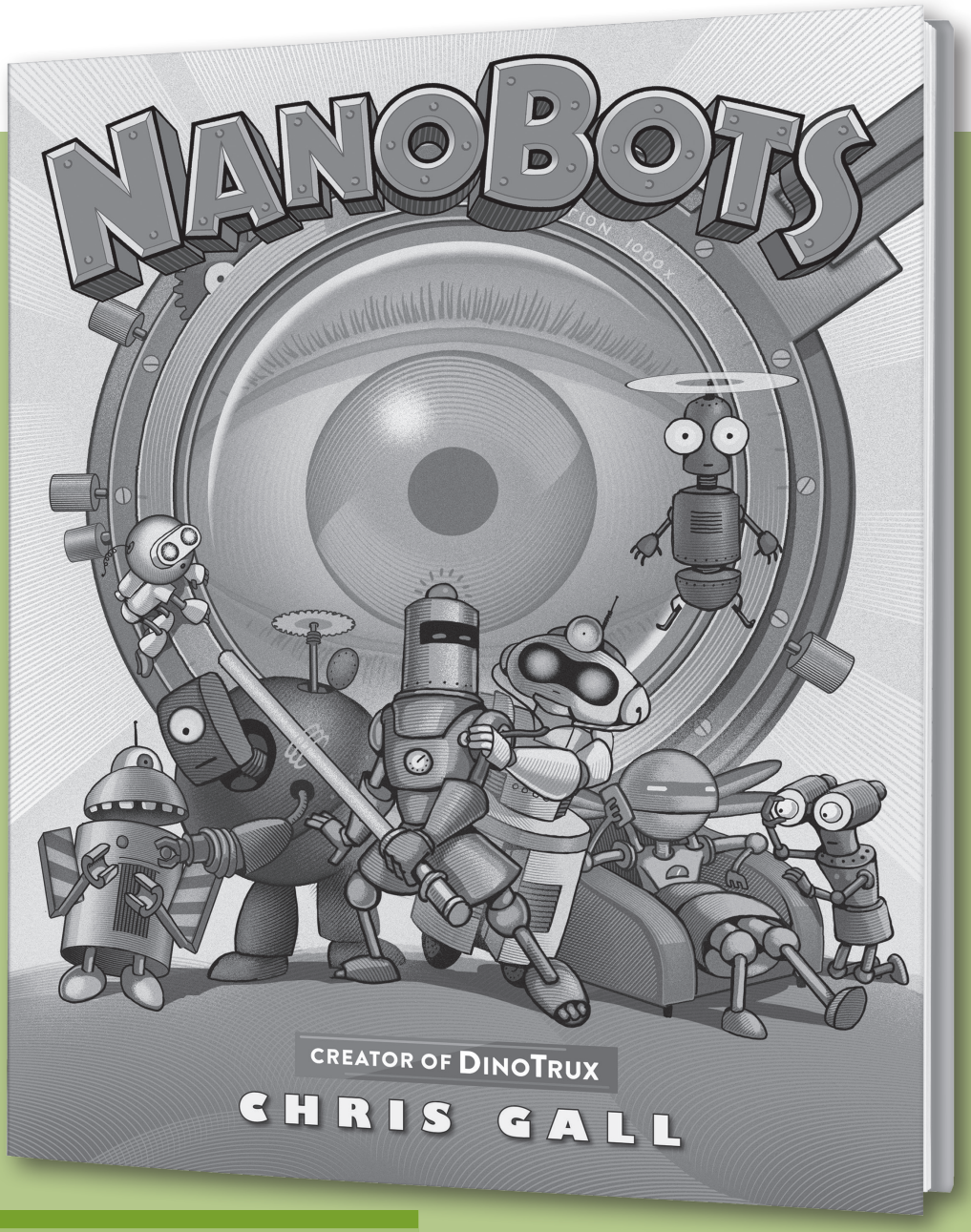
educator's guide

NANOBOTS



Curriculum connections

- Robotics
- Science & Technology
- Science Fiction

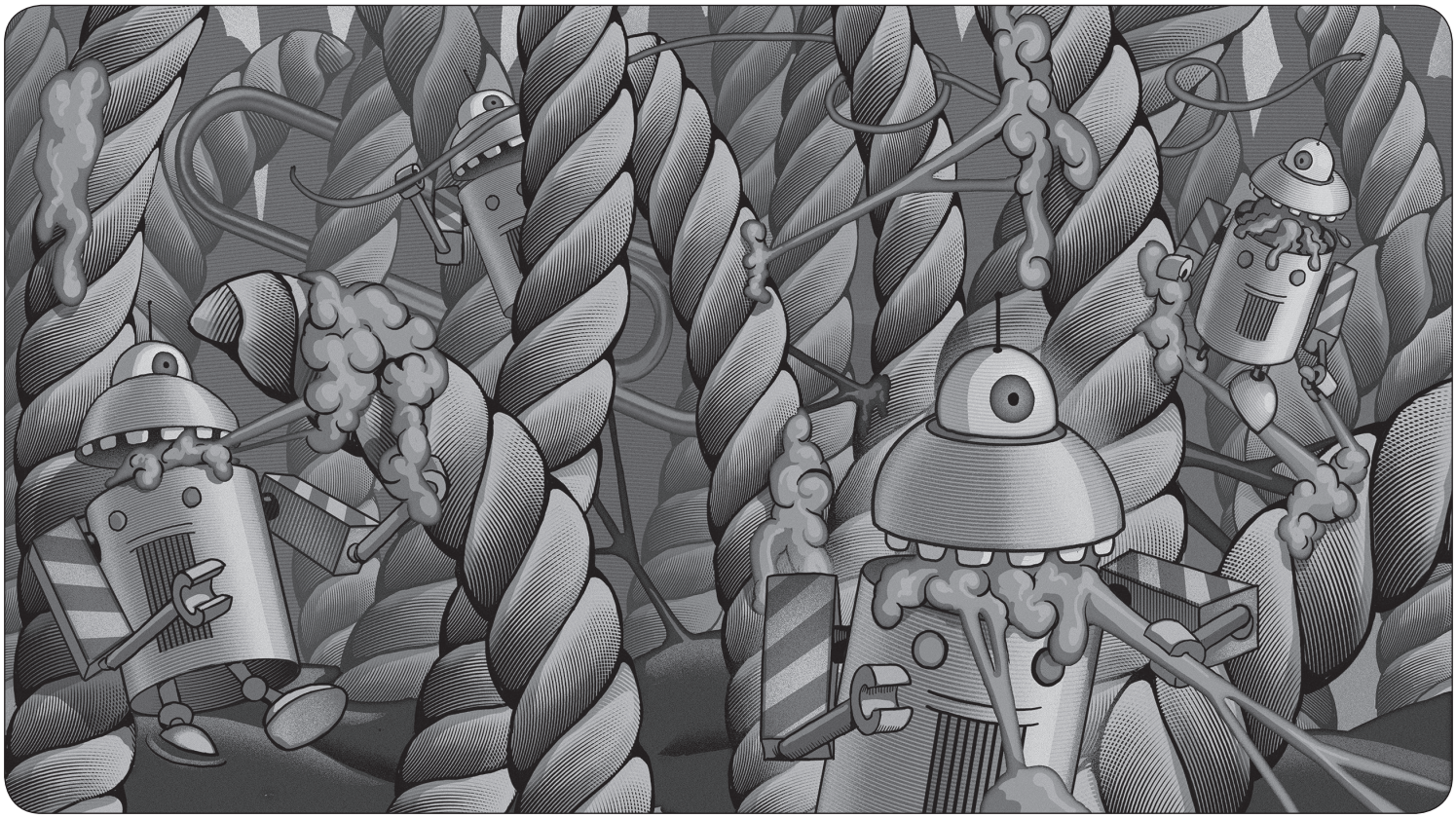
Ages: 4 – 8

by CHRIS GALL

Dear Teacher,

NanoBots will transform your classroom into a hands-on exploratorium where passions come alive! Author Chris Gall has harnessed the power of NanoBots into a 21st century adventure, engaging students in the science, engineering, and wonder of nanotechnology. Gall blurs the lines between the imaginable and the inconceivable, tapping into the amazing possibilities of nano-applications.

The NanoBots educator guide is as expansive as the NanoBots Gall describes. From SeekerBots to MediBots, every student will have a favorite. These nine NanoBots may be the world's smallest high-tech heroes, but they reflect the awesome power of individuality, creativity, and innovation. The projects in this guide go beyond the traditional. Like the NanoBots, they are designed to appeal to a wide array of learning styles, interests, and strengths. Over the course of ten projects, your students will be called upon to take risks, think critically, and problem solve in authentic and meaningful ways. From your visual spatial explorer to that kinesthetic investigator who just cannot sit still, every student in your classroom will find an outlet to plug into the extraordinary world of NanoBots.



