4-H National Youth Science Day

NATIONAL SCIENCE EXPERIMENT

ECO BOT CHALLENGE 2012

The 2012 National Science Experiment, *4-H Eco-Bot Challenge*, explores how robots can be used to preserve and protect the environment, while offering a glimpse into the future of science, technology, engineering and math.

Youth Guide

Why Robots?

Robots have a huge impact on society and affect our lives everyday. We use robots to assemble cars, manufacture cookies, and create computer parts. They can be programmed to carry out dangerous missions or complete boring, repetitive chores — even give us directions when we are lost!

The future of robots is bright. But, what does that future look like? How will robots affect the next generation — and the generation after that? Some things are certain. Robots will have to be very good at what they do. They will need to be dependable, predictable, and they have a good cost/benefit standard — that is, be reasonably priced for what they accomplish.

4-H Eco-Bot Challenge

The Experiment

In the 2012 National Science Experiment, *4-H Eco-Bot Challenge*, you will build and program a robot to clean up a simulated environmental spill — a mission that in real life would be too difficult or dangerous for humans to carry out.

Part One: Build Your Bot

Assemble your own Eco-Bot, and discover how it functions and determine what it can do.

Part Two: The Goal is Control

Design a set of control surfaces to program the Eco-Bot to perform a simulated environmental cleanup project.

Part Three: Make a Clean Sweep

Measure the effectiveness of your control surfaces controls by recording how much of the spill is "swept up" by the Eco-Bot. Ready to get started? Let's begin!

4-H PLEDGE

I pledge my **Head** to clearer thinking, my **Heart** to greater loyalty, my **Hands** to larger service, and my **Health** to better living, for my club, my community, my country and my world.

Introduction

In October 2012, millions of young people across the nation will become scientists for the day during the fifth annual *4-H National Youth Science Day* (NYSD). NYSD is the premiere national rallying event for 4-H Science's year round programming. It brings together thousands of youth volunteers and educators from the nation's 111 land-grant colleges and universities to simultaneously complete the National Science Experiment.

The 2012 National Science Experiment, *4-H Eco-Bot Challenge* will explore robots and how technology can be used to preserve and protect the environment.

Getting Started: Your Challenge

Congratulations! You are now a robotics engineer! Your first assignment is designing a solution for a very serious problem that recently took place on Bailey Beach:

Bailey Beach was the site of an unfortunate toxic spill. An old barrel that stored used insulation from fishing boat motors has rusted through and is beginning to spill out onto the surface of the beach. The Environmental Protection Agency (EPA) needs your help to establish a containment area on site. A containment area is a designated location area in which a toxic material is held in order to prevent further contamination.

Since the spill is lightweight, there is concern that it will continue to move toward the water, which will pose a danger to the fish and plant life around the beach. Because the concentration of toxin in the barrel is unknown, there is also concern for the well-being of those who might attempt to clean up the spill.

Your fellow engineers have been talking and they think a new robot called an "Eco-Bot" might be able to help clean up the toxic spill.

Your challenge is to create a containment area and discover how to build an Eco-Bot that solves this environmental problem.

On the Job

Robotics engineers are constantly researching new designs and testing them on robotic prototypes or models. They analyze different functions and make adjustments.

"Robotics engineers should focus on being innovative while providing the user an intelligent machine that is helpful and simple to use."

– John Koch, Software Engineer, and his colleague Adam Sharkasi, Systems Engineer, Lockheed Martin Missiles and Fire Control, Grand Prairie, Texas

Robots: What Are They? How Do They Work?

A **robot** is a machine that can be programmed to perform repetitious, physical tasks, or imitate some of the things that a person can do. Scientists developed the first industrial robots in the 1950s. Today they can be programmed to do almost anything — from vacuuming the house to defusing bombs, to exploring the moon.

DID YOU KNOW?

The idea of robots has been around for a lot longer than you might think! In 1495, Leonardo da Vinci sketched the first humanoid robot!

Some robots, such as robotic arms used in surgery, are monitored and controlled remotely by humans. Others robots, known as autonomous robots, are programmed to perform tasks on their own.

