Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
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# Hold Off on the Headphones

Curriculum Unit 06.05.04
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## Narrative

Sound is one of the most important of our five senses. It fills our environment and can be used to express a whole spectrum of emotions. Even though sound waves are common and simple they have a huge influence on our life experiences. Everyday we are exposed to different sounds in our environment such as a bird chirping, a wave crashing or the roar of a thunder clap. Sound is responsible for a musician's ability to create works of drama, excitement and joy, However when an individual is exposed to a harmful sound such as instant blast or an over extended use of headphones delicate structures in our inner ears become damaged which may result in a condition known as Noise Induced Hearing Loss.

This unit deals with sound waves and their influence on our society and physiology. Its goal is to have students develop a scientific understanding of the properties of sound waves and how these properties when abused can lead to negative physiological changes in our ability to hear sounds. It is an interdisciplinary approach which utilizes the sciences, mathematics and the humanities. It begins by introducing the concept of a longitudinal sound wave. It briefly compares these waves to transverse waves but then delves deeper into the properties of sound waves. It describes how the human ear is able to pick up sound and carry the information back to the central nervous system. At this point it examines the delicate structures of the inner ear's auditory cells. We then look at the destructive capabilities of abusing the properties of sound waves and how this abuse can be detrimental to the survival of these cells and the quality of hearing ability. Students will read various articles on the effects of headphone use on younger adults hearing. Students will write a persuasive essay for or against extended iPod use. With this knowledge students will create an ad campaign for modern biomedical technology for improving hearing after damage is done.

I work in a health science and business magnet school and often my students look at these subjects as two different entities. However these subjects when brought together as a career can be quite lucrative. When an individual is exposed to the physics of sound a variety of opportunities for future study can blossom. Science oriented students can direct their studies in a physics, anatomy and/or biotechnological fields. Students interested in business will learn about products on the market that will be in high demand when they are in the business world.

This unit will be ideal for 9th and 10th grade classes. It reviews physical and biological applications which were previously covered in their past science classes while continuing to promote reading and writing across disciplines. Students will cover the properties of longitudinal waves, anatomy and physiology of the ear, basic algebra problems and writing a persuasive essay. This review will be important in taking the CAPT science, math, reading and writing tests. Individual activities will be bases on a learning cycle method. The method I will uses is based on scientific inquiry. Students begin by exploring an individual understanding of the scientific concept being taught. They then create a more pronounced understanding of the concept being taught through readings and teacher guided instruction. They conclude by applying the concept to a new situation. There are three phases to this learning cycle. The Concept Exploration Phase begins by introducing the concept in small collaborative groups. The teacher provides each group with a problem and physical materials, articles, data and or graphs. The student's responsibility is to solve the problem presented to them by the teacher. The teacher is there only to facilitate students with questioning and observations. At the end of the exploration phase students should reach a state of disequilibrium in which they formulate questions and hypotheses abut their observations. The Concept Development Phase allows each group to discuss their observations and hypotheses with the class. The role of the teacher is to provide definitions and explanations to the results and discussions of the groups findings. At this point I provide notes and multimedia visuals to explain the concept being taught. In the Concept Application Phase students are again placed in small groups and provided with another similar activity that places the concept to another situation in which the students must use their experience and information gained from the initial phases to solve another situation or problem.

## Unit Goal

The overall goal of the unit is to have students develop a scientific understanding of the properties of sound waves and how these properties when abused can lead to negative physiological changes in our ability to hear sounds.

## Objectives

Students will be able to understand that waves carry energy and information from one place to another.

Students will be able to determine that wavelength, frequency and wave speed are related.

Students will be able to describe that sound is a longitudinal wave whose speed depends on the properties of the medium in which it propagates.

Students will be able to discuss how eukaryotic cells differ in complexity.

Students will be able to recognize that neurons transmit electrical impulses.

Students will develop and defend multiple responses to literature using individual connections and relevant text references and develop a critical stance and cite evidence to support the stance.

Students will solve problems relating to the mathematics of sound and music.

