Risk taking Genes — Genes, Environment, or Both?

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 113, Episode 3
"Risk-taking Genes" – approximately 8 minutes viewing time.

What makes someone want to be a skydiver, a fighter pilot, a racecar driver? Is it in the genes? What is it about high-risk behavior that gives some people a thrill and terrifies others? For those who love "living on the edge," it's a critical part of life. Without their thrill-seeking hobbies, depression or more serious illnesses can set in.

Ward Television
Producer: Ted Duvall
Featuring: Ernest Noble, Department of Psychiatry at University of California – Los Angeles
Lesson Author; Reviewers: Ellen Lamb; Catherine Dahl, Dick Rezba, and Selvi Sriranganathan
Trial Testing Teachers: Martin Shields

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 cell: cells have particular structures that underlie their functions.
- Biological evolution
- The behavior of organisms

Content Standard F: Science in Personal and Social Perspectives

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

- personal and community health.

Selected State Science Standards Connections

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

Virginia
BIO.4
The student will investigate and understand relationships between cell structure and function. Key concepts include:

- Modeling the cell membrane, cell communication and cell recognition.

Oregon
Life Science, CIM/CAM Grade 10
Describe, explain and compare the structure and functions of cells in organisms.

- Identify cell organelles and state how their activities contribute to a particular type of cell carrying outs its functions.

Overview

Many people experience a "rush" at the top of a roller coaster. Others feel the same excitement when they successfully accomplish a difficult task. Still others feel the rush of excitement when performing in front of an audience. In all cases, there is some element of risk; all are experiencing the effects of neurotransmitters working in the brain.

Dopamine is one of the major classes of neurotransmitters used in the human body. Found in both the central and peripheral nervous systems, it is released by certain neurons and received by others. A great deal of basic research continues to modify our understanding of the mechanisms and effects of this important messenger molecule. Although some questions have been raised as to dopamine's precise role in feeling pleasure, reward and reinforcement, it is generally accepted that dopamine plays some major role in generating such feelings. As with any messenger, errors or deficiencies in the dopamine pathway may result from an imbalance in the amount of the messenger molecule itself or from an imbalance in the number or condition of molecules that can receive dopamine. Thus, understanding how messages are passed from one cell to another is essential in understanding the impact of dopamine or its absence.

Deficiencies in stimulation by dopamine, regardless of the reasons, are implicated in Parkinson's disease, Alzheimer's disease, depression and obesity. Over-stimulation by dopamine has been implicated in schizophrenia, addiction and Tourette's syndrome.

Dopamine's role in drug addiction is interesting to study in that it allows us to examine tolerance reactions as the neurons attempt to maintain homeostasis. Such reactions may occur within minutes of the first exposure to a drug that increases effective concentrations of dopamine, such as cocaine, or they may involve changing the number and/or the sensitivity of receptors to dopamine.

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

Which of the following best describes the order of events that leads to genetic expression?

a. DNA_RNA_amino acids_proteins_genetic expression*
b. RNA_amino acids_DNA_proteins_genetic expression
c. DNA_amino acids_proteins_RNA_genetic expression
d. RNA_proteins_DNA_amino acids_genetic expression

Source: Mississippi Subject Area Testing Program, Biology I SAT Practice Tests, 2002

Video Preparation

Preview the video and make note of the locations at which you will later pause the video for discussion.

Before Viewing

1. Ask the students to individually think about and respond to following questions:
    - "What makes you feel satisfied?"
      Responses may include a good meal, a job well-done, winning a video game, a good workout
    - "What makes you feel excited?"
      Responses may include a roller coaster ride, a holiday with gifts, skiing a steep slope
    - "What makes you feel happy?"
      Responses may include warm weather, good food, a hug

Note: The responses will be different for each student, but all will have some things in common — they are environmental and/or behavioral, and they affect how we feel.

2. Briefly review the activity of genes as leading to the production of proteins.

3. Briefly review the structure and function of neurons, using a picture of two neurons to label with axon, dendrite, cell body and synapse. Recall that the physical/chemical signal must "jump the gap" between two neurons to allow the message to continue through pathways.

