Introduction to Dangerous Decibels

Dangerous Decibels is designed to help prevent **Noise-Induced Hearing Loss (NIHL)** and **tinnitus** (ringing in the ears, which is an early indicator of hearing loss) by changing knowledge, attitudes, and behaviors of school-aged children.

Aspects of the Dangerous Decibels project include this teacher resource guide with K-8 classroom activities, a teacher training program available with this curriculum on DVD, a museum exhibit at the Oregon Museum of Science and Industry (OMSI) in Portland, Oregon, OMSI Outreach programs to schools and fairs in the Pacific Northwest, a website (www.dangerousdecibels.org), and a research project.

The project is built upon an innovative collaboration between basic science researchers, museum educators, civic leaders, Oregon and Southwest Washington schools and volunteers in a unique public/private partnership.

Partners are the Oregon Museum of Science and Industry (OMSI), the Oregon Hearing Research Center at the Oregon Health & Science University (OHSU) in affiliation with the Portland VA National Center for Rehabilitative Auditory Research and the American Tinnitus Association.

Funding for the project comes from a National Science Partnership Award (SEPA) from the National Center for Research Resources (NCRR) division of the National Institute of Health, the Northwest Health Foundation, the OHSU Tinnitus Clinic, the Collins Medical Trust, and the Harold and Arlene Schnitzer CARE Foundation.

Why Teach About Noise-Induced Hearing Loss?

- Twenty-eight million Americans are affected by hearing loss.
- Over fifty million Americans have tinnitus.[1]
- Approximately one third of all hearing loss can be attributed to noise-induced hearing loss.[2]

Although many people are familiar with hearing loss among the elderly (called **presbycusis)**, fewer are aware of the extent of hearing problems among younger generations. Rates of noise-induced hearing loss are on the rise in all age groups. Tinnitus and noise-induced hearing loss can be caused by sounds in our jobs, homes, and recreational activities.

The Dangerous Decibels classroom activities are designed to help students understand and answer the following questions:

- What are the common sources of sounds that can damage ears?
- What are the effects of these "dangerous decibels"?
- How can I protect myself from them?

Behavior-Related Objectives

After participating in the Dangerous Decibels project – whether viewing the exhibit, receiving the outreach program, or participating in classroom activities from the teacher resource guide – students should understand the danger of loud sound and respond by one or more of the three following methods:

- **Turn Down the Volume,**
- **Use Hearing Protection, and/or**
- **Walk Away.**

[1] American Tinnitus Association, November 2004.

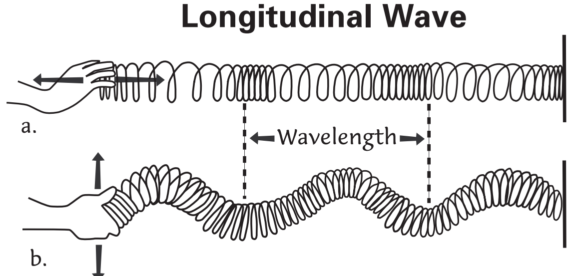
[2] Noise and Hearing Loss. NIH Consensus Statement, NIH Consensus Development Conference, Jan. 22-24, 1990;8(1) 3-4

The Science of Dangerous Decibels
Background Information for the Teacher

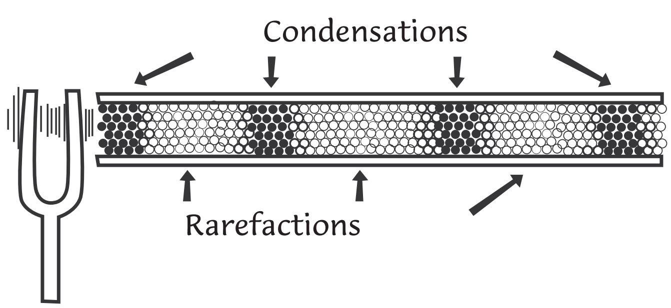
The Physics of Sound

Sound occurs when energy travels as waves of pressure through a substance like air, water, or even solid materials. Almost anything that vibrates can produce sound. When something vibrates it pushes the particles around it, and those particles in turn push the air particles around them, carrying the pulse of the vibration in all directions from the source. The particles themselves don't move very far, but the transfer of energy can be very fast, about 760 miles/hour (1 kilometer/3 seconds) in air, depending on the temperature and humidity. Sound travels about 5 times as fast in water and about 14 times faster in steel than in air because the molecules are closer together and the motion can be transferred more rapidly.

