from the pan so that its walls could serve as such a barrier. Again I placed a seed in the water near the barrier and blew on the water. When the seed hit the barrier it began to move parallel to it toward the right. Then, as it reached the other wall of the pan (another barrier) it began to float back in my direction and then again back into the water – making a cell.

Perhaps if I simulated a close entranced bay with some *plastilína* I would be able to force the waves into returning to the source. I had thought that by creating an interference the waves would return toward the entrance and would then strike the inner wall of the bay and create some turbulence at its entrance. It did not happen. The pulses of energy narrowed as they entered the mouth of the bay but immediately expanded into large arcs on the other side.

All of the tests that I tried in an effort to prove that waves were the transferal of water, and not just energy failed. In none of the trials was I able to detect any accumulation of water, and I was forced to accept the idea that waves are truly the transferal of energy. What happened to the energy once it left the water? Well, I remembered that at the beach there is a definite sound and sound is energy. The energy becomes sound and also heat.

Tides

Water waves are not to be confused with tides, the periodic rise and fall of the surface of the ocean and of the waters connected with the ocean. Although both involve the rise and fall of water they are products of very different origins. What is more, they have little effect on each other.

Tides have always been a source of fascination to man, ever since people noticed that the rising waters usually brought abundance of sea food to the shores and then within hours receded to the point of leaving the sea floor bare only to begin filling up again with a rhythm that could often be predicted. People were quick to notice a relationship between the moon and the tides; however, it was not until the very recent past, with the help of satellite probing, that true knowledge of the causality was ascertained. The moon does have a great deal to do with the tides, but so do the sun and some of the planets (McCully 39). What is more, when there is an eclipse, be it solar or lunar, the tides behave in spectacularly different ways. These tides influence the earth's rotational speed by the friction that they cause (Brosche et al. 2).

Gravity keeps all of the celestial bodies in our universe including earth in their particular orbits. In earth's case the sun attracts both the earth and the moon. Both moon and earth attract each other and their mutual attraction would eventually pull the bodies crashing into each other were it not for the fact that "our moon orbits an axis-point in space and remains in stable orbit because of its centrifugal force; and the earth also orbits the same axis-point in space and remains in stable orbit because of its centrifugal force" (McCully 22).

The moon's gravity is $1/6^{th}$ of the earth's surface gravitation. It is a relatively strong gravitation but its distance from us diminishes its effect on us. On the side of the earth that faces the moon its gravitational pull can be felt somewhat not by us but by the water. As the moon and earth follow their respective orbits the moon passes over large expanses of water both on land and away from it. The rigid portions of the earth hardly respond to that pull but the oceans do. They are deformed by the moon's gravity, and this deformation produces the tides (Bloomfield 287).

That deformation, a bulge in the surface of the water, will rise toward the moon and drop again to normal levels when the moon has passed and its gravitational pull weakens. It seems, to the normal observer on earth that the tidal high water is a wave moving around the globe approaching our coastline from the east. This would be an accurate description, but it would also be accurate to say that displacement of water remains in fixed alignment with the moon, while the earth revolves our coastline from the west toward the east (McCully 25). While this is taking place the opposite side of the earth is also experiencing a rise and fall of water levels. These tides however are not due to the lunar gravitation but to the centrifugal force caused by the earth's rotational velocity. This explains why although there is but one moon there are two high tides and two low tides.

