Perfect Pitch – the Musical Gene

Secrets of the Sequence Video Series on the Life Sciences • Grades 9 – 12

Teaching materials developed by VCU Life Sciences.

Virginia Commonwealth University

Classroom Tested Lesson

Video Description

"Secrets of the Sequence," Show 129, Episode 3

"Perfect Pitch" – approximately 10 minutes viewing time

DNA is the biochemical blueprint that is the basis for the expression of all physical traits. But is it responsible for the expression of artistry as well? This episode explores the genetic basis for one of the most amazing of all artistic gifts, perfect or absolute pitch. Dr. Jane Gitschier, who was trained as a classical opera singer, is trying to find the gene or genes responsible for perfect pitch. Dr. Gitschier and her colleagues are hoping to determine whether perfect or absolute pitch is inherited or a consequence of gene and environmental interaction.

Ward Television
Producer: Dave Bolton
Associate Producer: Mara Mlyn
Featuring: Dr. Jane Gitschier, Medicine and Pediatrics, University of California, San Francisco and Roy Boges, Concert Pianist.
Lesson Author; Reviewers: Stephanie Estes; Marilyn Elder, Sue Kirk, Catherine Dahl, and Dick Rezba
Trial Testing Teacher: Tommy Sommerville, Linda Barbour

National and State Science Standards of Learning

National Science Education Standards Connection

Content Standard C: Life Science

As a result of their activities in grades 9-12, all students should develop an understanding of:

- the behavior of organisms and
- the molecular basis of heredity.

Content Standard E: Science and Technology

As a result of activities in grades 9-12, all students should develop an understanding about:
science and technology.

Selected State Science Standards Connection

Use http://www.eduhound.com (click on "Standards by State") or a search engine to access additional state science standards.

Virginia

BIO.5 The student will investigate and understand life functions of archaebacteria, monerans (eubacteria), protists, fungi, plants, and animals, including humans.

Key concepts include:
e) human health issues, human anatomy, body systems, and life functions.

BIO.6 The student will investigate and understand common mechanisms of inheritance and protein synthesis. Key concepts include:
h) use, limitations, and misuse of genetic information; and
i) exploration of the impact of DNA technologies.

Georgia
Quality Core Curriculum Standards Topic 24: Human Body (Physiology)
Standard: Describes the physiology of each system.
24.1 Identifies the function of each structural part in the human body system.
24.2 Explains how the parts interrelate in a functioning system

Overview

This video and accompanying lesson is designed to help students understand the concept of perfect or absolute pitch and its relation to genetic makeup. There are unique people with perfect or absolute pitch who can accurately identify any pitch played. In the follow-up activity, students will test other hearing abilities that also have a genetic link by investigating their ability to judge the direction and distance of a sound.

Testing: A sample related multiple choice item from State Standardized Exams

Which structures in a human transmit electrochemical messages?
1. veins
2. lymphocytes
3. neurons *
4. nephrons

Source: Biology Regents Examination, August 2000, New York State Department of Education

Before Viewing

1. Obtain several different pitched tuning forks. Explain how a tuning fork works.
   - *When the fork is struck, it vibrates.*
   - *When the fork vibrates, it disturbs the gas molecules in the surrounding air, producing sound waves of a certain frequency.*
   - *This results in what is known as the pitch for that fork, or its key.*

   Note: There are unique people with perfect or absolute pitch who can accurately identify any pitch played. This video segment explores research being conducted to determine the genetic links to this trait.

2. Determine which students play a musical instrument and who would be willing to participate in a class demonstration with tuning forks.

3. Strike one of the forks and ask the student to identify its key. Repeat with other tuning forks and other music students.

Note: A trial test teacher noted that the more diverse selection of forks available the better it is to distinguish a student's true ability to identify pitches as opposed to "lucky guesses".

During Viewing

1. START the video.

2. PAUSE the video (2.44 minutes into the video) after Roy Boges describes the game he and his father used to play.
   - Ask: "How do you think Roy learned to identify pitch?"
     He was taught the names of the pitches, which he then used to name the pitches that he could identify naturally.
   - Ask: "How it is possible that this trait could be so natural in Roy and not in everyone else?"
     There may be a unique sequence of Roy's DNA that results in this special trait

3. RESUME the video.

4. PAUSE the video (4.52 minutes into the video) after Dr.Gitschier describes the hypothesis they are testing, "That ability (*of absolute or perfect pitch*) is in part dictated by genetics."
   - Ask: "What observations were made before formulating this hypothesis? Which part(s) were not dictated by genetics?"

