exploratorium pathways

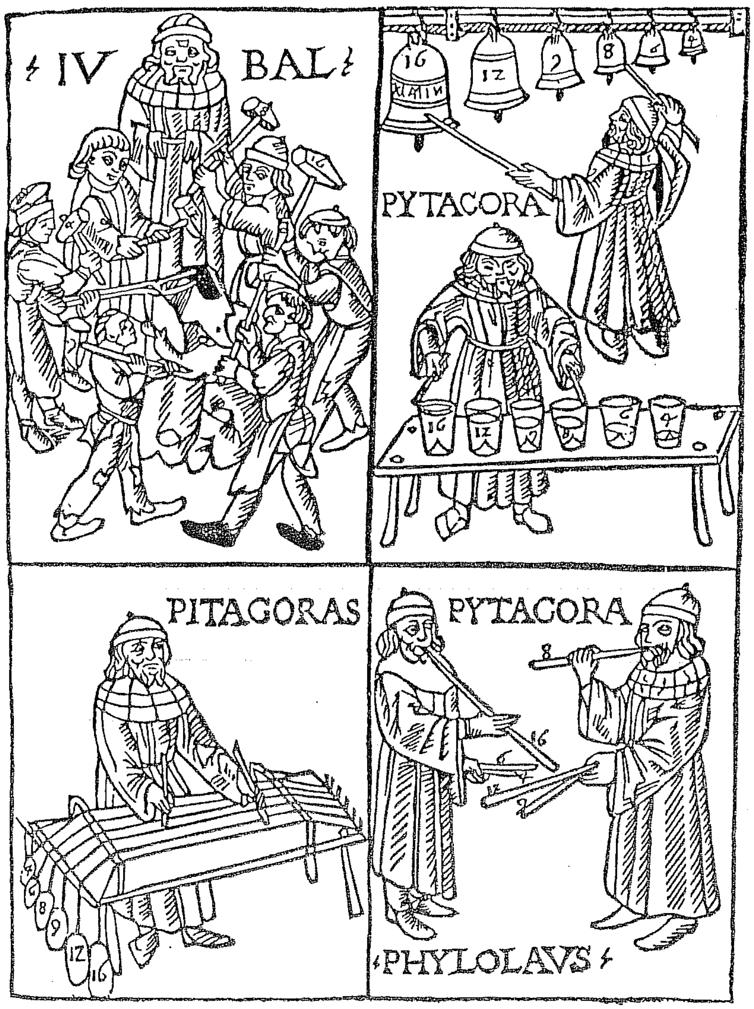
CHANGING SOUNDS

CLASSROOM ACTIVITIES

"A melody is taking a tone for a walk." —Paul Klee

Imagine going to a concert where all the instruments could play only one note (the same note) at only one speed at just one intensity. Sounds pretty dull, doesn't it? Fortunately for us, we live in a world where sounds can change. They can be loud or soft, high or low, resonant or tinny, or a combination of many different characteristics. How sounds change is dependent on the nature of sound itself.

Sound is vibration. Whenever you make a sound—when you drum your fingers on a table, for example—you begin a vibration. As each finger hits the table it smashes into the molecules of the table and gets them moving. They begin to vibrate, bumping into the molecules of air all around them. Soon pulses of vibrating air—sound waves—are moving out in all directions. When some of that moving air reaches your ears, it gets funneled into your inner ear and vibrates on your eardrum. Your brain interprets these vibrations as sound, and you hear the drumming of your fingers on the table.

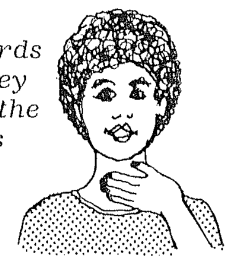


Franchino Gafurio's Theoric Musice *(1492) demonstrates an early understanding of how different vibrations make different sounds.*

In the first panel, Jubal, biblical father of music, muses on the tones produced by the resonances of different hammers. Three more panels depict Pythagoras testing the varying tones of bells of different sizes, glasses filled to different levels, strings attached to different weights, and pipes of different lengths.