Note: To find simple pictures of the neuron and synapse, do an "images" Web search for "neurotransmission". To find simple definitions for the parts of the neuron, do a Web search for "neuron structure".

During Viewing

1. START the video.

2. PAUSE the video immediately after the computer animated explanation of the role of dopamine (4:10 into the video).
   Ask the following questions:
    - "Do you think people vary in the amount of dopamine receptors they have?"
    - "If there is a genetic basis to risk-taking behaviors, does that mean a person has no control of his or her risky actions?"

3. RESUME the video.

4. PAUSE the video after the narrator says, "Could that explain other kinds of risky business like gambling, drinking too much or using drugs?"
   Ask the following questions:
    - "What risks do most of us take?"
      Responses may include driving cars, crossing streets, traveling away from home
    - "What sorts of risky things do you do for a thrill?"
      Responses may include riding roller-coasters or driving too fast

- What kinds of risks do we take that are not necessarily dangerous?
  Responses may include public speaking, giving a recital.

5. RESUME the video and play to the end.

After Viewing

1. Ask: "Early in the history of the human brain (thousands of years ago) what evolutionary benefits could there have been for being genetically inclined towards risk taking?"
   Responses may include increased success at procuring food or acquiring mates.

2. Ask: "What present day benefits might risk-taking genes offer?"
   Response may include accomplishing great tasks, proposing new ideas, solving problems in unique ways.

3. Remind the students of the following: The scientist in the video used the piano analogy to suggest that there were three factors affecting our behavior:
   a. The strings of the piano = our genes.
   b. The pedals of the piano = the impact of our environment.
   c. The pianist's personal style = our own influence on our behavior.

4. Ask: "What did the scientist mean when he spoke of our personalities being a concert of genes and environment?"
   Responses may include genetic make-up, environmental influences, and personal decision-making interact in complex way to affect how we act.

5. Conduct the Student Activity: Catch this! How does a neuron work?

Teacher Notes for Student Activity: Catch This! How Does a Neuron Work

Materials

- 10-12 ping pong balls
- Plastic grocery bag or other container to hold balls
- 1 tennis ball
- Masking tape

Note: For the simulation to work well, the teacher must choose 11 students, and prepare students #1 and #7 in advance for their respective roles. The teacher will stand in position 6.

Two lines are needed: Line 1 represents an axon and Line 2 represents a dendrite.

Line 1: (1) (2) (3) (4) (5) (6, the teacher)

Line 2: (11) (10) (9) (8) (7, catches ball)

Procedure

1. Have students line up with one hand on the next student's shoulder and form two parallel lines, with the teacher at the end of one line (see diagram above).

2. Simulate nerve impulse transmission by having student #1, in Line 1 with the teacher, gently tap the shoulder of student #2, who will then gently tap the next student's shoulder, triggering student #3 to gently tap the next shoulder, and so forth until the teacher's shoulder is tapped.

3. At that point, the teacher will toss a ping-pong ball across to student #7 (who represents a receptor) in the other line (which represents a dendrite of a neighboring neuron). Student #7 attempts to catch the ball with his or her one free hand. If the ball is caught, he or she will trigger a similar sequence of gentle shoulder taps, ending with student #10 gently tapping the shoulder of the last student #11.

4. Ask a student to summarize what just happened to assess student understanding of the simulation. Note: Hold all students accountable by calling on students not involved in the demonstration.

5. Repeat the activity, this time with a small basket next to student #7, into which he or she will place the balls after catching them (safety alternative: attach an open plastic grocery bag to student #7's belt; have student #7 put the ping pong balls into this bag as he or she catches them).

6. Student #1 should start the "message" repeatedly. As soon as student #7 has caught and deposited a ping pong ball, the teacher will toss one ping pong ball after another, timing them so that student #7 can just barely keep up. (Representing repeated "firing" of the neuron.)

7. Repeat more rapidly, so that student #7 causes a "blockage" by not being able to receive the next ball. (Demonstrating the concept of recovery time.)

8. Repeat the activity but this time tape student #7's catching hand – tape the thumb down so it is not free to move, thus making it more difficult to catch the ping-pong ball. (Representing a receptor made incorrectly due to genetic variation).