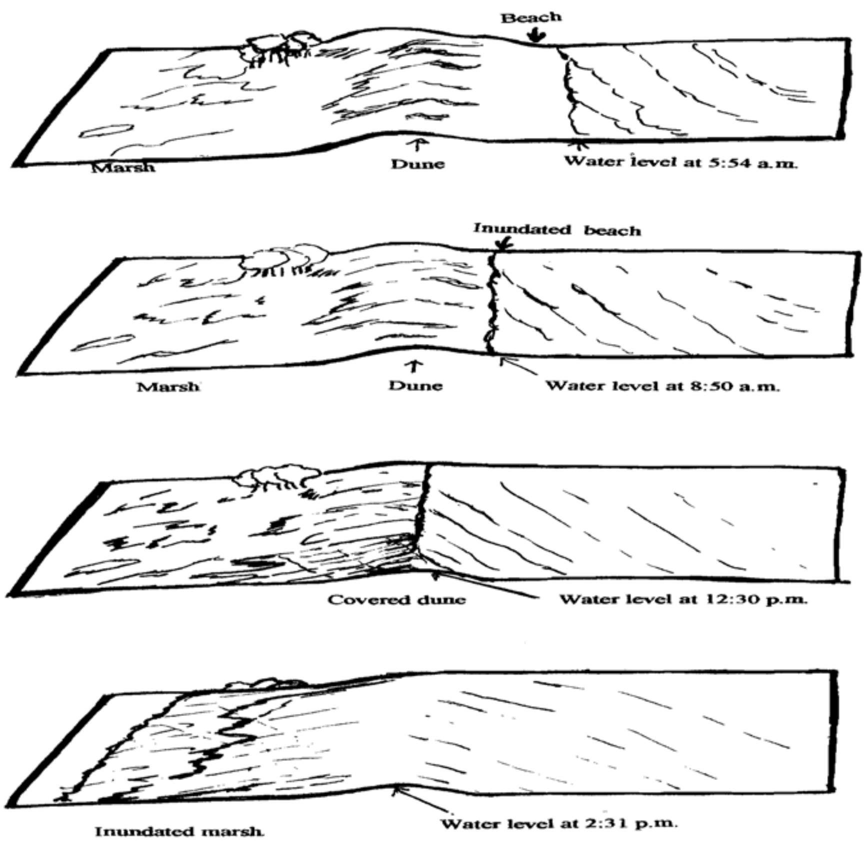

Figure 4: Tidal changes – from low tide to high tide during an eight hour period.

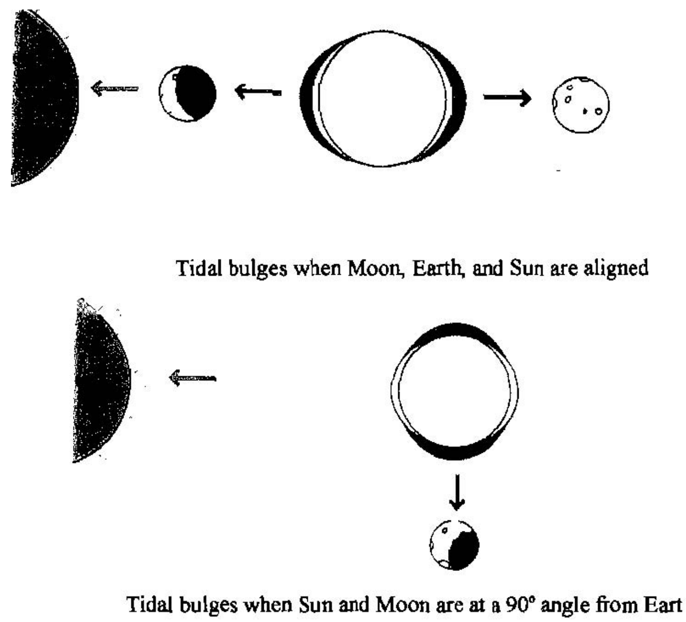

Figure 5. Tidal bulges and their relationships between Sun, Moon, and Earth.

When the sun, earth, and moon are roughly aligned in a straight line on earth we see either a full moon or a new moon. As the three celestial bodies combine gravitational pulls a larger than normal tidal wave called, spring tide, is created. Conversely during the quarter moons these tidal waves do not add together. Instead the solar bulges are subtracted from the volume of the high tide aligned with the moon causing a decline in volume. These tides are called neap (McCully. 50).