ON THE JOB

Environmental engineers work to protect the environment, control toxic spills, and make sure pollutants are not released into the air or water sources.

"An environmental engineer must understand how businesses can impact our surroundings and climate. Every decision has multiple effects: what is good for the groundwater may create a problem in the air. Balancing actions to have the least negative effects on the environment as a whole, or to improve it, is our ultimate goal."

-Phil Talucci, Senior Environmental Engineer for Lockheed Martin, Syracuse, New York

The Science of Spills: Robots and the Environment

On the surface, it may appear that robots have little in common with the environment. However, robots significantly contribute to the environment in a number of positive ways. They can clean asbestos from pipes, safely strip paint from ships, easily navigate through smoke and high temperatures, and, as we will in explore in this experiment, cleanup after a toxic spill or nuclear disaster.

A **toxic spill** is an unintended release of toxins into the environment that is capable of causing death or serious harm to humans, animals and/or plants. Toxic spills and accidents range from big to small and can occur anywhere chemicals are found.

Toxic spills are really bad news — both for humans and the environment. They can devastate wildlife and damage precious water sources. They can have lasting, negative effects on the air, water and soil — as well as the humans and animals that inhabit the area.

DID YOU KNOW?

An oil spill is one of the most severe ecological disasters that can happen. Cleaning oil from water is very difficult and the long-term domino effect it has goes far beyond the sea. It affects marine life, bird life, plant life, the climate — even our food supply and fishermen's ability to work. Can you think of other types of businesses that might be affected?

Some toxic spills are immediately dangerous to wildlife and humans, causing burns, poisoning or physical harm immediately upon contact. Other spills work more slowly, causing long-term illnesses and environmental problems. What starts off as a spill of toxic industrial chemicals can be washed away by floodwaters or other ground water and impact drinking water sources and compromise ecosystems way beyond the original spill.

Toxic spills can be tough to handle and remove and come in a variety of forms. They can consist of small particles, be sticky and gooey or slippery and smelly. How can engineers work to design robots for different kinds of clean-up efforts?

Cleanup efforts are critical, but they can be also extremely dangerous to humans if people do not wear protective gear and follow adequate safety precautions. That's where robots fit in.

From sniffing out toxins to collecting data from dangerous and hazardous locations, robots are increasingly being used to help scientists understand, combat and cleanup toxic spills. In this experiment you will create a **simulation**, or model, of how robots work to clean up spills.

THINK ABOUT IT

Where are some places that robots can go where humans cannot go?

What dangerous or difficult problems can robots solve?

Can you think of any adaptations that might be needed to better equip a robot to cleanup toxins?

ON THE JOB

"Environmental engineers work to responsibly manage natural resources and ensure sustainability for future generations. As an environmental engineer I have the opportunity to use my engineering skills to positively impact the natural environment and the community in which I work and live."

– Lori Smargiassi, Environment, Safety and Health Engineer for Lockheed Martin, Valley Forge, PA

DID YOU KNOW?

The world's smallest robot is a tiny robot helicopter that is 7 cm high and weighs just 10 grams. It was developed in 2004 to aid in natural disasters.

Real Eco-Bots in Action

Here are four examples of how robots robots are working today to protect people and preserve our environment:

In 2011, **iRobot™** sent four robots to Japan to aid in relief efforts following the nuclear disaster in Fukushima.

The **BEAR™** is a robot designed to locate and rescue people who are injured on the battlefield, in mine shafts, or at toxic spill sites.

Dr. Maurizio Porfiri's robotic fish are being used to redirect shoals of fish away from the danger of toxic spills. His work could potentially save thousands of undersea creatures!

Robotics engineers at **MIT** are working to preserve the quality of our oceans with Seaswarm, oil-absorbing robots who skim the ocean's surface to clean up spills.

Think Like an Engineer: The Engineering Design Process

Robotics engineers design robots. They maintain them, develop new applications for them, and conduct research to expand the potential of robotics. They have developed new uses for robots in manufacturing, agriculture, mining, nuclear powerplant maintenance, toxic waste cleanups and medical applications.