## Waves

Why is it important to learn about waves? Waves are all around us. When fault zones move potential energy is changed to kinetic energy. This energy then travels through earth and water via oscillating waves. These waves can cause destruction to surrounding societies. The sound of a guitarist's strum carries waves to our ears. Audio speakers translate electrical signals into physical vibrations to create sound waves. Waves help students contact their friend's cell phone while you may be teaching a class.

Waves are types of oscillations traveling from one place to the next. Waves propagate through various substances. Water waves and sound waves are both produced by some sort of oscillation. The water wave is a common known wave that most students can see. This is a good starting point to introduce the parts of a wave. Water waves are created by oscillations of water molecules. As water waves pass through an ocean, water molecules oscillate up and down and back and forth. Ocean waves are transverse waves. These waves are perpendicular to the direction of the wave. This means that the water wave is moving at a right angle to direction of the wave; as a water wave progresses from east to west for example, the wave itself moves up and down,

*Activity 1 Wave Observations In Our Environment*

I will begin my unit by asking our class to exit the school and stand on the corner of a busy street. We will consider how we are affected by waves. Students may respond with light waves: stop lights, the suns illuminations, sound waves: the sound of car engines combusting, horns, and people talking to each other, electrical waves flowing through wires, water waves rippling in a puddle and invisible waves from radio, TV and cell phone transmissions through the air around us. This activity will reintroduce the idea of a wave.

One type of wave that will be constantly changing is the sound wave. Students will be able to notices changes in sound from one second to the next. Ask students what type of changes they observe with sounds they hear. Students will be able to distinguish between different volumes and pitches. Some sounds will be soothing while others may be harsh. All these observation will be beneficial to use as examples when you delve further into the properties of sound waves later on in the unit.

*Activity 2 Measurements of Water Waves*

The properties of a wave will be introduced with a trip to the beach. Students will measure the height, amplitude, wavelength and period of the water waves. Data collectors cannot be water shy and a good pair of rubber boots will be necessary. Necessary materials will include a measuring tape, timer and a long wooden stake. Students will begin by measuring the height of the wave. The height is the vertical distance separating the high point on the crest from the low point of the trough. Students will then divide this value by two to get the amplitude of the wave. The wavelength will be measured by finding the horizontal distance between the crest of one wave to the crest of the next. The period of the wave will be the time it takes one two successive crests to pass a stationary point. The speed of the wave can then be calculated by dividing the wavelength by the period. Students will have to be quick in their observations. Increasing the number of trials, and finding the mean of the values, will generate accuracy in data and excitement for a rather mundane topic. This activity will provide a tactile body kinesthetic representation of waves and how waves are measured.

## Sound Waves

Sound waves are waves that are created by oscillations of vibrating energy through various substances. Sound waves can pass though gasses, liquids and solids. As sound waves pass through air, the air molecules oscillate back and forth parallel to the direction of the wave. This back and forth motion creates a longitudinal wave. A longitudinal wave has oscillations that are in the same direction as the traveling wave.

Sound waves are used to carry information and energy over long distances. When sound waves propagate through the air they transport vibrations our ears. Our ears pick up theses vibrations and process them as music. In a similar way radio waves carry information to a stereo which then translates it into sound via its speakers.

Almost anything that vibrates can produce a sound. When something vibrates it pushes the air molecules around it. This push then occurs in all directions around the vibrating source. Energy is then transferred (Hsu Tom, 2003). This in fact is the concept of force: force = pressure x area, which represents a push.

## Properties of Sound Waves

There are several characteristics that should be thoroughly understood to fully grasp the idea of longitudinal sound waves. These waves all have frequency, amplitude, wavelength and speed. At this point the teacher may want to introduce these concepts to the students. There are some wonderful websites that are available for educational use which provide video clips and interactive diagrams. See the website section at the end of the unit.

**Frequency**

Frequency is the measure of "how often" a wave oscillates during a period of time. Frequency of a sound wave is measured in Hertz (Hz). One Hz is a measurement that describes a wave which makes a complete cycle in one second. Ten Hz is a wave that makes 10 cycles or vibrations in one second. We hear high valued frequencies as a higher pitch and lower frequency as a low pitch. Thus the rumble of thunder will have a lower frequency and a whistle will have a higher frequency. The normal range of frequency that a human can hear is between 20 Hz and 20000 Hz. In reference the range of the lowest not of a piano is 27.5 Hz and the highest note is 4186 Hz.