Another constituting interaction between the three bodies that influences the tides is neither linear nor uniform. It is instead related to earth's elliptical orbit around the sun and will result in varying heights of solar tidal waves. As the earth travels away from perihelion (closest point to the sun) toward aphelion (furthest from the sun), it slows down a bit. As it orbits back toward the perihelion it is going toward the sun and speeds back up. Needless to say, the moon's orbital speed will also be affected by the distance to the sun because solar gravitation attracts both the earth and the moon.

Solar and lunar eclipses, because of their linear alignment, exert particularly strong gravitational pulls on earth. The resulting effects are especially large tides. At this time it behooves us to discuss the effect that tides have on the planet itself.

The mechanics behind tidal action draw huge amounts of water together increasing the load and exerting greater than normal pressure on the surface of the lithosphere. This pressure helps to decelerate the earth's rotation by a fraction of a second. Piper and Lambeck declare that there is sufficient data from paleontological bivalves, corals and stromatolites to attest that tidal friction has always occurred (Lambeck 147 – 151; Piper 211) Piper suggests that tidal friction is also partially responsible for tectonic plate shifts and possibly continental growth. He argues convincingly for their role in their drift and ultimate breakup of Gondwanaland; an opinion that seems to be shared by Brosche, Sündermann and Lambeck (Brosche).

Tidal Systems

A view that is much closer and immediate to our lives here in the Houston / Galveston area is that of estuarine tidal systems as they influence land usage, international navigation, commercial fishing, and, of course, biodiversity. The area is particularly moist because it lies between the Trinity, San Jacinto, and Brazos Rivers. The resulting marshlands are subject to frequent flooding and, were it not for the natural and man-made bayous that constantly drain the region, urban activities such as we have would hardly be possible. The easternmost portions of the city and many of the lands toward Galveston are generally marshy and subject to tidal activity.

Marshes can be defined as beds or inter-tidal rooted vegetation alternately inundated and drained by the rise and fall of the tide. Inundation may be offset somewhat by the concurrent deposition of river-borne sedimentary material. A typical salt marsh may occupy narrow fringes along the ocean, or they may be several kilometers wide. Their boundaries often depend upon tidal range as well as upon natural relief having different degrees of salinity. The farther inland they are the fresher their water will be.

Marshes are found most frequently in high latitudes because in the tropics and subtropics their ecological niche is usually mangrove swamps. Marshes in the temperate area tend to have two main parts: a lower portion, exposed at low tide and entirely underwater at high tide; and a higher one, covered by water only during spring high tides or storm surges (Stickney 66-68).

These conditions determine and limit usage of land: agricultural, industrial, or commercial. One of the most evident examples is effect that the normal tidal cycles have on the inflow and outflow of ships into and out of the Port of Houston. Here there are two high tides and two low tides which occur every twenty-four hours and fifty minutes a condition that regiments all shipping because of heightened or lowered water depths.

Transportation and traffic can often be slowed down by the tides in the Bay Area of town since the ferries need sufficient water depth to make the crossings. When the traffic report is made it sometimes it is announced that the Lynchburg Ferry will not be running that day until sometime later; presumably when the tides rise sufficiently. A wonderful aerial photograph of the bay area crossed by the Lynchburg Ferry can be seen on http://wikimapia.org/17241/Lynchburgferry. In it one can see the areas normally subject to tidal changes.

Marshes are important for commercial fishing and shrimping because the tidal cycles provide them with the relatively low saline conditions that make them ideal nurseries for a large number of opportunistic migrant marine animals among them: red fish and shrimp. Both are important resources in the local economy.

In these ecosystems the importance of insects cannot be underestimated as most of the members of the community, especially the juveniles feed and thrive on their larvae (Moore 558). Although reptiles and amphibians are relatively scarce in brackish water habitats, alligators and turtles do exist in fairly large numbers and reach a considerable biomass.