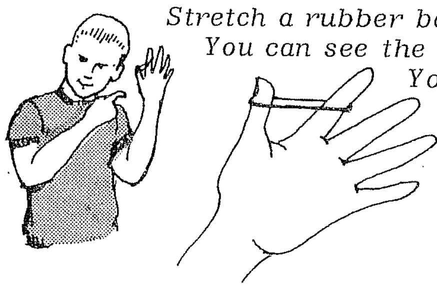
When you speak or sing, it's your vocal cords that are vibrating, deep inside your throat. If you put your hand gently on your throat as you speak, you can feel the soft buzzing of your vibrating vocal cords.

Ask your students to feel their own vocal cords vibrate as they speak softly, and then as they speak in a normal tone of voice. Notice that the louder you talk, the harder your vocal cords vibrate.



Weak vibrations make soft sounds; strong vibrations make loud sounds. When you speak softly, your vocal cords move back and forth very gently. When you speak in a normal tone of voice, your vocal cords vibrate harder, and you can feel them more easily. If you were yelling at the top of your lungs, your vocal cords would be vibrating like crazy!

Making a sound louder or softer is just one way to change that sound. You can also change how high or low a sound is—its pitch—by changing the rate of vibration of the object making the sound. The faster the vibration, the higher the sound.



Stretch a rubber band by your ear and pluck it with a finger. You can see the rubber band move back and forth as it vibrates. You can feel the vibrations on your fingers. Notice how the sound changes as you stretch the rubber band tight, and then as you let it relax. The tighter it is, the faster it will vibrate. Try using different rubber bands—long and short, thick and thin—and compare the sounds they make.

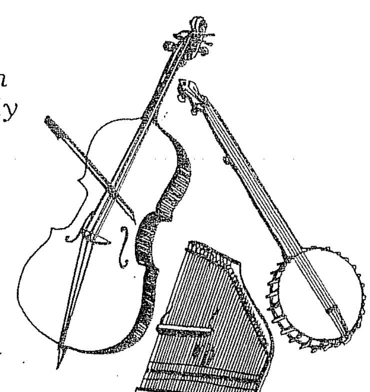
When you sing the high notes in a song, you tighten your vocal cords so that they vibrate very quickly. When you let your vocal cords relax, they vibrate more slowly, and then you can sing the low notes. By changing the way your vocal cords vibrate, you can change pitch and sing all the notes in a song.

A guitar, or any stringed instrument, can show you some of the ways different vibrations make different sounds.

THICK AND THIN STRINGS: There are both thick and thin strings on a guitar. The thicker strings vibrate more slowly than the thinner strings, and make a lower sound.

TIGHT AND LOOSE STRINGS: The tighter the string, the faster it vibrates and the higher the pitch. Notice that when you turn the peg to tighten a string the pitch gets higher.

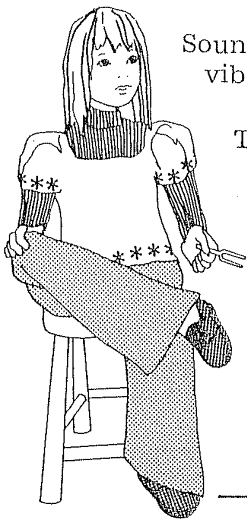
SHORT AND LONG STRINGS: When you press down on a string, only part of that string is free to vibrate when you pluck it. The shorter the string, the higher the sound.



If you have any musical instruments available, you and your students can look for shorter/tighter/thinner things that make higher notes, or longer/looser/thicker things that make lower notes. If you have a xylophone, for instance, notice that the shorter keys make the higher sounds and the longer keys make the lower sounds.

CHANGING SOUNDS

Tuning Forks



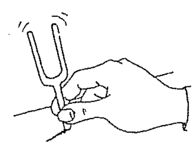
Sound waves are invisible, but you can feel, hear, and even see the vibrations that make sound when you play with a tuning fork.

To use a tuning fork, hold it by the stem and strike the prongs firmly against the rubber heel of a shoe—or use the small block of rubber that comes with some tuning forks. Be gentle when you strike a tuning fork: the prongs are easily damaged.

As soon as you strike a tuning fork, its prongs will begin to vibrate. The prongs of a tuning fork will always vibrate at the same speed, so a vibrating tuning fork will always make the same note. Because the note is always the same, tuning forks are often used to help tune musical instruments and to make sounds for scientific experiments.