**Amplitude**

Within a sound wave air molecules are compressed at each interval. The region of condensed air molecules creates an atmosphere of greater air density. In between these compressed regions are rarefied areas where there are fewer air molecules and a less dense atmosphere. The larger the difference in pressure between the compressed molecules and the rarefied molecules causes greater amplitude and a louder sound.

Amplitude measures how high and how low a wave moves in relation to the average of the wave. Amplitude of a sound wave is one half the difference of the highest pressure and the lowest pressure measured in the wave (1/2 (HP - LP)). Amplitude is therefore the measurement of pressure difference within a wave which results in the loudness of the sound.

Because the pressure difference is so small we measure the loudness of a sound wave with decibels (dB). Decibels measure the loudness of a sound just as amplitude does. The decibel scale is a logarithmic measure of sound pressure. Different than a linear measurement every increase of 20 dB means the pressure of the wave has increased 10 times greater in amplitude. At 20 dB the amplitude is 10, at 40 dB the amplitude is 10x10 =100, at 60 dB, the amplitude is 100x10=1000, etc. (Figure 1,2).

**Wavelength**

Wavelength is the length of one complete cycle of a wave. In terms of amplitude it is the distance between two high pressure points.

**Speed of Sound**

Speed of a sound wave measures how fast an oscillation travels from one place to the next. The speed of sound is about 660 miles per hour or 344 m/s at room temperature. In one complete cycle a wave moves forward one wavelength; therefore if we know the frequency of the sound wave and the wavelength then we can calculate speed of sound in air by using the formula:

(V = f/\) where V = speed, f = frequency and /\ = wavelength.

*Activity 3 Speed of Sound*

I will have students calculate the speed of sound in air. Students will be separated into groups of two. Each group will be given a cow bell, a pair of binoculars, a stopwatch and a measuring tape. I will have students stand 200m apart from each other. One student A will have the cow bell. Student B will be provided with the binoculars and the stopwatch. As the student A strikes the bell student B while looking through the binoculars will begin timing. Once student B hears the bell the timing will end. The speed of sound will be calculated by using the formula for velocity; velocity = distance / time.

Another activity that can be done with your students is to film or obtain video clips of lightening storms and have students measure the time they see the lightening and hear the sound of thunder. Have the student calculate the speed of sound by using the formula v = d / t. You can use a scale of 3 seconds per kilometer or 5 seconds per mile. This time interval corresponds to a speed of sound in air. For example if the time it takes between a flash of lightening and the sound of thunder on the video is 6 seconds then the speed of sound will be calculated by dividing 2 km / 6 s which would equal 1km/3s or 333.3 m/s (Hsu Tom, 2003).

*Activity 4 Properties of Sound Wave Calculations and Observations*

Students can now use the formula to calculate various problems for wavelength, frequency and speed. By knowing the speed of sound and the frequency, wavelength can be determined. Starting with the original given formula V = f/\ have student solve the equation for /\ (wavelength). This is a simple algebraic procedure which can be solved by isolating the variable by using the inverse operation. The students will have to divide both sides of the equation by "f" which will isolate /\ and give the new equation /\ = v/f (Hsu Tom, 2003).

Frequency can be described using a guitar and a tuner. Have the students use a guitar tuner to tune a guitar to standard tuning. Standard guitar tuning has the open notes tuned, from lowest pitch to highest pitch, to: E, A, D, G, B, E. Use a sound level meter to determine the frequency of each string. To tune the notes tighten or loosen the string according to the guitar tuner. This is a standard tuning sequence for many popular songs. Ask students to make observations about the pitch and frequency of each string after they have been plucked. Next have the students observe what happens to the frequency when you cause the string to become sharp and flat. Have students make observation on the how different frequencies of the same string cause a change in what they hear.

A guitar is divided by frets. Holding down a finger on a string at different frets changes the wavelength of a plucked sting. This wavelength also changes the frequency of the sound. By using a guitar you can have students calculate wavelength by measuring the frequency of the plucked, fretted sting.