How do they do it? They follow the **engineering design process**, a step-by-step process that helps them produce solutions and develop systems and products. It features seven basic steps:

1. ***Identify the problem:***
   Determine what constraints (or drawbacks) limit your choices in solving this problem.

2. ***Generate ideas:***
   Brainstorm possible solutions that might address those constraints.

3. ***Evaluate and compare possible solutions:***
   Decide which of the possible solutions are the most logical or make the most sense.

4. ***Build a prototype:***
   A prototype is a first attempt at a design and is built to test your hypothesis.

5. ***Test the prototype:***
   Conduct a series of experiments to see if your prototype works.

6. ***Tell your story:***
   Record your data to share what you learn with others.

7. ***Refine your design:***
   Explore how you can use what you've learned to improve or change your design.

As part of the engineering design process, engineers may repeat these steps over and over again - refining and changing their designs until they get it just right.

Let's Experiment

Now that you know a little bit more about robots, toxic spills and the engineering design process, let's get back to Bailey Beach.

It's time for you to help engineer the containment area, and assemble the Eco-Bot in order to save the shore of Bailey Beach.

HERE ARE THE FACTS:

Bailey Beach was the site of an unfortunate toxic spill and it is too hazardous for humans to clean.

The EPA needs to establish a containment area to hold the toxic spill in place.

They are proposing that a special robot, called an "Eco-Bot," be used to solve this problem.

Part 1

BUILD AN ECO-BOT

Time Required: 30 minutes

OBJECTIVE

Build an Eco-Bot. Then discover how it functions and what it can do.

MATERIALS YOU WILL NEED:

The 4-H Eco-Bot Challenge supply kit contains:

Oral-B CrossAction® Pro Health® manual toothbrush

10 mm pager vibrator motor with wires attached

3 cm piece Scotch® Foam Mounting Double-Side Tape #110

1 cm piece Scotch® Foam Mounting Double-Side Tape #110

LR44 1.5 volt Button Cell Watch Battery

INTRODUCTION

As engineers who will program an Eco-Bot to clean Bailey Beach, it is important for you to understand what an Eco-Bot is and what it can do. See a demonstration of the Eco-Bot at www.4-H.org/NYSD.

THINK ABOUT IT

How does the Eco-Bot work?

What are its moving parts?

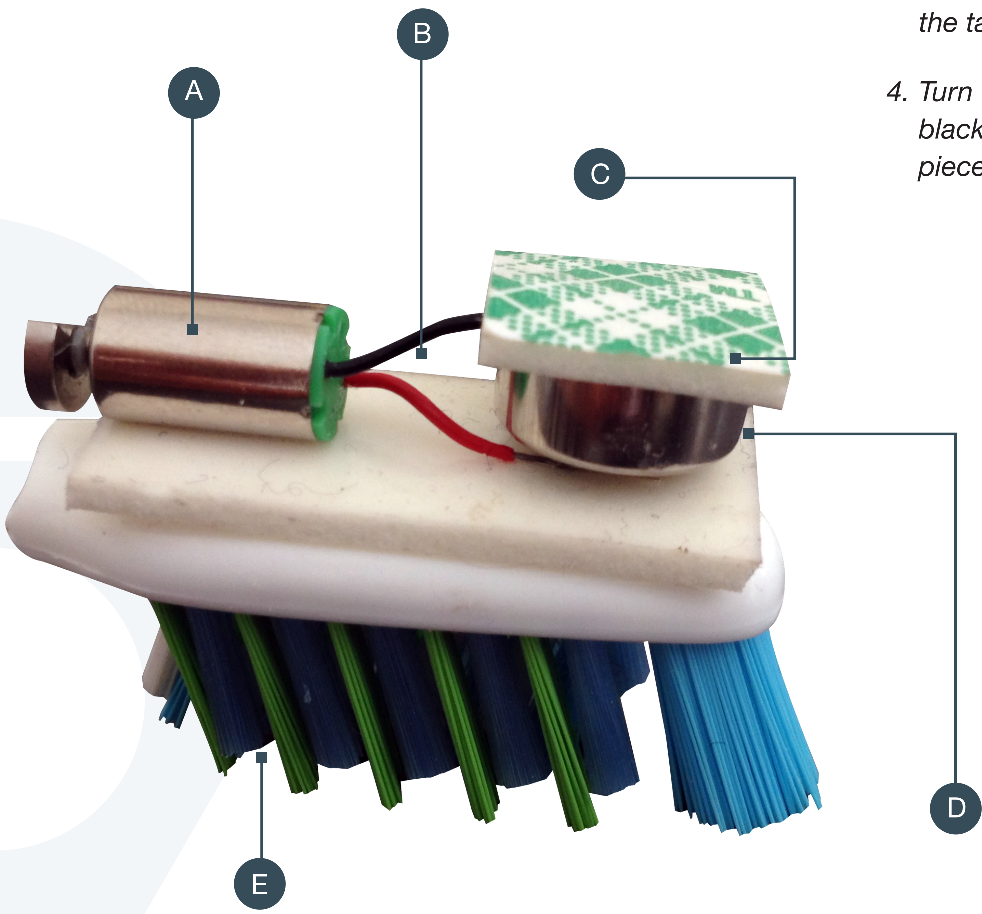
Do any of the parts look familiar?