Sound waves are called **"longitudinal"** pressure waves, which are different from the **"transverse"** waves we're familiar with in water because the molecules move back & forth rather than up and down (see diagram below).



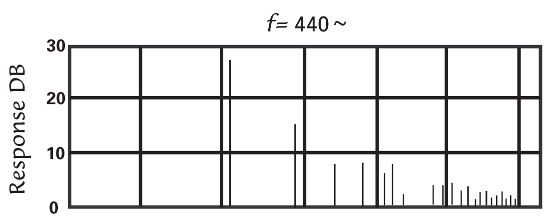
Sound has three characteristics basic to how we experience it: **loudness, pitch,** and **timbre.** The **loudness** of a sound results from the difference in pressure between the compressed areas and the rarefied areas – a greater difference being louder. (See diagram below showing a graphical representation of the sound produced by a tuning fork.)



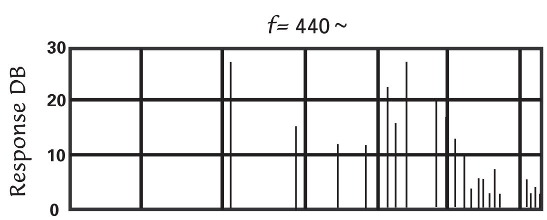
Pitch results from the rate or “frequency” of the vibrations, which we experience as higher and lower tones like the “do – re – mi” of a musical scale. The frequency of vibrations is not the same as the speed of sound. Different frequencies all travel at the same speed in the same medium – imagine listening to music if they didn’t!

The **timbre** is what makes a sound distinct and recognizable as a particular instrument, voice, vowel sound, or just noise. Almost all vibrating objects create several vibrations of various frequencies and intensities in addition to the main or “fundamental” frequency. These are called “overtones” and if they are simple whole number multiples or “harmonics” of the fundamental frequency (2x, 3x, 4x...) we hear the overall sound as a pleasing or musical tone. If they are a more random combination of frequencies we usually just call it noise. Different sources may create the same fundamental note with all the same harmonics, but individual harmonics are louder or softer depending on the source. That’s what makes violins, saxophones, and voices all sound unique.

violin



piano



A piano and a violin playing the same note (A-440hz). The unique set of harmonics that each one produces is what makes them sound different.

This is also how we create vowel sounds: by altering the shape of our mouth we change which harmonics resonate loudly and which are suppressed. So, if you loose the ability to hear the higher tones it can become difficult to hear the difference between an “a” “e” “i” “o” and “u.” The result is not just an inability to hear high-pitched sounds, but to distinguish one type of sound from another!

Fun Facts About Sound:

- Sound travels at 760 miles/hr.
  Have older students calculate how long it takes for sound to travel one mile. (1 mile in a little less than 5 seconds) So during a storm you can calculate the distance to a lightning strike by counting the seconds between a lightning strike and the resulting thunder and then dividing it by 5 to get the approximate distance in miles!
- Frequency and wavelength are inversely related (freq. = speed of sound/ wavelength), so given the range of voices from bass to soprano we can figure that the sound waves coming from our mouths are between 1 and 12 feet long!
- The actual difference in the density of the compressed and rarefied air in a sound wave, from a piano string for example, is only about 1/100th of 1%!
- For more about the Physics of Sound and of Music look for Physics of Music demonstrations in the physics lab at the Oregon Museum of Science and Industry.

Add more fun facts that you or your students find below:

More Fun Facts About Sound

Anatomy and Physiology of the Ear:
The Mechanics of Hearing

Note: Refer to the color diagram of the ear on page 92 (Appendix B) of this resource guide.

1. The **pinna** is the only part of your ear located on the outside of your head. It is what we commonly refer to as the ear. It is made of skin and cartilage. The pinna helps direct sounds into the ear. It also helps your brain to figure out where the sound is coming from.

2. The **auditory canal** (commonly called the ear canal) is a short tube. An adult's ear canal is only about one inch long and directs sound to the eardrum. This is also the part of our ear where **earwax** is found. Earwax is actually a good thing to have; the wax traps dirt before it reaches the eardrum, keeps skin moist and protected, and also repels bugs with its scent!