You could also go the music room and gather information of the various frequencies of each note on a piano and graph the information to provide a visual auditory representation of different frequencies. This can be done using a sound level meter. A sound level meter is an instrument that provides objective, reproducible measurements of sound pressure. It works very similar to the human ear. The meter will give you measurements in frequency and decibels. A bar graph can be draw with the keys on the x axis and the frequency on the y axis.

Students can then measure wavelengths, frequencies and amplitudes of musical instruments using sound. This will provide students with the ability to collect and analyze data. Students will use the sound and wave simulation software to examine the intensity and waveforms created from voice and musical instruments. Wave forms are then displayed on an oscillogram representing the wave of a physical sound. Students can print the graphs produced. Have student compare the wave patterns from different instruments tuned at the same frequency. Have students compare the wave patterns of the same instrument tuned at different frequencies.

## Waves In Motion

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Sound waves react differently when they come in contact with an obstacle. Have you ever called out at the top of a mountain only to hear your call a few seconds later? This occurs because the sound waves that your voice box produced were reflected back to your ear. Reflection of a wave occurs when a sound wave bounces off an obstacle. When this occurs the wavelength and the frequency are unchanged.

Refraction occurs when sound waves cross a boundary and pass into or through objects. When this occurs the wave is bent as it crosses the boundary.

Absorption occurs when the sound wave pass through objects. As a sound wave is absorbed the amplitude of the wave gets smaller and smaller as it passes through the material. Heavy curtains are used in theaters so that audiences are unable to hear what is going on back stage. Earplugs are used to diffuse the amplitude of a loud noise that may be harmful to the delicate hair cells of the inner ear (Hsu Tom, 2003).

## Natural Frequency and Resonance

Natural frequency occurs when an object vibrates; it creates its own frequency each time it vibrates. Take for instance a guitar string tuned in A; each time this string is plucked it will vibrate at a frequency of 440 Hz. If this string is plucked and it does not have a frequency of 440 Hz then we know that the string is not in tune. One way to explain this would be to use a guitar tuned in A and have the students listen to it. Change the natural frequency of the string to 450 Hz. Play the string and ask if they have noticed a difference. Do the same thing for a frequency of 430 Hz.

When two frequencies are heard together at the same time they can be amplified or they can cancel each other out. If the waves are in consonance amplification occurs. This means that the two waves are in phase with each other. If waves are in dissonance with each other they are out of phase with each other and the waves cancel each other out.

By understanding dissonance engineers have been able to create noise canceling technology which is being used at the work place and in leisure. (Hsu Tom, 2003). (See Activity 7).

## How Animals Hear

How do humans experience sound? Sound waves are collected in the pinna. The pinna is located on the outside of your head. It is the outer visible part of the ear made up of skin and cartilage. Sound waves are collected in the pinna and transported through the outer ear canal. Sound waves entering the ear at a certain frequency cause the ear drum to vibrate at the same frequency which in turn causes three tiny bones; malleus, incus and stapes in the middle ear to vibrate. The vibrations are transferred to the cochlea in the inner ear. The cochlea is filled with fluid and lined with 18,000 sensitive hairs. They are called hairs because each cell is topped with hair like structures called stereocilia. Excited hairs trigger the generation of nerve signals that are sent to the brain via the auditory nerve.

The cochlea is a spiral canal that starts out wide and gets narrower. The nerves near the wider part of the channel respond to long wavelength, lower frequency sounds. The inner channel responds to shorter wavelength, higher frequency sounds. On average, people can hear sounds in the frequencies between 20 to 20,000 Hertz.

As people age our hearing ability tends to change. Often older people will loss their ability to hear high frequencies of sound. Many adults cannot hear sounds higher than 15,000 Hz. while children can often hear as high as 20,000 Hz. (Katsuk Y, 1982).

Natural sources and modern technology are able to make sounds higher than the human ear can hear. Ultra Sound is a sound that has a frequency of 100,000 Hz or more. The human ear is unable to detect this frequency however the sound waves can easily pass through our bodies. Medical ultrasound instruments use the refraction and reflection of sound waves to produce images of structures inside the body. This is common procedure for doctors to produce images of beating hearts and developing babies in the womb. An echocardiogram is a moving image of the heart's action. A video is produced with false colors to indicate the speed and direction of blood flow and heart valve movements (Hsu Tom, 2003).