Moore states that at least three hundred species of birds can be seen in the Western Gulf Coast's freshwater and low salinity habitats and divides them into three major categories: waterfowl (ducks, geese, and swans); gruiform birds (cranes, rails, gallinules and coots); and wading birds (herons, egrets, ibisis, etc). Many of these birds are migratory traveling from the Yucatan Peninsula in Mexico to different points in Canada. The tidal marshes of the Trinity Bay area are among their most important stopping places (Moore 564 – 567).

Mammals that visit and depend on the Gulf Coast low saline tidal marshes are raccoons, swamp rabbits, meadow voles, shrews, mice river otters, mink, white tailed deer, muskrat, and nutria. Although porpoises are not habituated to low salinity environments, they do occasionally enter estuarine areas (Moore 569). Of course, the aggregation of these mammals to the area attracts top predators such as coyotes who will feed on unsuspecting herbivores.

As can be seen coastal marshlands and the biota that inhabit them are part of a great concatenation of physical conditions: the positions and occasional alignments of different celestial bodies, especially the moon and earth; gravitation; origins of rivers; the gradients of their river beds and resulting speeds with which their waters travel and ultimately empty into the ocean; the minerals carried by the waters; and the tidal cycles.

LESSON PLANS

Earth Science

Objectives:

TEKS Sci.4.2.7.D: Identify events and describe changes that occur on a regular basis such as in daily, weekly, lunar and seasonal cycles.
TEKS Sci.2.3ABC: Analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information. (B) Draw inferences based on information. (C) Represent the natural world using models and identify their limitations.

Lesson I: Night and Day

Focus: Relationship between Earth and Moon
Two sessions each: 45 minutes

***Materials*:** World globe, lamp, and notebooks.

Guided Practice: Discover, through discussion what the young scholars already know about the planet earth and its classroom model, the world globe. With students sitting on the floor near the teacher, she places a piece of modeling clay on a given spot on the globe and then sticks a pin into it. She lights the lamp and darkens the rest of the room. She explains that the lit lamp is going to represent the sun and that the clay ensemble represents the place on earth that the students are in.

Having established this, the teacher begins to turn the orb toward the east asking students to notice how much light is reaching the clay. If this is done slowly enough, the students will notice when the sunlight is no longer direct and the clay is beginning to move into an increasingly darker area. Eventually they will be able to see that the clay begins to enter into a lighter and lighter region until it is again in the fully direct light.

The second time the teacher slowly turns the globe, she can direct the students' attention to the shadow cast by the pin. Ask students why the shadow changes. Have students generate questions about this. Write the questions on the board

Group Practice: A group of students will practice turning the globe and getting their classmates to make their own observations.

***Independent Practice**:* Students will record their findings in their individual journals.

Concept Review: The teacher will invite the students to gather around again to report their observations and conclusions. Through the discussion the teacher will discover if students' observations accurately responded to the questions they had made at the beginning of their practice. When the answer is correct, the teacher asks the students to write down the facts discovered. When the answer is not accurate, the students will repeat the exercise and observe more carefully to reach a factual conclusion.

Assessment: Because this is an introductory lesson and the concept is very abstract, the assessment can be postponed until further information has been acquired.

Lesson II: Seasons

Objectives:
TEKS Sci.4.2.7.D: Identify events and describe changes that occur on a regular basis such as in daily, weekly, lunar, and seasonal cycles.
TEKS Sci.2.3ABC: Analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information. (B) Draw inferences based on information. (C) Represent the natural world using models, and identify their limitations.

Focus: Seasonal cycle

Two sessions each 45 minutes

Materials: World globe, a lamp, a large table and four cards; each with the name of a season and the date of its beginning and a projector.

Setting: The teacher arranges the classroom so that there is a large table in the center of the room. Then she places a lit lamp in the center of the table and places the globe a couple of feet from the lamp.

Guided Practice: Remind the students about the earth's rotation on its axis and draw their attention to the imaginary divisionary line called the equator. Then introduce the concept of Northern and Southern Hemispheres.

Turn off the lights and begin to move the globe in a west east direction asking the students to observe it carefully at the distribution of light on the globe. As you move the globe ask the students to identify what part of the globe received most light and then which part received the least amount.

