

Instructor Notes

Exposure!

In this simulation, participants are “exposed” to various agents (confetti pieces) and then determine their exposure levels. A comparison between naturally occurring and synthetic pesticides is also made.

This activity helps participants understand that chemicals may affect different people in different ways. Participants also realize that their perceptions of dangerous materials may not be realistic and that the news media may not provide all of the information needed to make healthy choices.



This activity is written for workshop participants and may need modification for classroom use.

Suggested Background Readings for Grades 5–12

- An Introduction to Toxicology
- A Scientific View of Risk

National Science Education Standards

Science as Inquiry

- Abilities Necessary to Do Scientific Inquiry
Conduct scientific investigations. Models are tentative schemes or structures that correspond to real objects, events, or classes of events, and that have explanatory power. By modeling the effects of exposure to various agents, students gain a greater understanding of the interactions between a living organism and its environment.

Use mathematics to improve investigations and communications. Students use mathematics to calculate and graph simulated exposure levels, develop explanations, and communicate results.

- Understanding about Scientific Inquiry
Mathematics is essential in scientific inquiry. Students use mathematical tools and models in this activity to guide and improve the gathering of data, calculation of results, and construction of explanations.

Physical Science

- Chemical Reactions
Complex chemical reactions involving carbon-based molecules take place constantly in every cell in our body. In this activity, students investigate the impact of those reactions when human beings are exposed to various agents, both natural and synthetic, in their environment.

Life Sciences

- Diversity and Adaptation of Organisms
Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment. Students investigate the relationship between exposure level and individual genotype in an activity demonstrating that individuals metabolize different synthetic chemicals at different rates.

Science in Personal and Social Perspectives

- Personal and Community Health
Personal choices concerning fitness and health involve multiple factors. Throughout this activity, students are asked to compare the risks of synthetic and natural exposures. Discussions include the way information about personal choices can be obtained and analyzed.
- Risks and Benefits
Individuals can use a systematic approach to thinking critically about risks and benefits. Students are asked to analyze and compare the risk of exposure to natural versus synthetic agents.

Materials

Per class

- phenotype cards
- different-colored confetti to represent various agents, purchased or made with colored paper and a hole punch
- different-shaped confetti to represent various agents, purchased or made with colored paper and scissors
- masking tape or strips of contact paper
- small disposable cups
- broom and dust pan

Getting Ready

In Part 1 of this activity, you will use different colors of confetti to find out what happens when people are exposed to various synthetic chemicals. Part 2 will use confetti to focus on the effects chemicals have on people who are genetically different from each other. In Part 3, you will use different-shaped confetti to compare natural and synthetic chemicals for toxicity.

Because different colors of confetti will represent different agents in Parts 1 and 2, if you purchase the confetti you'll need to take a random sample and count the number of each color present. Assign the colors in greater quantities to represent agents that require a

large exposure level in order to affect a person. (See the Parts 1 and 2 Chemical Descriptions handout for exposure level information.) If you're making your own confetti, the colors can be produced in appropriate relative quantities. For each participant in the class, fill a disposable paper cup about one-quarter or one-third full with a random mix of this confetti. You don't need to count out the pieces, just make sure each cup contains roughly the same amount of confetti.

Photocopy, cut apart, and shuffle the phenotype cards for Part 2.

For Part 3, prepare the confetti by counting it into individual disposable cups (one cup for each participant) as follows: 20 multicolored stars, 15 multicolored hearts, and 9 black hexagons.

Procedure Notes and Outcomes

Before beginning this activity, select an area with open floor space that can be easily cleaned. Give each participant a 10-cm x 50-cm piece of wide masking tape or contact paper and have them write their name and the date on the non-sticky side of this strip.