☐ Start your tuning fork vibrating and gently touch the tips of the prongs to the surface of a bowl of water. The ripples you see are made by the vibrations of the ringing tuning fork. In air, these vibrations make sounds that you can hear.

☐ Strike the tuning fork and listen to the sound it makes. Strike it again and hold the end of the vibrating stem on the top of the table. Put your ear down on the table and listen. Notice how much louder the sound is when you hear it through the table than when you hear it through the air.

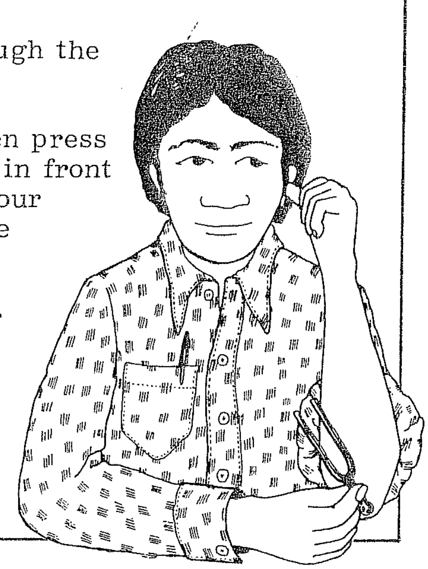


☐ Hold the stem of a vibrating tuning fork against many different surfaces and listen carefully. Try all kinds of things: hard and soft, rough and smooth, solid and hollow, animal, vegetable, and mineral. See if you can predict how loud the sound will be.

☐ You can feel and hear the vibrations of a tuning fork through the bones in your body. Try this simple experiment:

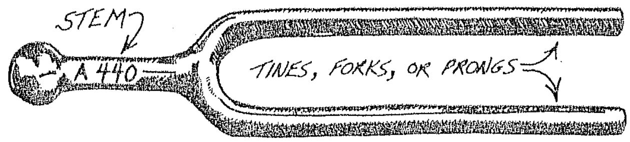
If you have long sleeves, roll one up above the elbow. Then press the forefinger or thumb of your bare arm against the bone in front of the little flap of skin at the opening of your ear. With your other hand, strike the tuning fork and hold the stem of the vibrating fork against your bare elbow. Hear it?

☐ Gently touch the prongs of the ringing tuning fork to your lips, cheek, or fingertips. You can feel the tickle of the quickly moving prongs.



More activities on the back...

☐ If you look carefully at the stem of your tuning fork you'll notice a letter and some numbers inscribed on one side. The number on the stem of a tuning fork tells you



the number of times the prongs vibrate in one second. The letter next to the number gives you the name of the musical note you hear. A-440, for instance, means that you are hearing an "A" on the musical scale, and that the tuning fork is vibrating 440 times per second.

☐ Match the sound of your voice to the sound of the tuning fork. Guess how many times the vocal cords in your throat are vibrating each second. If the tone you are singing is the same tone that the tuning fork is making, then your vocal cords must be vibrating the same number of times.

Note: Tuning forks can often be borrowed from school science or music centers, or they can be bought at music supply stores for a few dollars each.

RELATED EXHIBITS (* denotes exhibits on this Pathway)

Bells
Walking Beats
Voice Trace
Listening Vessels
Echo Tube
Conversation Piece
No Sound Through Empty Space
Harmonic Series Wheel
Kettledrum
Piano Strobe
Vocal Vowels

Speech Dissector
Delayed Speech
Tone Memory
Hearing Range
Stereo Sound 1
Stereo Sound 2
Selective Hearing
Pygmalion

Ear Organ
*Circular Scales
*Pipes of Pan
*Pitch Switch
*Two Ways to Look at Sound
*Harmonic Series Wheel
*Frequency Excluder
Pentachord
Air Reed
Theremin

PUBLICATIONS

Sound and Hearing. Life Science Library, Time-Life Books, Inc., New York.
The Composer in the Classroom; Ear Cleaning; The New Soundscape; When Words Sing, by R. Murray Schafer. Associated Music Publisher, Inc., New York.
Musical Instruments Recipe Book; Whistles and Strings. Elementary Science Study, McGraw-Hill Book Company, New York.
Make Mine Music, by Tom Walther. Little, Brown & Company, Boston.
The Science Book, by Sara Stein. Workman Publishing Company, New York.
Science and Music, by Sir James Jeans. Dover Publications, Inc., New York.
Conceptual Physics, by Paul G. Hewitt. Little, Brown & Company, Boston.