After one orbit is completed, ask students for their ideas about the amount of light they saw reaching the Northern Hemisphere at different points. Repeat the questioning for the Southern Hemisphere. If observations are reasonable, ask the students to forward ideas about the temperature that those regions would be having.

Here it will be a good idea to explain that the earth goes around the sun in a little over 365 days and that is what we call a year. Ask the students what happens in 6 months; in 3 months.

Before beginning the second orbit, place the cards marked Spring, Summer, Autumn, and Winter at the four principal areas on the orbital line. (Be careful to place them in accordance to the amount of light received). Repeat the comment that the earth takes three hundred and fifty-six days (or twelve months) to make the trip around the sun. After turning out the lights again begin to move the globe around the table. Stop at the card named spring and draw their attention to the amount of light – and its distribution – that reaches the hemispheres.

After a brief discussion continue toward summer. Question the students and tap into their knowledge of summer heat. Then show them that the northern hemisphere is tilted toward the sun and, therefore, is exposed to greater amount of energy. But as the globe continues toward the card named *autumn* the students will be able to notice that the two hemispheres are receiving basically the same amount of energy. As the globe travels toward the card named *winter* point out that the northern hemisphere is now pointing away from the sun and, therefore, sunlight does not reach it in as much concentrated quantities as before.

Students will make a drawing of the earth's position at different stages of its orbit around the sun. Ask them to write what they have learned.

Independent Practice: It is a good idea to allow the students to manipulate the globe and observe the relationship light/temperature if they so indicate. I find that they accept it more if they have tried it out on their own. As reinforcements I would give my students the attached drawings of the “Sun and the Seasons” and one showing the globe divided into six regions: two polar, two temperate and two tropical.

Reinforcing Group Activity: A student holding a broomstick at a 23º angle will walk around the room with someone shining a flashlight on the stick itself. If a line simulating the equator is drawn on it the observing students should see a difference. The most important part of this practice is to remember the direction in which earth’s axis points and the amount of light that reaches the northern hemisphere and the temperature that can be expected there.

An added, very useful activated reinforcing resource on this subject is: www.teachersdomain.org/resources/ess05/eiu/seasons. It is a very well presented activated version of the earth’s rotation, its tilt, orbit and relationship between tilt, orbital position, and resulting seasons.

Assessment: Students will identify the seasons on an untitled diagram of the earth’s orbit. They will also indicate the regions where there are four definite seasons, warm all year round and cold all year round also.

Lesson III: Water Waves

Objectives

TEKS Sci. 2.10A Identify the Sun as the major source of energy for the Earth and understand its role in the growth of plants, in the creation of winds, and in the water cycle.
TEKS Sci. 2.2.2E Analyze and interpret information to construct reasonable explanations from direct and indirect evidence.
TEKS Sci. 2.3ABC: Analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information. (B) Draw inferences based on information. (C) Represent the natural world using models and identify their limitations.

Focus: Waves are transmitters of Energy.
Three sessions each 45 minutes

***Materials*:** Overhead projector, a transparent shallow pan, water, plastilina, tongs, two wooden beads, a ruler, foam to simulate beaches, a convex parabolic reflector, and a concave parabolic reflector or you can purchase a water wave set through any science teacher supply stores.

Guided Practice: Discover through conversation what students know about waves and ripples. Ask how they are made and what makes them move and where they go. Write ideas on the board for reference. Inform the students that they are going to help you learn what the waves and ripples are by means of scientific procedures. In other words, we are going to do an experiment.

Place the pan on the overhead and pour enough water into it to make it about half an inch deep. Turn the light on the overhead and project the image on the screen and touch the water lightly with the bead. Students will see a circle form and move outwardly with others following. Ask students where the water goes and if it returns. More than likely they will say that the ripples mean water moves away.

Insinuate that if the ripple carries water then an object on the water should be able to travel on it. Place a sunflower seed (or one similar) on the calm surface and touch the water lightly near the seed. Instruct the students to observe carefully if it moves along with the water or just stays there.