To simulate exposure to the agents, instruct the participants to hold the tape strip sticky side out and against their chest, and to walk toward you while you throw the different-colored confetti at the tape. Require that the participants hold their tape steadily at chest level. They should not be allowed to move the tape up and down to avoid the exposure. Once all participants have returned to their desks and recorded their results on Table 1, repeat the exposure simulation for Part 2 with the same piece of tape. This simulates the possibility that the previous exposure may affect the current exposure levels. Part 2 instructs the participants to remove any particles that their phenotype allows them to metabolize or that are rapidly excreted according to the descriptions in the Parts 1 and 2 Chemical Descriptions handout.

Put three of the following class data tables on the chalkboard for Parts 1, 2, and 3:

Class Data Table		
agent	number of people exposed	number of people affected
1		
2		
3		
4		
5		
6		
7		
8		

For Part 1, the number exposed will equal the number affected. For Part 2, the number exposed should be greater than the number affected. For Part 3, the agents will be represented by confetti pieces in the shape of stars, hearts, and hexagons, and the number exposed will equal the number affected.

Plausible Answers to Questions

1. If you were asked to repeat this activity, what things could you do to reduce your exposure levels?
Participants might say they would walk faster through the exposure area to shorten exposure time or wear protective gear to minimize exposure level.
2. Why did some colors of confetti take a higher number of particles per exposure to cause damage?
The confetti colors represent different types of chemical agents. In a real environment, organisms experience adverse effects depending on the exposure level of each chemical agent. While some chemical agents produce adverse effects at very low levels, other agents do not produce adverse effects until much higher levels.
3. Did there seem to be any correlation between number of particles necessary to cause damage and the type of damage that occurred?
There seems to be no correlation because some chemical agents require very little exposure to cause lethal effects while other agents require heavy exposure to cause minor effects.

4. In what situations or jobs might it be necessary to keep track of the chemicals and quantities you were exposed to?
Answers will vary, but some examples are workers who apply pesticides and herbicides to lawns, shellacs and varnishes to furniture, and oil-based paints to homes.
5. Although most employees do not keep data notebooks, there are laws that require employers to keep such records. What types of chemicals might people be exposed to on the job?
Answers will vary, but examples include glacial acetic acid used to process photographs and arsenic trioxide used in rat poison.
6. What types of chemicals might people be exposed to in the home?
Answers will vary, but examples include weed killer, bug spray, and household cleaners.
7. Why is it helpful to know a little bit about chemistry before using chemical agents such as the pesticide Roundup® or bathroom cleaners?
By taking a few precautions such as wearing gloves or having adequate ventilation, people using household products can reduce their exposure level to harmful chemical agents found in the home. Always read and follow manufacturers' instructions and warnings.
8. Describe a situation in which you were exposed to toxic chemicals.
Answers will vary.
9. Why do people react differently to the same exposure level of the same chemical agent?
People are genetically different from one another so their bodies react to different chemical agents in different ways.
10. Why do you think so little attention is paid to the effects of natural pesticide exposure on the human population?
It is very hard for us to avoid exposure to natural pesticides occurring in plants. However, consumers can avoid or protect themselves against synthetic pesticides found in some manufactured products.
11. How do people obtain important health information? What are the benefits of these methods? What are the limits to these methods?
Answers will vary.
12. How could you become better informed about what you could do to have a healthier lifestyle?
Answers will vary.

References

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Fiero, B.; Mackie, S. "A Natural Selection Lab for Environmental Biology," *The American Biology Teacher*. 1997, 59 (6), 357–358.

HERP Index Website. <http://potency.berkeley.edu/herp.html> (accessed February 14, 2001).

The Merck Index, An Encyclopedia of Chemicals, Drugs, and Biologicals, 10th ed.; Merck: Rahway, NJ, 1983.

The University Library Website. http://www.ulib.org/webRoot/Books/National_Academy_Press_Books/env_tobacco_smoke/0000001.htm (accessed February 14, 2001).