Step 1: Bring Your 'Bot to Life

Now it's time to assemble your own Eco-Bot and get it moving!

Eco-Bot Assembly

1. *Remove the backing from one side of the 3 cm piece of foam tape and firmly stick it on the flat side of toothbrush head.*
2. *Remove the backing from the other side of the tape and gently push the motor on top of it with rotating part hanging off the back-end of toothbrush. This will allow the motor to spin without touching the tape. The wires should be positioned toward the head of the toothbrush.*
3. *Gently push the watch battery (+) side up onto the tape with the red wire underneath.*
4. *Turn the Eco-Bot on by pressing the black wire onto the battery with the 1 cm piece of foam on top.*



Eco-Bot Assembly

A—Motor

B—Red and Black Wires

C—Foam Mounting Tape

D—Button Cell Battery

E—Scrubber

Step 2: Observe What It Does

Observe the movements of your Eco-Bot for 3-5 minutes. Take note of what you learn.

Observation Notes

1. *What did you observe about how your Eco-Bot moves?*

2. *What works? What doesn't?*

3. *What problems did you encounter?*

4. *What do you think controls the movement of your Eco-Bot?*

5. *What sort of tasks do you think you could use an Eco-Bot to do?*

Part 2

THE GOAL IS CONTROL

Time Required: 30-45 minutes

OBJECTIVE

Working in pairs, use the engineering design process to create a set of control surfaces to optimize your Eco-Bot's performance in "sweeping up" the toxic spill on Bailey Beach.

MATERIALS YOU WILL NEED:

For each pair of participants you will need:
Challenge Mat for Bailey Beach

Suggested materials for testing environment:
Piece 8.5 x 11 in. copy paper

Piece 8.5 x 11 in. card stock

Scissors

(10) Flexible straws

(10) 3-oz paper cups

One 11 inch piece of masking tape

INTRODUCTION

The Role of Control

All robots require **programming,** or commands, in order to complete tasks. One way that robots are programmed is through the use of control surfaces. **Control surfaces** are materials that restrict and redirect movements of a robot.

Autonomous robots have the ability to "sense" their environment (for example, through touch, sound, temperature or chemical changes). The robot's movement can be programmed by what it touches, hears, or feels and then adapt its behavior accordingly. The Eco-Bot is "programmed" through touch when it comes into contact with the control surfaces.

> **THINK ABOUT IT**
>
> *How can we program our Eco-Bots to go where we want them to go?*
>
> *What are the control surfaces that might be involved for a robot that is programmed to vacuum, mow the lawn, or work in a factory?*
>
> *How might autonomous robots work in toxic spill cleanup situations?*

Working in pairs, use the engineering design process to engineer a set of control surfaces to optimize your Eco-Bot's performance in "sweeping up" the chemical spill on Bailey Beach.

Step 1: Identify the Problem.