Group Activity: There will probably be a great deal of discussion about the results so you might allow a few students to manipulate the water themselves. Do not worry about the mess they will make. It can be cleaned later.

One of the students is bound to move the water violently and succeed at moving the seed. That will give you the opportunity to question the students about the external forces that caused the seed to move. Direct the conversation to the kinds of external forces that could make the water in large bodies of water to move like that. Most second graders will eventually suggest "wind" which is exactly where you want to go.

Ask the children what would happen if we lightly blew on the water trying to emulate the wind? They should discover that ripples still form in concentric circles only they form more rapidly. The stronger they blow the higher their crests are likely to be.
The pumpkin seed will probably remain practically in the same place proving that there is no displacement of water, just energy traveling through.

Second Session – Continuation of Waves conducting energy

Focus: What is wind?

Guided Practice: Remind students that the sun is the source of heat. Cut a spiral shaped length of paper and tack it on to the ceiling. Place a lit lamp under the spiral and watch it begin to move as the air over the lamp begins to warm up. While it begins to move or as part of the explanation make drawings on the board to show how the earth's water and land surfaces warm up. Draw how the heated air rises and is displaced by heavier cold air. Explain that the displacing act creates a strong movement of air which we call "wind."

Group Practice: *Energy Kid's Page* at www.eia.doe.gov/kids/energyfacts has good information about the wind that reinforces your version. Have the students read it along with different books on the subject, such as Robert Gardner's *Wild Science Projects about Earth's Weather*, or *Wonderful Weather* by Shar Levine and Leslie Johnstone. Although these books are about weather and a bit above the learning level of second graders they convey some of the information needed to reinforce the concept of wind.

Third session: – Continuation of Waves conducting energy

Focus: What happens to the water when it reaches the beaches?

Guided Practice: In order to simulate beaches place the foam rubber wedges around the inside of the transparent pan.

Ask the students to observe the ripples and to tell you if the water returns to the source of disturbance. First blow on the surface of the water and watch the waves travel to the beach. The students and I will observe closely to see if the waves return to the source. After a brief discussion about the direction that the water took, blow on the water again. This time do it more vigorously. Repeat this activity a number of times pausing for discussions about the direction. The students will notice that the ripples (waves) fade on or near the beach.

Remind the students that the waves are simply the transferal of energy from the sun to the wind to the water. Then ask them if they can suggest where that energy goes. After a little while ask them to close their eyes and pretend to be on the beach and to describe it. They will more than likely mention the sound and the heat.

Those, of course are the forms of energy into which the energy has transformed.
As reinforcement you can show them an animated version of the transferal of energy as shown in www.kettering.edu/~drussel/Demos/waves/wavemotionhtml.

Another re-enforcer that students enjoy is to have them sit together in a huddle. Tell them that they are water molecules and you are energy. Begin to walk among them. They will instinctively draw away to let you by. When you have walked through they automatically return to the position they were in. Point out that just as you walked through them, so does energy go through water. Just like they bunched up to either side so do the molecules. The bunched up part is the wave.

Independent Practice: Students should now write the information in their journals.

Assessment: A short simple teacher generated cloze type assessment can be given to the students at this time. Remembering that the information in these lessons is a bit complicated for second graders and that the lessons are meant to teach them to observe and make inferences based on those observations.

Lesson IV: Tides

Objectives

TEKS Sci. 2.7D Identify events and describe changes that occur on a regular basis such as in daily, weekly, lunar, and seasonal cycles.
TEKS Sci. 4.11C Identify the Sun as the major source of energy for the Earth and understand its role in the growth of plants, in the creation of wind, and in the water cycle. TEKS Sci. 2.6AB Describe some interactions that occur in a simple system.

Focus: An effect of the Moon on the Earth: Tides.