Phenotype Cards

Phenotype Card #1	
Agent	Resistance
1	0
2	0
3	50%
4	100%
5	0
6	0
7	50%
8	0

Phenotype Card #2	
Agent	Resistance
1	50%
2	0
3	0
4	100%
5	0
6	0
7	0
8	50%

Phenotype Card #3	
Agent	Resistance
1	100%
2	0
3	50%
4	0
5	0
6	0
7	100%
8	0

Phenotype Card #4	
Agent	Resistance
1	0
2	50%
3	100%
4	0
5	0
6	50%
7	0
8	0

Phenotype Card #5	
Agent	Resistance
1	50%
2	0
3	100%
4	0
5	0
6	0
7	50%
8	0

Phenotype Card #6	
Agent	Resistance
1	100%
2	50%
3	0
4	0
5	0
6	100%
7	0
8	0

Phenotype Card #7	
Agent	Resistance
1	50%
2	100%
3	0
4	0
5	50%
6	0
7	0
8	0

Phenotype Card #8	
Agent	Resistance
1	0
2	100%
3	0
4	0
5	0
6	50%
7	0
8	50%

Phenotype Card #9	
Agent	Resistance
1	50%
2	0
3	0
4	0
5	100%
6	0
7	0
8	100%

Phenotype Card #10	
Agent	Resistance
1	0
2	0
3	50%
4	0
5	0
6	0
7	50%
8	100%

Phenotype Card #11	
Agent	Resistance
1	50%
2	0
3	0
4	50%
5	0
6	50%
7	0
8	100%

Phenotype Card #12	
Agent	Resistance
1	100%
2	0
3	100%
4	0
5	0
6	100%
7	50%
8	0

Phenotype Card #13	
Agent	Resistance
1	0
2	0
3	75%
4	0
5	0
6	100%
7	50%
8	0

Phenotype Card #14	
Agent	Resistance
1	50%
2	0
3	0
4	75%
5	0
6	0
7	0
8	50%

Phenotype Card #15	
Agent	Resistance
1	100%
2	0
3	25%
4	0
5	50%
6	0
7	0
8	0

Phenotype Card #16	
Agent	Resistance
1	0
2	75%
3	0
4	0
5	100%
6	50%
7	0
8	0

Phenotype Card #17	
Agent	Resistance
1	0
2	0
3	75%
4	0
5	0
6	0
7	50%
8	50%

Phenotype Card #18	
Agent	Resistance
1	0
2	25%
3	0
4	50%
5	0
6	0
7	0
8	100%

Phenotype Card #19	
Agent	Resistance
1	75%
2	0
3	0
4	100%
5	50%
6	0
7	0
8	0

Phenotype Card #20	
Agent	Resistance
1	50%
2	50%
3	0
4	0
5	75%
6	0
7	0
8	0

Phenotype Card #21	
Agent	Resistance
1	100%
2	0
3	25%
4	0
5	50%
6	0
7	0
8	0

Phenotype Card #22	
Agent	Resistance
1	0
2	0
3	100%
4	50%
5	0
6	0
7	0
8	75%

Phenotype Card #23	
Agent	Resistance
1	50%
2	0
3	0
4	75%
5	0
6	0
7	0
8	50%

Phenotype Card #24	
Agent	Resistance
1	0
2	25%
3	0
4	50%
5	0
6	0
7	0
8	100%

Activity Instructions

Exposure!

You are exposed to chemicals in the art room, shop area, and the cafeteria at school, your garage or basement at home, and just by being alive! In Part 1 of this activity, you will find out what happens when people are exposed to various synthetic chemicals. Part 2 will focus on the effects chemicals have on people who are genetically different from each other. In Part 3, you will compare exposure levels of natural and synthetic chemicals.

You will record your data and use the information provided to determine the effect of the chemicals on your health.