9. Repeat the activity, this time with student #7 holding a tennis ball in his/her catching hand so he or she cannot catch the ping-pong at all. (Representing another molecule already filling or blocking the receptor, thus inhibiting the continuation of the response.)

10. When students are seated again, go back through their experiences with a picture of two neuron endings and a synapse. Have students identify all of the parts represented in the simulation: axon of one neuron (first line of students), dendrite of a second neuron (second line of students), neurotransmitter (ping-pong ball), synapse (space between teacher and student #7), and receptor (student #7's hand).

Answer Key to questions 2 - 6 on Student Handout:

1. The student would not be able to catch the ball, just as a receptor would not be able to receive the neurotransmitter.

2. As soon as the first ball was dropped into the basket.

3. More signals could be received more rapidly.

4. The student would not be able to catch the ball, just as a receptor would not be able to receive the neurotransmitter.

5. The student would become tired and less accurate in catching; similarly transmission and reception of a neurotransmitter require energy, and eventually, will need to rest.

6. Some possible responses:
    - Ability to catch the ball – efficiency of receptors
    - Quantity/frequency of balls released – variation in quantities of neurotransmitters like dopamine produced
    - Number of hands to catch the balls – number of post synaptic receptors
    - Speed of dropping the ball into the basket – efficiency of neurotransmitter breakdown

Student Handout: Catch This! How Does a Neuron Work?

A. If your teacher selected you to be part of a line, follow your teacher's directions to form two lines like this:

Line 1:	(1)	(2)	(3)	(4)	(5)	(6, the teacher)
Line 2:		(11)	(10)	(9)	(8)	(7, catches ball)

B. If you are part of the class watching this simulation from your seat, think about these questions as you observe the actions along the lines:

1. What happened when the receptor (student #7) was already occupied by another kind of ball?

2. When the neuron was firing repeatedly, what determined how fast the next ping-pong ball could be received across the synapse?

3. What would happen if there were multiple people (lots of #7's) who could catch the ball at the end of each dendrite?

4. What happened when the receptor's hand was held shut with masking tape?

5. What would happen if the teacher tossed many balls very quickly for several minutes?

6. Which aspects of our modeled nerve cells might vary in different people because of genetic and environmental influences?

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.

Nervous system, in general
http://vadim.www.media.mit.edu/MAS862/Project.html
http://faculty.washington.edu/chudler/chmodel.html

General
http://www.utexas.edu/research/asrec/dopamine.html
http://www.columbia.edu/~jh299/DA.html
http://www.acnp.org/g4/GN401000014/Default.htm
http://worldbook.bigchalk.com/164190.htm
http://www.unc.edu/news/newsserv/research/mar99/wightman.htm

www.bscs.org Teaching model *Genes, Environment and Human Behavior* available for free download. It is found under Center for Curriculum Development/High School/Human Genome Project Curriculum.

Tourette's syndrome
http://www.sfn.org/content/Publications/BrainBriefings/tourettes.html

Video games
http://www.indyrad.iupui.edu/public/emorris/VirtualJournalClub/Koepp98NatureVideoGameRaclopridеBindingChange.pdf

Obesity
http://www.bnl.gov/bnlweb/pubaf/pr/2001/bnlpr020101.htm
http://www.sciencedaily.com/releaes/2001/02/010205075129.htm

Knockout Mice
http://www.hhmi.org/news/caron.html
http://www.mightipen.com/portfolio/dopamine_theory/dopamine_theory.pdf

Parkinson's disease
http://members.nyas.org/events/conference/conf_02_0918.html
http://www.mayo.edu/fpd/pd-info/chem.htm

Smoking and alcohol
http://abcnews.go.com/sections/living/Healthology/SCOUTDopamine_Smoking020905.html
http://www.macalester.edu/~psych/whathap/UBNRP/Dopamine/alcoholtobac.html

Stress and dopamine levels (science as a process)
http://serendip.brynmawr.edu/bb/neuro/neuro99/web1/Brock.html

Genomic Revolution
http://www.ornl.gov/sci/techresources/Human_Genome/education/education.shtmL
The Web site to the government-funded Human Genome Project with 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