5. RESUME the video and play to the end.

After Viewing

1. Ask: "How might perfect pitch be advantageous to organisms other than humans?"
   Responses may include
   - *ability to produce songs that may sound more attractive to potential mates*
   - *increased sensitivity to sounds when used as communication between organisms*
   - *protection from other organisms whose sounds/pitches are not recognized.*

2. Ask: "If some people can identify pitch better than others, do you think people also differ in their abilities to judge a sound's direction and distance?"

3. Explain to students that they are going to conduct an activity to help answer this question by testing various students' accuracy in judging a sound's source direction and distance.

4. Conduct the student activity: Testing Your Hearing Abilities – Sound Direction and Distance

Teacher Notes for the Student Activity: Testing Your Hearing Abilities – Sound Direction and Distance

This activity was designed to test students' ability to localize sound (direction and distance) and is based on the experiments, "Our Sense of Hearing" by Dr. Marjorie A. Murray, http://faculty.washington.edu/chudler/hearing.html and "Sound Localization" by Dr. Eric H. Chudler, University of Washington, http://faculty.washington.edu/chudler/chhearing.html

Materials

- Student Handout: Testing Your Hearing Abilities — Sound Direction and Distance
- 2 pencils per student (or have students use their own)
- Blindfolds (3 or 4)
- Meter stick
- Masking tape

Introduction

The purpose of the experiment is for students to determine a sound's direction and distance when generated by students hitting two pencils together.

Procedure

Distribute the Student Handout and go over detailed instructions with the class.

Part A: Judging Direction of Sound

1. Divide students into groups of 8 to 10.
2. One student will be the test subject and another will be the data recorder.
3. The remaining students in the group will sit in a circle around the test subject
4. Blindfold the test subject
5. Position the data recorder standing or sitting outside the circle.
6. The data recorder will silently instruct a particular student or noisemaker to hit pencils together three times.
7. The test subject will point in the direction from which he thinks the sound was generated.
8. The data recorder will record the result for that trial as correct or incorrect.
9. Steps 6 - 8 are repeated four more times, for a total of five trials.
10. The data recorder will total the number of correct and incorrect responses for this student and record the data on a class data table on the board or overhead transparency.
11. Groups repeat with additional test subjects as time allows.

Part B: Judging Distance of Sound

1. Using masking tape, groups will make 4 marks in a straight line at the following intervals: 0, 2, 4, and 6 meters.
2. The blindfolded test subject will stand on the 0 mark.
3. The data recorder will silently indicate which mark (2, 4, or 6 meters) for one of the students or noisemakers to stand on and to hit his pencils together three times.
4. The test subject will state how far away he thinks the noisemaker is (2, 4, or 6 meters).
5. The data recorder will record the response as correct or incorrect.
6. Steps 3 - 5 will be repeated for a total of five trials.
7. The data recorder will total the correct and incorrect responses for this student and record the data on the class data table.
8. Groups repeat with additional test subjects as time allows.

Part C: Analysis

Have students complete Part C: Analysis on the Student Handout.

Student Handout: Testing Your Hearing Abilities – Sound Direction and Distance

Our sense of hearing is one of the most important ways we gather information about our surroundings. Accuracy in locating both the source and distance of a sound is an important ability, especially if any of our other senses become impaired. In this activity, you will:

- test and measure the accuracy in determining the direction of a given sound.
- test and measure the distance from which a sound is generated.
- combine group data and determine class percentages.
- identify the pathway by which sound is transmitted to the brain.

Materials

- 2 pencils per student
- 1 blindfold per group
- Meter stick
- Masking tape

Safety

Movement by the blindfolded student should be limited.

Procedure

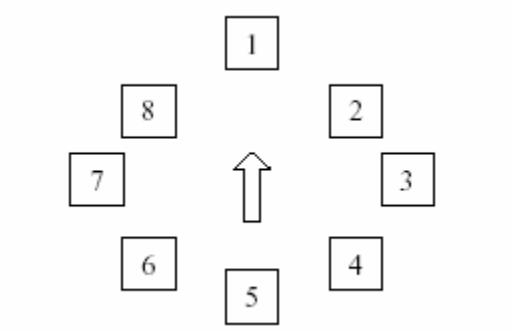
Part A: Judging Direction of Sound

You belong to a group of 8 to 10 students who have specific roles in this activity:

- One person is the test subject. He or she will wear a blindfold and will sit in the center of the group.
- One person is the data recorder. He or she will direct the repeated trials, record the responses of the test subject, and record the data on the class data table.
- The remaining group members are the noisemakers. They will arrange themselves in a circle around the test subject as indicated below. The job of the noisemakers is to hit the two pencils together three times when directed to do so by the data recorder.

Select a role for each group member and find a location in the classroom where your group can arrange itself according to the following diagram:

Positions of the test subject (arrow) and the noisemakers (squares)
The data recorder will sit or stand nearby



1. When all members are in their positions, the test subject puts on the blindfold.

2. The data recorder points to a particular noisemaker, who hits his pencils together three times. Intensity of sound should be constant so noisemakers should practice this once or twice before the trials begin.