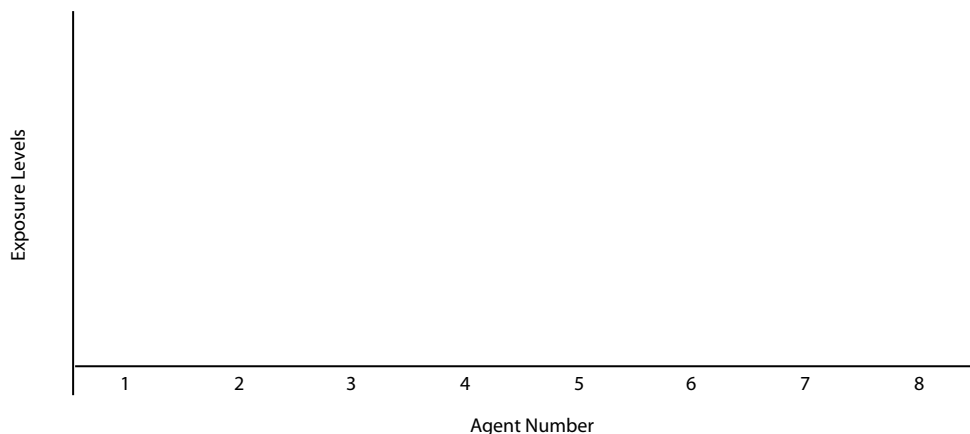
Procedure

Part 1: Synthetic Chemicals

1. Obtain a piece of masking tape or contact paper, approximately 10 cm x 50 cm. Put your name on the non-sticky side of one end.
2. Carry this tape horizontally against your chest with the sticky side outward.
3. Walk through the "exposure" area while being showered with different-colored confetti.
4. Count the number of "particles" of each color that stuck to the tape during this period of exposure and record these numbers on Table 1. Do not remove any of the pieces of confetti.

agent	confetti color	number of particles on tape
1		
2		
3		
4		
5		
6		
7		
8		

5. With this information, create a bar graph for each color you were exposed to.



6. Read the Parts 1 and 2 Chemical Descriptions handout to determine if your exposure to a specific agent is enough to cause an adverse reaction. If so, put a large "X" at the top of the bar for that chemical in the graph.
7. Finally, record your results on the class data table.

Part 2: Synthetic Chemicals and Phenotypes

1. Use the same piece of masking tape you used for Part 1 and follow the same exposure procedure.
2. Count the total number of "particles" of each color that stuck to the tape during both exposure periods. Record this data on Table 2.

agent	confetti color	number of particles on tape	number after phenotype data and excretion information	were you affected?
1				
2				
3				
4				
5				
6				
7				
8				

- Obtain a phenotype card from your instructor. Use this information to determine the effect of the exposure on you based upon your exposure levels and your genotype. The resistance is shown as a percentage. If you are 100% resistant to a chemical agent, your body metabolizes all of the chemical agent into something it can handle. If you are 50% resistant, your body metabolizes 50% of the agent. A resistance of 0% means that none of the agent is metabolized. Record the number not metabolized under “number after phenotype data” and remove the appropriate number of confetti pieces to reflect your metabolism or the amount of agent rapidly excreted according to the description in the Parts 1 and 2 Chemical Descriptions handout. (Remove the appropriate confetti even if you received it in Part 1.)
- Using the Parts 1 and 2 Chemical Descriptions handout, determine whether you were affected by each agent after you were exposed and your body had a chance to metabolize or excrete the chemical agents. Record your results on Table 2 and the class data table.
- Different participants in the class should graph the class data (both number exposed and number affected) for a different one of the eight chemicals. Share results with the class.

Part 3: Synthetic vs. Natural Chemicals

- Obtain a new piece of masking tape, approximately 10 cm x 50 cm. Put your name on the non-sticky side of one end. As before, carry this tape horizontally against your chest with the sticky side outward. Walk through the “exposure” area while being showered with different-shaped confetti.
- Count the number of “particles” of each type that stuck to the tape during this period of exposure and record this data on Table 3.
- For the total number of stars that stuck to your tape, multiply by 100 and record this number on Table 3. For the total number of hearts that stuck to your tape, multiply by 100 and record this number. If hexagons stuck to your tape, divide the number of pieces by 100 and record this number. The discrepancy that exists between the stars and hearts vs. hexagons represents the vast difference in the exposure level of Americans between natural and synthetic chemicals. (This is further explained in the Part 3 Chemical Descriptions handout.)

particle type	total number stuck to the tape		actual exposure
Stars		x 100	
Hearts		x 100	
Hexagons		÷100	

4. Use the information in the Part 3 Chemical Descriptions handout to help you analyze your data. Provide your information for the class data table and answer the questions for this activity.