Materials: Book: *The Gulf of Mexico: A Special Place*, Styrofoam ball on a skewer, world globe, an articulated paper model that includes sun earth and moon, *A Day in the Salt Marsh*.

Note: As mentioned above; second grade curriculum does not include tides, but I cover the subject anyway because of our proximity to the Gulf of Mexico. Here the principal biome is a wetland compound consisting of estuaries, adjoining lagoons, and back bays subject to tidal systems.

Guided Practice: Direct a discussion on water waves in which the students will be reminded that water waves transfer energy; not water. Then introduce tides. These have a different source and do transfer water. Place the globe on the table in the middle of the room and then move the Styrofoam ball around it simulating the lunar orbit. As you do remind the young scholars of the gravitational pull between two celestial bodies and mention the concept of centrifugal force.

Comment that as the moon passes over large bodies of water its gravitational pull will draw huge amounts of water together. As it continues on its orbit, it will drop that large quantity of water while picking up more.

Group Activity: Take students to the playground near a bare patch of ground. Explain that the grassy part is the ocean and the bare spot is land and that they are water molecules and you are the moon.

The students form a huddle over the grassy part, and you, holding a Styrofoam ball in your hand high above your head, will walk in front of them. They have to follow you because they are attracted to your gravitational pull. Walk a ways into the bare patch with the student huddle in your wake. Say: "High Tide" and begin to walk out of the bare spot. When far enough away say: "Low Tide." Repeat the procedure a number of times. You'll soon have them identifying the tides before you.

Point out that they always remained in a huddle when they were part of the tides. That is because they were moving in response to a pull. Remind them of the waves and how they differ from the tides.

Group Practice: Back in the classroom have students draw the earth and the moon on the board. Include the temporary deformation that the moon's gravity causes over the oceans. Have students manipulate their individual articulated paper models so that they can follow the drawing and the concept behind it. If they have a white sheet of paper under their model, they might draw the bulge.

As the moon continues on its orbit, the bulge will decrease in size while another is forming. Once the students have understood this principle, you can add the information that on the other side of the world another bulge develops as part of the centrifugal force. This double bulge is the reason why in many places there are two high tides and two low tides per day.

Group activity: Students will go to the yard again and, holding both a classmate's hands begin to spin around rapidly. They will notice that their bodies will lean outwardly in order to keep their balance.

Guided Practice: When the students return to the classroom, you will discuss the reasons for their outward leaning. Point out to them that the same thing happens to the water bulge on the other side of the world where a high tide is likely to be occurring.

Hand out copies of a map of Texas that includes the Gulf of Mexico and ask students what happens when the moon is nearing land and then over it. Make sure to have the globe on hand to facilitate the visual application.

From the hand outs the students will notice the many rivers that empty into the Gulf of Mexico and will understand why the area is so wet and subject to tides albeit only one high and one low one per day. Let the students use their articulated models again, this time having the moon over the continental mass. This will help them understand you when you point out to them that the moon will be going over a large mass of land so that a second high tide will not occur here.

Still the students must understand that our area is subject to tides and that they are very important to the wildlife of the region. Since this lesson will be given to the students in the latter part of the school year, they will be familiar with the idea of the wetland biome in which we live. To reinforce the concept of the tides, read aloud the book *A Day in the Salt Marsh*.

Independent Practice: *The Gulf of Mexico: A Special Place* has many challenging and enjoyable work sheets that help to reinforce the importance of the tidal planes in the Houston Galveston area.

Assessment: Students will produce a book with drawings that show what makes tides and the effects that they have on the wetlands.

ANNOTATED BIBLIOGRAPHY

Works Cited

Bloomfield, Louis A. *How Things Work: The Physics in Everyday Life*. Hoboken, NJ: John Wiley and Sons, Inc., 2006.

Brosche, P. *Tidal Friction and the Earth's Rotation.* Ed. P. Brosche and J. Sűndermann. Berlin: Springer –Verlag, 1978.
This is a compilation of papers presented by an international group of scientists at a convention held in Germany. The subject of the convention was Tidal Friction and its effects on the Earth.