3. The test subject indicates the direction the noise comes from by pointing in that direction. The data recorder records the response as correct or incorrect in Table A: Test Subject Data on Direction.

4. The data recorder continues to select random noisemakers and records the responses of the test subject for a total of five trials.

5. The data recorder totals the number of correct and incorrect responses and records the results in Class Data Table A on the board.

6. Repeat with additional test subjects as time allows or as directed by your teacher.

Table A: Test Subject Data on Direction

Trials of test subject : _____ (Name)	# of correct responses	# of Incorrect Responses
1st		
2nd		
3rd		
4th		
5th		
Total of Trials		

Part B: Judging Distance of Sound

Keep your roles from Part A or select new ones. Your group needs one test subject, one data recorder, and the remaining group members to serve as noisemakers.

1. Using masking tape and a meter stick, make the following marks on the classroom floor in a straight line:
   - 0 meters (starting line)
   - 2 meters
   - 4 meters
   - 6 meters

2. Have the test subject stand on the "0 meter" mark with either ear toward the line and then put on the blindfold.

3. The data recorder silently indicates where one noisemaker should stand (2, 4, or 6 meter line). At the data recorder's signal, the noisemaker hits his pencils together three times. Intensity should be constant.
   - The test subject states the distance (2, 4, or 6 meters) at which he thinks that the noisemaker is standing. The data recorder records the test subject's response as correct or incorrect on Table B: Test Subject Data on Distance.
   - Repeat Steps 4 and 5 until five trials are conducted. The data recorder totals the number of correct and incorrect responses for that student and records the data in Class Data Table B on the board.
   - Repeat with additional test subjects as time allows or as directed by your teacher.

Table B: Test Subject Data on Distance

Trials of test subject : _____ (Name)	# of correct responses	# of Incorrect Responses
1st		
2nd		
3rd		
4th		
5th		
Total of Trials		

Part C: Analysis

When all groups have collected their data, enter this information on a class data table on the board or in the tables below.

ClassTable A: Direction Data*

	# Correct Reponses	# Incorrect Responses
Group 1- Total:___		
Group 2 Total:___		
Group 3 Total:___		
Group 4 Total:___		

ClassTable B: Distance Data*

	# Correct Responses	# Incorrect Responses
Group 1 Total:___		
Group 2 Total:___		
Group 3 Total:___		
Group 4 Total:___		

*Expand table as needed for additional test subjects' data

1. Calculate the means as well as the percent correct and incorrect for each group in the Class Data Tables A and B on the tables below

Part A: Direction Data

Group	Mean	% Correct Responses	% Incorrect Responses
1			
2			
3			
4			
5			

Part B: Distance Data

Group	Mean	% Correct Responses	% Incorrect Responses
1			
2			
3			
4			
5			

2. Were the results in Part A different from group to group? What could explain these differences? How would the class data differ if every person had a chance to be a test subject?

3. How did the results in Part B differ from one group to another?

4. Based on the class data, is human hearing more accurate in determining the direction or the distance of a sound? What is your evidence?

5. Use http://faculty.washington.edu/chudler/hearing.html#back or another resource to explain how sound travels from the ear to the brain. Use a simple drawing to help explain your answer.

6. How does the brain determine sound direction using signals from the ears?

7. Extension: Compare ear shape, position and mobility in mammals to the ability to determine sound direction. Why have different species evolved such different hearing strategies?

Additional Resources

Because Web sites frequently change, some of these resources may no longer be available. Use a search engine and related key words to locate new Web sites.

Web sites
http://perfectpitch.ucsf.edu/
A link to Dr. Gitschier's study at UCSF.

http://www.stanford.edu/~meep/abspitch.html#gene
Stanford University's site that answers many questions about absolute pitch, including its genetic components.

http://faculty.washington.edu/chudler/chhearing.html
Dr. Eric Chudler's site with many hearing experiment extensions for you to try.

http://webspace.utexas.edu/~kal463/abspitch.html
An overview of absolute pitch.

http://ww2.mcgill.ca/psychology/levitin/grove.html
A study from the Journal of Experimental Psychology on absolute pitch.

http://www.jhu.edu/~gazette/janmar97/mar1097/hulse.html
An article from John's Hopkins about absolute pitch in birds.

Genomic Revolution
http://www.ornl.gov/sci/techresources/Human_Genome/education/education.shtmL
This Web site of the government-funded Human Genome Project has links about genomics, the history of the project, and more.

Secrets of the Sequence Videos and Lessons
This video and 49 others with their accompanying lessons are available *at no charge* from www.vcu.edu/lifesci/sosq