Questions

1. If you were asked to repeat this activity, what things could you do to reduce your exposure levels?
2. Why did some colors of confetti take a higher number of particles per exposure to cause damage?
3. Did there seem to be any correlation between number of particles necessary to cause damage and the type of damage that occurred?
4. In what situations or jobs might it be necessary to keep track of the chemicals and quantities you were exposed to?
5. Although most employees do not keep data notebooks, there are laws that require employers to keep such records. What types of chemicals might people be exposed to on the job?
6. What types of chemicals might people be exposed to in the home?
7. Why is it helpful to know a little bit about chemistry before using chemical agents such as the pesticide Roundup® or bathroom cleaners?
8. Describe a situation in which you were exposed to toxic chemicals.
9. Why do people react differently to the same exposure level of the same chemical agent?
10. Why do you think so little attention is paid to the effects of natural pesticide exposure on the human population?
11. How do people obtain important health information? What are the benefits of these methods? What are the limits to these methods?
12. How could you become better informed about what you could do to have a healthier lifestyle?

Handout: Parts 1 and 2 Chemical Descriptions

The eight chemical agents represented by the different-colored confetti pieces in Parts 1 and 2 are discussed in the following paragraphs. Note that the exposure levels given are relative amounts.

Agent 1 is a minor skin irritant at levels of three particles per exposure. It is excreted rapidly by the body within 24 hours of exposure.

Agent 2 produces no immediate symptoms at exposure levels below eight particles per exposure. However, once Agent 2 enters the body, it is not eliminated. At a total body burden of eight or more particles, it is known to cause severe softening of the bones, making them break easily. Total recovery from this disorder is very rare, and those who suffer must restrict their lifelong activities to eliminate stress on the weakened bones.

Agent 3 is a carcinogen. Any exposure increases a person's likelihood of contracting nasal cancer by a factor of 30. The cancer may occur up to 20 years after exposure.

Agent 4 causes irreversible lung damage at levels of 14 particles per exposure. However, if exposure is accompanied by any level of exposure to Agent 5, lung damage occurs at only three particles per exposure. (This is an example of synergy.)

Exposure to Agent 5 alone does not cause any known disorder.

Agent 6 causes death at one particle of exposure.

Agent 7 is not currently suspected of being hazardous at any level.

Agent 8 is processed very slowly and not eliminated from the body. A total body burden of 26 particles is known to cause severe liver damage and death within 2 years. If you have absorbed less than 26 particles you may still be in danger if you were previously exposed or if you are exposed to it in the future.

Handout: Part 3 Chemical Descriptions

Stars: These represent the estimated daily average American exposure to burned material in the diet. Studies have shown that burned material (on toast, meat, cheese, roasted coffee, etc.) contains carcinogenic materials that are the by-products of burning.

Hearts: These represent the daily average American exposure to natural pesticides (the chemicals that plants produce to defend themselves against fungi, insects, and animal predators). Studies have shown that the carcinogenicity of natural and synthetic chemicals is similar. Therefore, a diet free of chemicals that induce tumors in tests on rodents is virtually impossible. While we tend to fear the threat of synthetic pesticides, note that much of the exposure is actually coming from natural pesticides. Humans ingest roughly 5,000 to 10,000 different natural pesticides and their breakdown products.

Hexagons: These represent the daily average American exposure to all synthetic pesticide residues combined. Note the large discrepancy between the amount of this exposure and the amount of exposure to naturally occurring pesticides. Despite this enormously greater exposure to natural chemicals, 78% of the chemicals tested by national health organizations for carcinogenicity are synthetic (do not occur naturally). Are we focusing on the right risks?