*Activity 5 Analysis of different Specialized Cells*

This will be a good time to review the parts of the eukaryotic cell. It is important to highlight the fact that we are made up of billions of cells. Of these billions of cells many are not at all the same. There are dozens of specialized groups of cells with different functions. I will obtain electron micrographs of different specialized cells and have student make predictions about what the function of each cell is. Students will be required to describe the similarities and differences of each cell. Most will be able to determine that each cell has a nucleus and cell membrane; however the shape and size of each cell will be different. One of the cells that will be used will be the hair cell of the inner ear. Students will notice the stereocillia of the cell and they will be asked to predict the importance of the appendage before the true function is reveled.

## Noise Induced Hearing Loss and Headphones

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Humans are born with 15,000 hair cells per ear. When large quantities of these cells become damaged hearing loss occurs. There has been an increase in hearing loss within the population. It is estimated that one in three adults over the age of 65 has a hearing loss condition due to irreversible damage to sensory cells. (Heller S, Oshima K, 2005).

There are two types of Noise Induced Hearing Loss (NIHL): sensineural hearing loss and tinnitus. Sensorineural hearing loss occurs when sound waves oscillate through the inner fluid of the cochlea and over stimulate and kill the hair cells. This damage is due to exposure to harmful sounds. Two types of noise cause this to occur: a loud impulse noise, such as canon, and loud continuous noise, such as music from headphones.

Sound is measured in decibels. Exposure to sounds greater than 85 decibels may cause hearing loss. People with noise-induced hearing losses typically have reduced hearing of high pitch sounds (that is, for frequencies between 3000 and 6000 Hz). In general, the louder the noise and the longer you are exposed to it, the greater the amount of hearing loss you may suffer. OSHA suggest that the louder the sound the less time it takes for damage to occur. Sounds of less than 80 dB, even after long exposure, are unlikely to cause hearing loss.

A loud impulse sound can result in permanent hearing loss from the time of exposure. This will cause a condition called Tinnitus. Tinnitus is a slight ringing in one or both ears, however some cases, if severe enough will cause a buzzing or even a roaring sound. These symptoms may subside over time but often times the condition will prevail throughout a lifetime. Continuous exposure to a loud noise will also damage the structure of the inner ear hair cells.

As hair cells from a certain frequency range are damaged those frequencies are no longer heard. The most sensitive cells are those that pick up high frequency sounds. So often when a person has contracted NIHL they are unable to hear sounds with high frequencies. Vowel sounds are unique because they are high frequency sounds. Those that have NIHL often acknowledge that they cannot hear vowel sounds. When tinnitus occurs the damaged cells will continuously send signals to the auditory nerve cell even though there is no real sound. This sound is described as a persistent buzz in the head at the frequency of the hearing damage. That means if the sound that caused the damage was 100 dB then the perceived Tinnitus buzz will equal that value. This condition will compromise the quality of life and ruining all ability to hear the same (www.nidcd.nih.gov).

*Activity 6 Measurements of Headphones and Noise Induced Hearing Loss*

When listening to music through earphones at mid level the sound generated reaches levels of 100 dB this is loud enough to cause permanent damage after just 15 minutes a day. Students will conduct a survey with a digital sound level meter. Each group of students will set their portable listening device to their normal listening volume. Students will be asked to estimate the total amount of time that they listen to their music during the day. The device will then be measured to determine the average decibel (dB) output. Students will then compile the data and determine the average amount of time and decibel reading for a typical high school student. They will then compare this data to the *OSHA Regulation 1910.95 Occupational Noise Exposure* scale to determine if the average student may be causing damage to their hair cells (Table 3).

*Activity 7 Persuasive Essay on Noise Induced Hearing Loss*

Students will be given three news articles about iPod use and hearing loss. Students will then write a persuasive essay that takes a stance for or against passing new laws on headphone technology. The Articles that I have chosen are; Behind the Music: IPods and Hearing Loss, More Headphone Use Leading To Hearing Loss, Ipod Trend Brings Spike in Noise Induced Hearing Loss and Walkmans and Hearing Loss (See references for sources).