From the Exploratorium:
Hearing & Listening and *Sound Around*, Exploratorium Idea Sheets.

MATERIALS

Tuning forks can be found in most music stores

We're interested in your comments and ideas! Write to Pathways, c/o Sally Duensing, 3601 Lyon Street, San Francisco, CA 94123

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Although it may seem obvious to you, some students confuse "high" sounds with "loud" sounds, and "low" sounds with "soft" sounds. They might say, for example, that a fog horn makes a high sound because it sounds loud. The more examples you can provide for your students, the less confusing these terms will be.

You and your students can use bottles to play with changing pitch. Just about any empty glass bottle will work: wine bottles, soft drink bottles, beer bottles, etc.

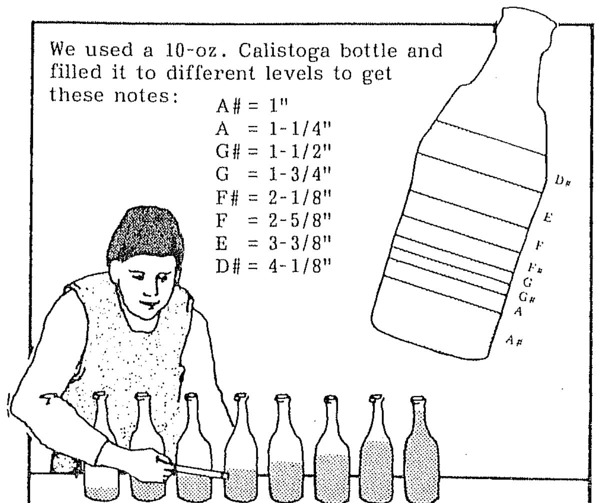
Set eight bottles that are alike in a line. Fill them to different levels with water. Ask your students to predict which bottles will make high sounds and which will make low sounds when you tap the bottles with a pencil. Put the bottles in the order they suggest and test their predictions. (Note: When you tap a bottle, tap below the water level, not on the empty portion of the bottle.)

Make a musical scale by changing the level of the water inside the bottles. We've given you one formula in the box at right. Now you have a musical instrument! Ask your students to try playing simple tunes on the bottles.

Now try blowing across the tops of the bottles instead of tapping on them. Notice that the pitches of the bottles have reversed! How would you place the bottles to get the same scale that you got when you tapped on them with a pencil?

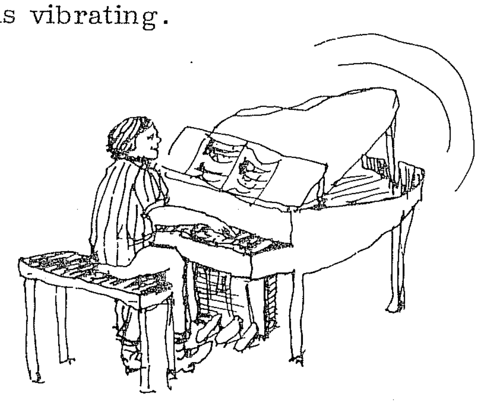
We used a 10-oz. Calistoga bottle and filled it to different levels to get these notes:

A# = 1"
A = 1-1/4"
G# = 1-1/2"
G = 1-3/4"
F# = 2-1/8"
F = 2-5/8"
E = 3-3/8"
D# = 4-1/8"



If you use wine bottles or any other large-size glass bottles, you can increase the range of notes you can make. For group performances you can tune your bottle instruments to the pentatonic scale. The pentatonic scale is a scale of five notes that sound harmonious together. At the Exploratorium, we have have xylophones tuned to a pentatonic scale so that many people playing at the same time will always sound good together. The two pentatonic scales are: C#, D#, F#, G#, A#, and C, D, E, G, A.

