



## NATURAL VIBRATIONS

Have you ever wondered where the organization of musical notes comes from? Every day we hear many sounds: a bee buzzing, car brakes squeaking, people humming tunes, wind whistling through the trees. These sounds can make us feel happy or sad, excited or calm. They affect us in many ways. The sounds we call music are unique in that they are intended to change the way we feel. What are sounds, and what are notes?

In fact, music is a series of notes, and notes, like all sounds, are just vibrations. The rate or *frequency* of vibration determines what note we hear. A fast vibration (high frequency) is a “high” note, and a slow vibration (low frequency) is a “low” note. Musicians organize these different frequencies of vibration in ways that our ears find pleasing—in ways that make music.

For musicians to make music that sounds good to our ears, the frequencies must have some kind of organization. You can’t just string together a bunch of vibrations and think it will be pleasing. So where does the organization of vibrations come from? Is it natural, or is it entirely a human invention?

Have you ever heard the rope on a flagpole bang around in the wind? It seems random, but after a gust of wind, the way the rope bangs against the pole always follows the same pattern. In this way, the rope on the flagpole is like a string on a guitar. If you pick up a guitar and pluck a string, the string will definitely vibrate at a particular frequency. The moving string makes the air vibrate with the same frequency. The vibrating air then strikes your ear, and you hear one pure note—the note that corresponds to the frequency of the guitar string’s vibration.

Guitar players make different notes by shortening and lengthening the string with their fingers, pressing the string against the fretboard. Short strings vibrate faster than longer strings, so short strings make higher notes than longer strings. Another way guitarists can change the frequency of vibration (the note) of a guitar string is to change how tightly the string is stretched. Strings with more tension have a higher pitch than strings with less tension. A third way to change the frequency is to change the material the string is made of.

When we look deeper, we see that any string has a variety of different but related ways it can vibrate without anyone changing its length, its tension, or what it’s made of. These ways of vibrating produce different notes, called *harmonics*. Western classical musicians organized these harmonics into *scales* and used them to make music.

The harmonic vibrations of a string follow a natural law of physics that humans did not create and cannot change. So, as it turns out, the basis for the music we hear today was created by nature.

The ancient Greek mathematician Pythagoras recognized this. He studied the mathematical relationships between vibrating strings and pitch and developed a way to determine the frequencies that have formed a basis for Western music. In the activity *Scaling the Scale*, you will follow the same steps that Pythagoras followed—going from observing nature’s vibrations to creating a Western musical scale.