## Modern Technology of Hearing Loss

New research suggests that hair cells are able to rebuild the hair structure in a 48 hour period. Permanent hearing loss occurs when the damage is severe enough so that the self repair mechanism is not induced. Because of this scientists have been working diligently to give those people who have lost this sense their hearing back. There are a variety of mechanisms that are on the market or that are still in the research phase. Some alleviate the problem while others hold a promise for complete recovery.

**External Sound Amplifiers and Cochlear Implants**

Current treatments for hearing loss are hearing aids which are external sound amplifiers, and cochlear implants which are electronic devices inserted into the inner ear that send sound-generated electrical pulses directly to the brain. These solutions do not give the same sense of hearing back to the patient and often pick up and amplify background noise creating frustration and embarrassment for the patient.

**Drug Therapy**

Modern drug therapies are now being researched for hearing loss. During periods of loud noise blood flow is limited to the cochlea. Drugs used to treat peripheral vascular disease maintain blood circulation to the cochlea during exposure to loud noise (www.nidcd.nih.gov)

**Stem Cell Technology**

Stem cells are undifferentiated cells. Theses cells have not differentiated into more specialized cell type, which have specific functions whether they are there to carry oxygen, maintain skin elasticity or determine pressure differences within the cochlea. These cells differ from the stem cell. The stem cell has the ability to become any one of these specialized cells.

Stem cells are unique because have the ability of self renewal as well as differentiating into specialized cells. Recently it has been observed that these cells are able to populate a tissue after they have been transplanted.

Two types of stem cells can be used for medical applications; embryonic stem cells and adult stem cells. Embryonic stem cells can only be harvested from a developing embryo during the blastula stage. Adult stem cells are found in most tissues of an adult organism. During embryonic development theses cells specialize into different organs of shapes and sizes. Adult stem cells are found in small quantities with in each tissue and are there to serve as a perennial source of differentiated tissue cells.

Growing cells in a laboratory require a special recipe for growing and sustaining the cells. Stem cells are no different. To grow a stem cell in culture is one thing but to cause the cell to differentiate into a desired specialized cell can be a lot more difficult. In certain areas stem cells are already being used to replace cells lost to disease in the body. Scientists have been able to isolate hematopoietic (blood) stem cells (HSC) from a patient. These cells have been transplanted into patients whose bone marrow has been damaged due to radiation or chemotherapy. These cells have shown to repopulate the marrow and initiate the production of various blood cells (Saltzman M, Tran V,).

Stem cells are important to medical applications because they are able to repopulate and regenerate tissues that have been damaged. Current research suggests that stem cell can be differentiated into cochlea hair cells. This line of research began at Harvard Medical School by Stephan Heller, Phd and his team. Initially Heller was able to locate adult stem cells that resided in the inner ear. He extracted these stem cells from a mouse and created cochlea hair cells in a culture dish. With the right nutrients Heller was able to coax the stem cells to grow into mice cochlea hair cells. These cells were transplanted into the embryo of a chicken simply by injecting them into the embryo though a tiny hole in the shell. According to Heller, the mouse stem cells began to grow in the inner ear of the young chicks and showed all the requirements of inner ear hair cells.

His most recent work is on creating inner ear hair cells and auditory neurons from stem cells. He has shown that both embryonic and adult stem cells can be used for this. Currently he is exploring signaling pathways that control hair cell and neuronal regeneration in the lab and in living organisms. In a recent article in Neuroreport his team has shown that certain proteins such as Sonic hedgehog (Shh) accelerates inner ear stem cell proliferation. Initial research will be conducted on mice and if the process seems to work the next step will be on humans. Heller hopes that some day hearing loss can be cured with ear drops containing the proteins, or the stem cells or both. (Heller et. al. 2005)

*Activity 8*

Students in the lab cannot grow stem cells but a good way to introduce growing cells in culture would be to grow bacterial cells. This activity is a lab in which we grow bacteria in different media to see which nutrients are most suitable for this type of growth.