Discuss with your fellow engineers the situation at Bailey Beach:

> **THINK ABOUT IT**
>
> *Where is the spill?*
>
> *Why is it important to contain it?*
>
> *What control surfaces will you use to program your Eco-Bot to cover the spill area?*
>
> *What challenges do you have in containing the spill?*

Step 2: Generate Ideas.

Brainstorm different ideas for how to keep their Eco-Bot on a piece of paper using straws, cardstock, and cups as control surfaces. How can you use straws, cardstock or cups to control the movement of your Eco-Bot?

List your ideas here:

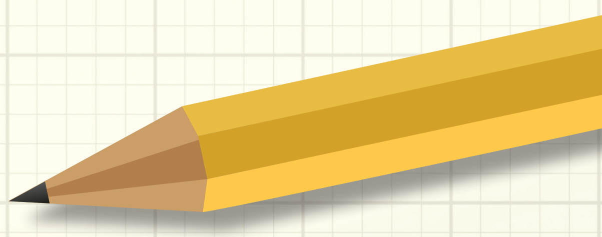
1. (Idea #1)

2. (Idea #2)

3. (Idea # 3)

4. (Idea #4)

5. (Idea #5)



Step 3: Evaluate and Compare Possible Solutions.

Choose your best ideas and create a plan for cleaning up the spill. Draw your design here:

What other materials would you like to try?

Step 4: Build a Prototype.

After you decide on a plan, you are ready to get our Challenge Mat and build your prototype. Remember, you can only use the materials they have been given!

In order to get your Challenge Mat, have your leader approve your plan here:

Step 5: Test the Prototype.

Let the sweeping begin! Observe the movements of the Eco-Bot and evaluate the success of your design. Record your observations below.

OBSERVATION NOTES

How did you use your materials to create control surfaces?

What challenges did you experience?

What questions do you have?

6. Tell your story.

What was your best idea? Write it below and share it with your fellow engineers.

7. Refine your Design.

How can you make your Eco-Bot move more efficiently over the toxic spill? What adjustments would you make?

The engineering design process repeats over and over as you work to refine and make adjustments to solve a problem.

Part 3

MAKE A CLEAN SWEEP

Time Required: 45-65 minutes

OBJECTIVE

How effective is your Eco-Bot? Can it clean up the toxic spill? Work in pairs to measure how much of the spill is "swept" by your Eco-Bots, and how quickly it can produce results.

MATERIALS YOU WILL NEED:

Challenge Mat with control surfaces in place

(1) tablespoon of bird seed or rice

(2) Eco-Bots

Timer

Masking tape

Calculator (for calculating percentages)

INTRODUCTION

The Challenge Mat and Eco-Bot robot serve as models and are meant to show the construction or appearance of something, and help youth understand the potential for using robots to cleanup a real spill.

In order to measure the effectiveness of the robot, we need to discover how much of the toxic spill has been cleaned up. In this case you will use birdseed or rice to represent the toxic spill. When the Eco-Bot "sweeps" it out of the way, it can be assumed the spill has been "cleaned." The grid on the Challenge Mat will allow participants to use a **ratio** (amount of cleaned spaces/total amount of spaces) to measure the amount of spill that has been cleaned.

In this experiment, the only independent **variable** is the control surface. It can be manipulated to influence the robot's performance. The remaining variables are fixed variables that cannot be manipulated. In this way, as in real scientific experiments, you will change only one variable at a time and compare the outcome.

Step 1: Set Up the Simulation.

1. Tape the Challenge Mat to a table or a flat surface.
2. Add one tablespoon of birdseed to the containment area within the control surfaces you created. Spread it evenly over each spot.
3. Decide who will be the **Eco-Bot Analyst** (the person who operates the timer and serves as the recorder) and who will be the **Eco-Bot Engineer** (the person who can "touch" and monitor the Eco-Bot).
4. Read the Rules for the Eco-Bot Engineer.

Rules for the Eco-Bot Engineer

1 Only one team member can be an Eco-Bot Engineer.

2. If the Eco-Bot falls over, you must wait 3 seconds to pick it back up.
3. If the Eco-Bot gets stuck, you must wait 3 seconds to tap it or move it.
4. If the Eco-Bot leaves the containment area, you must wait 3 seconds to put it back.
5. You may only touch your Eco-Bot a total of 5 times during the 2-minute challenge.