Energy Kid's Page. Energy Information Administration. <http://www.eia.doe.gov/kids/energyfacts>.

Heidorn, Keith C. *The Weather Doctor*: *Weather Phenomenon and Elements: Sea and Land Breezes*. 2008. <www.islandnet.com/~see/weather/elements/seabrz.htm>.

Kurtz, Kevin. *A Day in the Salt Marsh.* Mt. Pleasant: Sylvan Dell Publishing, 2007.
This is a very pleasant and informative scientific book for children. As the name implies, it is about salt marshes and the tidal waters that maintain the large number of biota in them. The illustrations are very nice.

Lambeck, H. "Earth's Paleorotation" *Tidal Friction and the Earth's Rotation.* Edited by P. Brosche and J. Sündermann. Berlin: Springer- Verlag, 1978.

Maraniss, Linda. *The Gulf of Mexico: A Special Place*. Washington D.C.: Center for Marine Conservation, 1991.
Undoubtedly this is one of the best resources for teaching students of many ages about the coastal plains ecosystems in the Gulf of Mexico.

McCully, James Greig. *Beyond the Moon: A Conversational, Common Sense Guide to Understanding the Tides.* Singapore: Mainland Press, 2006.
This delightfully informative book does much to explain tides. For those readers who desire more academic expression, McCully inserts formulas and calculations to make his point.

Moore, Richard H. *Low Salinity Backbays and Lagoons in Biodiversity of the Southeastern United States: Aquatic Communities*. Ed. Hackney, Courtney t. Marshall Adams, and William H. Martin. New York: John Wiley & Sons, Inc., 1992.A very light informative book on biodiversity in the regions affected by tides in the southeastern portion of this country.

Piper, J.D.A. "Geological and Geophysical Evidence Relating to Continental Growth and Dynamics and the Hydrosphere in Precambrian Times: a Review and Analysis" *Tidal Friction and the Earth's Rotation.* Edited by P. Brosche and J. Sundermann. Berlin: Springer- Verlag, 1978.

Russell, Dan. *Longitudinal and Transverse Wave Motion.* 2008. <www.kettering.edu/~drussell/Demos/waves/wavemotion.html>.

Stickney, Robert R. *Estuarine Ecology of the Southeastern United States and Gulf of Mexico*. College Station: Texas A&M University Press, 1984.

Teacher's Domain. *Seasons*. <www.teachersdomain.org/resources/ess05/eiu/seasons>.

"Wind." *Weather Talk.* 2008. Naval Meteorology and Oceanography Command. <https://pao.cnmoc.navy.mil/pao/Educate/WeatherTalk2/indexwind.htm>.

Supplemental Sources

"Angular Velocity." 2002. <http://fden-2phys.uaf.edu>.

"Demonstrating Inertia." *Ask Dr. Math*. 1994-2008. The Math Forum @ Drexel University. <http://mathforum.org>.

Hackney, Courtney T; Marshall Adams and William H. Martin. *Biodiversity of the Southeastern United States: Aquatic Communities*. Ed. Hackney, Courtney T. Marshall Adams, and William H. Martin. New York: John Wiley & Sons, Inc., 1992.
Although this work does not have many illustrations it is very academic and informative.

"Measurement in Motion." *Connect: A magazine of Teachers' Innovations in K-8 Science and Math.* 1991-2006. Synergy Learning Archives. <http://cf.synergylearning.org>.

Nilsson, Pernilla, Ann-Marie Pendrill, and Hakan Pettersson. *Learning Physics with the Body.* <http://fy.chalmers.se/LISEBERG/eng/ioste04.htm>.

Stephenson, F.R. "Pre-Telescopic Astronomical Observations" *Tidal Friction and the Earth's Rotation.* Edited by: P. Brosche and J. Sündermann. Berlin: Springer-Verlag, 1978.

"Wave." *Encyclopaedia Britannica.* Vol. 12. 15th edition, 2005.