**Noise Canceling Technology**

For people who work in environments that are often to loud there is an invention which cancels out unnecessary noise. This is special set of headphones which measures the undesirable noise. A computer then measures the frequency of the noise and figures out how to make the same sound, only 180 degrees out of phase. The new sound is sent back into you ear through the headphones. When the two sounds combine they work against each other and the person is unable to hear the two sounds. The opposing frequencies cancel each other out. (Hsu Tom, 2003)

*Activity 9*

Students will develop an ad campaign to sell their product which will solve the problem of increased hearing loss among the overall population. Students will have to portray that they understand the properties of sound waves and their damaging affect on the inner hair cells. They will then use their marketing skills to promote the modern biomedical technology their company is involved with.

## Figures and Tables

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**Table 1. Logarithmic Growth Curve of Decibels to Amplitude**

(table available in print form)

**Table 2: Comparison of a Logarithmic Scale of Decibels to a Linear Scale of Amplitude**

(table available in print form)

**Table 3. OSHA Regulation 1910.95 Occupational Noise Exposure**

(table available in print form)

**Table 4. Decibel Levels of Common Sounds**

(table available in print form)

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## Student Reading List

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Harrison, Robert V., The Biology of Hearing and Deafness. Charles C Thomas Pub Ltd (April 1988) This gives a good overview of how our anatomy changes when we can no longer hear.

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Behind the Music: IPods and Hearing Loss, 1/10/06 The Wall Street Journal Online. A powerful article which will be good for the classroom.

More Headphone Use Leading to Hearing Loss, 9/12/05 msnbc.com. A powerful article which will be good for the classroom.

Ipod Trend Brings Spike in Noise Induced Hearing Loss 2/13/05, The Boston Globe Online. A powerful article which will be good for the classroom.

Walkmans and Hearing Loss, July 1997, Vibes Magazine. A powerful article which will be good for the classroom.

Websites

www.unitedstreaming.com United Streaming website offers a variety of video clips on sound and the anatomy of the ear.

www.physicsclassroom.com provides tutorials, multimedia and physics help on all physics topics.

www.hhmi.org/ The Howard Hughes Medical Institute's website provides multimedia and scientific related articles on sound.

www.kettering.edu/~drussell/demos.html provides excellent animations on waves and sound.

www.nidcd.nih.gov National Institute on Deafness and Other Communication Diseases part of the Nationoinal Institute of Health. A very informative website on Noise Induced Hearing Loss.

## Materials

Rubber boots, measuring tape, timer and a long wooden stake will be needed for the water wave lab.

A cow bell, a pair of binoculars, a stopwatch and a measuring tape will be needed to determine the speed of sound.

Video clips of lightening storms to determine the distance and speed of a on coming storms

A guitar, piano and a tuner for determining frequency and decibels with the sound level meter.

Wave simulation software to examine the intensity and waveforms created from voice and musical instruments.

A Sound Meter is very important for determining frequency and decibels of instruments and headphones.

Electron micrographs of different specialized cells including a picture of inner ear cells.

The articles: Behind the Music: IPods and Hearing Loss, More Headphone Use Leading To Hearing Loss, Ipod Trend Brings Spike in Noise Induced Hearing Loss and Walkmans and Hearing Loss, for the writing of the persuasive letter.

## Appendix

Implementing District Standards

Connecticut English Language Arts Content Standards

1. Reading and Responding
2. Communicating with Others

Students will be reading current articles in the New York Times and Newsweek. These articles represent current research on how iPod headphones are showing signs that they are responsible for hearing loss in young adults. Students will interpret, analyze and evaluate these articles. They will then communicate in the form of a persuasive essay for or against listening to music too loud.

Connecticut Mathematics Content Standards

1. Algebraic Reasoning

Students will be calculating wavelength, frequency and speed of sound waves. Students will also convert between amplitude and decibels.

2. Working with Data

Students will be collecting, organizing and displaying data that they gathered from a survey on how high students keep their volume at and for how long of a time period they listen to the music.

Connecticut Science Content Standards

1. Scientific Inquiry

Students will make observations about the physical world around them by observing waves that are present in their environment. Students will collect data on the properties of water waves. Students will collect data on the speed of sound, and the frequency of various musical instruments. Students will analyze the graphs of various instruments and draw conclusions about similarities and differences. Students will then collect data on the decibels measurements of their portable music devices and determine if they fall within the range of

OSHA's standards for occupational noise exposure for noise induced hearing damage. With this knowledge students will determine a statistic for the average decibels and average time students listen to headphones of their portable music device.