Step 2: Put It to the Test

1. Place the Eco-Bot at any location on the Challenge Mat.
2. Set the timer for 2 minutes.
3. Turn on the Eco-Bot and start the timer.
4. Observe the movement of the Eco-Bot and follow the rules if it falls over, gets stuck or leaves the containment area.
5. Remove the Eco-Bot at the end of 2 minutes.

Step 3: Measure Your Eco-Bot's Effectiveness

Rules for the Eco-Bot Analyst

1. *Count the number of times the Eco-Bot Engineer touches the Eco-Bot.*
2. *Count the number of black spaces that are "swept" or completely clear of contaminant.*
3 *Use the following ratio to calculate the amountof the spill that was cleaned and enter it in the graph below:*

This will give a percentage (a fraction or ratio with 100 as the understood denominator) that expresses the effectiveness of the Eco-Bot.

Test 2 minutes	Number of touches	Total Spaces Cleaned	Total spaces covered by spill	Ratio Calculation *X 125*	Answer as a percentage
Example	5	62	125	$\frac{62}{125 \times 100}$	49.6%
#1			125		
#2			125		
#3			125		

$$\frac{X\ (x)\ 100}{125} = \underline{\qquad\qquad\qquad}\text{\% of effectiveness}$$

- X = number of black spaces free from birdseed after 2 minutes.
- 125 = approximate number of spaces that are in the containment area.

Step 4: Repeat, Repeat.

Repeat these steps two more times and record your results. This is a good time to trade roles, allowing everyone the opportunity to be an Eco-Bot Analyst and an Eco-Bot Engineer.

Step 5: Average It Out.

Ask participants to compute the average of the final percentages using the following formula:

Test 1 _______________%	Test 2 + _______________%
+ Test 3 _______________%	divided by 3 = _______________%

Test 1 Malfunctions _______________%	Test 2 Malfunctions + _______________%
+ Test 3 Malfunctions _______________%	divided by 3 = _______________ Average Malfunctions

Step 6: Share the Results.

1. *Discuss your results with your fellow engineers.*
2. *Calculate an average group percentage.*

Think About It

Discuss the amount of "touches":

How do these touches represent malfunctions?

Were the touches necessary due to the design of the robot? Or the control surface?

How could you reduce the amount of touches/ malfunctions?

Examine the most successful designs. What do they have in common?

What other tests could be done?

Step 7: Review Your Performance

Share with the group what you have learned so far and what you would do differently. Has your thinking and understanding of robots changed and evolved throughout the process?

THINK ABOUT IT

What changes would you make to your control surfaces?

What characteristics or abilities does an autonomous robot need in order to complete a task like this one?

In what ways in this a realistic simulation? What makes it unrealistic?

How did the engineering design process help you when completing this challenge?

What role did you play during this activity that was particularly interesting to you? How could this be related to a future career or area of interest?

Notes:

THEORIES AND QUERIES

The engineering design process is a circular, never-ending process in which there is always an opportunity to design, test and observe new approaches, new ideas and new technologies. Explore different methods for improving the Eco-Bot's performance.

Step 1: Make a Scientific Guess

Hypothesize cleanup efficiency results given the following modifications:

Modification	Hypothesis Will this modification make the Eco-Bot more efficient? *Yes or No? Why or Why Not?*	Data and Results
1. Two Eco-Bots cleaning at the same time.		
2. Two Eco-Bots connected together using a 2 cm piece of foam tape.		
3. Designing and adding a blade or wing to one Eco-Bot using a 3.5 x 5 cm 3M Post-it Note.		
What ideas do you have?		

Step 2: Test Your Hypotheses

Choose two modifications from the chart and repeat the engineering design process in Part Three. Share your data and discuss whether your hypotheses were correct.