When you blow across the top of a water-filled bottle instead of tapping on it, you hear a different sound because a different substance—the column of air sitting on top of the water—is vibrating.



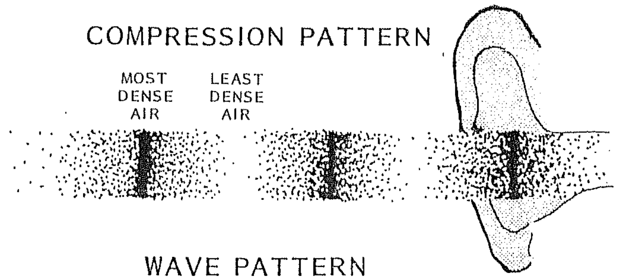
A sound is measured by its "frequency," that is, the number of times it vibrates in a given amount of time.

Generally, our ears hear sounds that vibrate in frequencies between 20 and 20,000 times per second. Middle C on a piano vibrates 256 times per second. If you double the frequency to 512 times per second, the sound you hear is the C an octave higher.

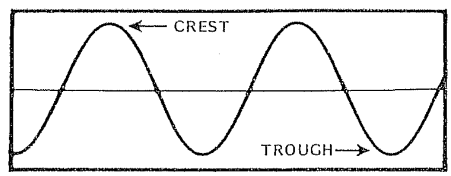
Sound waves behave much like other kinds of waves—like water waves, for instance. A disturbance in water makes the water rise and fall. A disturbance in air pushes air molecules together, and then apart. These periodic rises and falls in air pressure can be drawn in many different ways. Compression patterns and wave patterns are two of the most common methods of diagramming the pulses in air made by sound waves.

In a compression pattern, the densest air corresponds to the highest peak (the crest) of the wave pattern. The least dense air corresponds to the lowest point (the trough) of the wave pattern.

COMPRESSION PATTERN

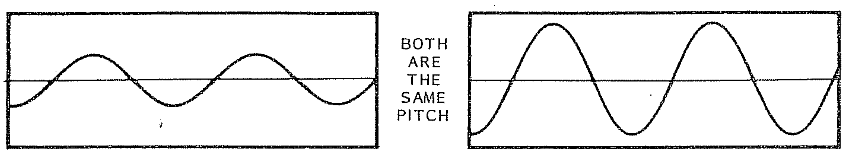


WAVE PATTERN



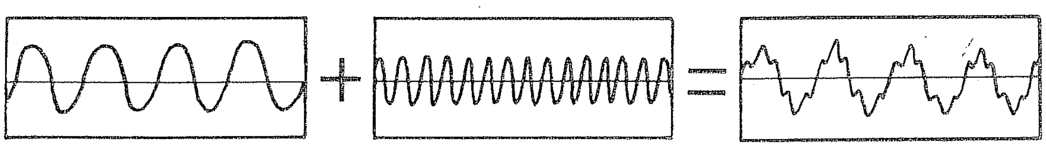
Since sound waves are invisible, oscilloscopes are used to show the wave patterns of sound. To find the frequency of a sound, we count the crests of the waves that pass by a particular point in one second.

A wave picture can show the loudness of a sound (its amplitude) as well as its frequency (its pitch). For example, the two wave pictures below show the same frequency or number of sound waves, but notice that the waves are taller in the second picture. This means that the vibrations are stronger; the sound is louder. If you raise the pitch of the sound (increase its frequency), you'll see more sound waves on the screen of the oscilloscope.



SOFT SOUND LOUD SOUND

Most sounds are not pure. They are usually a combination of many different frequencies. The wave pictures of most sounds look more like craggy mountains than smooth rolling hills. For example, if you combine the first sound wave, below, with the second one, you end up with the complex wave picture on the right.



Combining different frequencies is what gives things their characteristic sounds. When you play a "middle C" on a piano and on a saxophone, both set air vibrating at the same rate, but they certainly don't sound alike! Both have small amounts of other frequencies mixed in. In contrast, a computer-synthesized voice sounds flat to us because these extra frequencies are missing. Computers that synthesize the sounds of musical instruments try to mimic the characteristic mix of frequencies to make electronic versions of the real things. Combining and changing sound vibrations is what makes things interesting to listen to.