3. The **eardrum**, or **tympanic membrane**, is a thin membrane that vibrates in response to sound. The tympanic membrane vibrates at the same frequency (rate of vibration) as the incoming sound, and in turn, causes a small bone in the ear to vibrate at that same frequency.

4. The **ossicles** are three bones found in the ears of all mammals. (The root word 'os' refers to bones.) These bones are the smallest bones in a person's body, and they act like a system of levers.
The **malleus**, or hammer, is the bone attached to the eardrum. When the eardrum begins to vibrate as a result of sound, it pushes on the malleus, which then begins to vibrate.
The **incus**, or anvil, lies between the other two ossicles. When the malleus vibrates against it, the incus also begins to vibrate.
The **stapes**, or stirrup, is the third ear bone. When the incus vibrates against it, the plate at the end of the stapes vibrates. The stapes is connected to a window in the cochlea.

5. The **cochlea** is the snail-shaped structure in the inner ear. The cochlea is filled with fluid, and lined with about 18,000 microscopic **hair cells**. They are called hair cells because they are topped by hair-like structures called stereocilia. All 18,000 hair cells could stand on the head of a pin. As vibrations from the stapes enter the cochlea, the fluid is set into motion, causing the stereocilia on the hair cells to move. The hair cells in turn stimulate the auditory nerve.

6. The **auditory nerve** (not shown in the diagram) acts like a telephone line to the brain. The electrical signals generated by the hair cells are sent to the brain via the auditory nerve. The hearing centers in the brain interpret the signals as sounds we can recognize.

Causes of Hearing Loss

There are many different causes of hearing loss. The following are a few examples of some specific causes of hearing loss:

- **Otosclerosis** – a disease that causes bony growth on the ossicles. As a result the stapes becomes immobile and prevents the transfer of sound vibrations to the cochlea.
- **Meniere's disease** – a problem involving fluid pressure within the cochlea resulting in intermittent episodes of hearing loss, dizziness, and tinnitus. These episodes can occur any time and for varying lengths of time. Episodes are often associated with stress.
- **Drug-induced** – prolonged use of some medications (called ototoxic) results in an unwanted side effect of damage to the auditory system. Examples of drugs known to cause hearing loss include: aminoglycoside antibiotics (such as streptomycin, neomycin, kanamycin); salicylates in large quantities (aspirin), loop diuretics (lasix, ethacrynic acid); and drugs used in chemotherapy regimens (cisplatin, carboplatin, nitrogen mustard).
- **Tumors** – one common tumor in the ear develops around the 8th cranial nerve, which is also known as the auditory nerve.
- **Trauma** – trauma to the ear can include fractures of the temporal bone, puncture of the eardrum by foreign objects, sudden changes in air pressure, and very loud noises.
- **Presbycusis** – this hearing loss is caused by natural aging of the human body and begins after age 20 but often, it is not noticed until the ages of 55 to 65. Presbycusis affects the high frequencies in the speech range, making understanding and hearing speech difficult.
- **Noise-Induced Hearing Loss (NIHL)** - this is hearing loss due to exposure to either a sudden, loud noise or exposure to loud noises for a period of time. A dangerous sound is anything that is 85 dB SPL (sound pressure level) or higher.

Dangerous Decibels focuses on noise-induced hearing loss.

Noise-Induced Hearing Loss (NIHL)

- Of the roughly 28 million Americans suffering from hearing loss, 10 million can be attributed to Noise-Induced Hearing Loss (NIHL).
  NIHL can be caused by a one-time exposure to loud sound as well as by repeated exposure to sounds at various loudness levels over an extended period of time.

- Damage happens to the microscopic hair cells found inside the cochlea. These cells respond to the mechanical sound vibrations by sending an electrical signal to the auditory nerve.
  Different groups of hair cells are responsible for different frequencies (rate of vibrations). The healthy human ear can hear frequencies ranging from 20 Hz to 20,000 Hz.

- With noise exposure over time, the hair cells' hair-like stereocilia may get damaged or broken. If enough of them are damaged, hearing loss results. The high frequency area of the cochlea is often damaged by loud sound. Many people with noise-induced hearing loss have trouble distinguishing high-frequency sounds, because the hair cells responsible for high-frequency sounds are located at the base of the cochlea. Vibrations here tend to be more forceful, resulting in more damage to cells.

- Cases of noise-induced hearing loss and/or tinnitus are on the rise. Niskar says that 6.2 million US children (6-19 years of age) have hearing loss, **5.2 million due to noise-induced hearing loss (1998 & 2001).**

How Loud Is Too Loud?