Test 2 minutes	Number of touches	Total Spaces Cleaned	Total spaces covered by spill	Ratio Calculation X 125	Answer as a percentage	Was my hypothesis correct?
Example Type of Modification: Adding a blade to the Eco-Bot	5	75	125	$\frac{75}{125}$	60%	Yes - this Eco-Bot cleaned better with a blade.
Type of Modification:			125			
Type of Modification:			125			

Going Beyond: Additional Activities

Choose one of these activities for your next engineering challenge:

1. ***Make it reality.***
Find an opportunity to participate in a local community cleanup effort and offer engineered solutions for making the cleanup easier or automated.

2. ***Consider replacing materials needed to perform the cleanup to reduce costs and improve efficiency.***
Redesign the control surfaces and provide engineering constraints that meet an approved budget. Charge "money" for tape, straws, cups and cardstock. Which design is the cheapest? Does this impact the effectiveness? Which design is the cheapest AND the most effective?

3. ***Design your own challenge mats.***
Create new measuring grids and use other materials.

4. ***Spread the knowledge.***
Educate others about autonomous robots by sharing this activity with younger children.

5. ***Super size the experiment.***
Connect the challenge mats from end-to-end and use multiple robots to simulate a large-scale toxic spill.

6. ***Explore career opportunities.***
Investigate the role of engineers in robotics, environmental cleanups, and chemical engineering. List the potential careers in each of these areas.

GLOSSARY

Area - the size of a surface, the amount of space inside the boundary of a flat object. (Area = Length x Width)

Autonomous Robot - robots that perform tasks without continuous human guidance

Control Surface - materials (in this case straws, cups, cardstock) that restrict and redirect movements of the Eco-Bot

Containment Area - determined area in which a toxic material is held in order to prevent further contamination

Efficient - performing or functioning in the best possible manner with the least waste of time and effort

Effective - adequate to accomplish a purpose; producing the intended result, functioning at a set level

Engineering Design Process - a highly flexible process used by engineers to produce solutions and develop systems and products

Hazmat - hazardous materials

Hypothesis - an educated guess that uses information that we already know in order to estimate or predict the expected outcome

Optimize - to make as effective as possible or as useful as possible

Model - a representation, generally in miniature, that shows the construction or appearance of something

Percentage - a proportion or share in relation to a whole or part; a fraction or ratio with 100 as the understood denominator; for example, 0.65 equals a percentage of 65

Programming - in regards to robotics, these are commands given to a robot to complete, tasks

Ratio - shows the relative sizes of two or more values; for example in this case, 65 black spaces cleaned out of a total of 125 black spaces that need to be cleaned

Robot - a mechanical agent that can perform tasks automatically or with guidance, typically by remote control

Simulation - to imitate, pretend; set up a situation as a model

Toxic spill - an unintended or accidental release of toxins into the environment that is capable of causing death or serious harm to humans, animals, and/or plants

Toxin - a poisonous substance that is capable of causing sickness, harm or disease on contact

Variable - a factor or condition that is subject to change, especially one that is allowed to change in scientific experiment to test a hypothesis

United States Department of Agriculture

National Institute of Food and Agriculture

For more than 100 years, 4-H has been at the forefront of teaching youth about science, engineering and technology. 4-H National Youth Science Day is an annual event. It is part of 4-H's national *One Million New Scientists. One Million New Ideas.* campaign, which has a bold goal of attracting one million new youth to science, engineering and technology programs by the year 2013.

Learn more about 4-H

www.4-H.org

Find us on: facebook®

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The 4-H Name and Emblem are protected by 18 USC 707.

The 2012 National Science Experiment was designed in partnership with The Ohio State University, part of our nation's Cooperative Extension Sytem. Thanks to Windell Oskay of Evil Mad Scientist Laboratory for use of his "BristleBot" design.

4-H is a community of six million young people across America learning leadership, citizenship, and life skills. National 4-H Council works to advance the 4-H Youth Development movement, building a world in which youth and adults learn, grow and work together as catalysts for positive change. National 4-H Council partners with the Cooperative Extension System of Land-Grant Universities, 4-H National Headquarters located at the National Institute of Food and Agriculture (NIFA) within USDA, communities, and other organizations to provide technical support and training, develop curricula, create model programs and promote positive youth development to fulfill its mission.

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