Measuring Sound/Decibels

The pressure of a sound is measured in **decibels** (dB), or more specifically, dB sound pressure level (SPL). The decibel measure was developed to compare sound intensities. Like many temperature scales, the decibel scale goes below zero, the lowest level an average person can hear.

- Decibels (dBs) actually express a ratio. There has to be a reference value in order to calculate a ratio. The reference value for 0 dB SPL is 2×10^5 Newtons/meter^2. A filter can be used when measuring sound to give a correction equivalent to that of human hearing. When this is done, the units are measured in dB A (meaning the A-weighted measurement of sound pressure level).

- The average person can hear sounds down to about 0 dB[3], the level of rustling leaves. Some people with very good hearing can hear sounds down to -15 dB.

- If a sound reaches 85 dB or stronger, it can cause permanent damage to your hearing.

- The amount of time you listen to a sound affects how much damage it will cause. The quieter the sound, the longer you can listen to it safely. If the sound is very quiet, it will not cause damage even if you listen to it for a very long time; however, exposure to some common sounds can cause permanent damage. With extended exposure, noises that reach a decibel level of 85 can cause permanent damage to the hair cells in the inner ear, leading to hearing loss.

- Many common sounds may be louder than you think.

- A typical conversation occurs at 60 dB, not loud enough to cause damage.

- A bulldozer that is idling (note that this is idling, *not* actively bulldozing) is loud enough at 85 dB that it can cause permanent damage after only 1 work day (8 hours).

- **When listening to music on many earphones at a mid-level volume, the sound generated reaches a level of 100 dB, loud enough to cause permanent damage after just 15 minutes per day!**

---

[3] This is true only at 3 KHz frequency. Hearing specialists prefer to use a term dBA, a calibration of sound pressure level (SPL) using frequency range and sensitivity similar to human hearing. However, in this curriculum we will refer to the more commonly used dB.

- A clap of thunder from a nearby storm (120 dB) or a gunshot (140-190 dB, depending on weapon) can cause immediate damage.
- Noise is probably the most common occupational hazard facing people today. It is estimated that as many as 30 million Americans are exposed to potentially harmful sounds at work.
- Even outside of work, many people participate in recreational activities that can produce harmful noise (musical concerts, use of power tools, etc.). Sixty million Americans own firearms, and many people do not use appropriate hearing protection devices.
- Noise-induced hearing loss is of particular concern to veterans.
  Because NIHL is not immediately apparent (having a gradual onset), many veterans leaving the service are unaware of the full extent of hearing damage.

Tips for Communicating with Individuals with a Hearing Loss

presented by:

The Audiology Awareness Campaign

The following tips are provided to enhance communication with individuals that have a hearing loss. Often, very minor adjustments by the person speaking will greatly increase the ability of the listener to understand what is being said. These tips can even help communication among individuals with normal hearing.

1. Always speak clearly and naturally

   Shouting can cause distortion of hearing aids and often makes the words even more unintelligible. Speak slowly enough that the words can be distinguished from one another, but not so slow that the natural rhythm of the sentence is disrupted.

2. Use different words if you are misunderstood.

   Certain sounds may cause the listener difficulty, so if you need to repeat your sentence, try to use different words that may be easier to understand.

3. Face the listener and encourage speech/lip reading

   Many people can speech/lip read to some degree even if they have not been formally trained. Do not hide your mouth or chew while talking. Also try to have the room lighting in front of you to prevent shadows.

4. Attract their attention BEFORE you begin

   Be sure the listener knows that you are trying to communicate with them before you even begin your sentence. You can say their name or lightly touch them to let them know your intentions.

5. Stay close to the listener

   If the listener can hear better on one side, try to stay on that side if possible. Also do not attempt to talk to someone if you are in a different room or if there is distracting noises. Always try to remain within 3 to 5 feet of the listener.

6. Turn off or decrease room noises

   Other noises can mask out or block speech. Televisions, radios and even other people talking can greatly affect the ability to discriminate speech. For example, you can request a quiet corner of a restaurant instead of sitting in the main seating area. Reduce the background noise as much as possible before beginning a conversation.

7. Use facial expressions and hand gestures to emphasis your feelings

   This will help the listener understand your emotions and thereby help them understand what you are trying to communicate.