BUILDING BACKGROUND KNOWLEDGE

Before reading *NanoBots*, discuss the prefix "nano" and the root word "bot" in Nanobot. Show students a meter stick and explain that a nano is one-billionth of a meter. Use a blade of grass in a football stadium as an analogous point of reference for the scale of one-billionth.

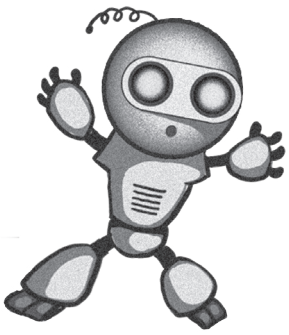
Nanobot: noun

1. A machine or robot built on the nanoscale, still in the research-and-development stage, with potential applications in medicine and industry.
2. A machine or robot that can manipulate nanoscale objects with great precision.

The following multimedia resources will introduce your students to the term "nano" as it relates to size, as well as the concept of "nanotechnology," specifically Nanobots and their applications in the real world.

Grades 2–3:

Explore videos and apps as a whole group before having students watch or play on their own.



Grades 4–5:

Students may work as partners with an iPad to watch movies and explore apps. All of these resources are free on iTunes, Youtube, and the Apple App store.

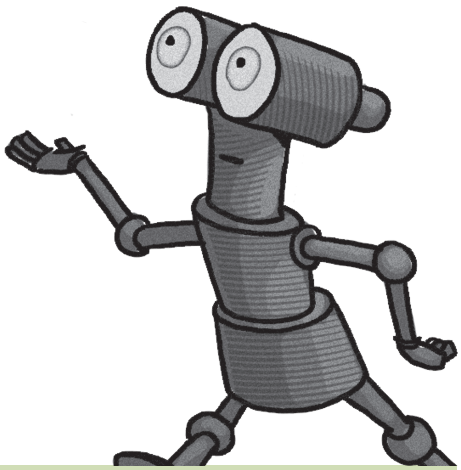
- **Mysteries of the Unseen World by National Geographic:** youtube.com/watch?v=DFyBEPaeBew
  Cue this YouTube video at 21:37. Concepts covered include compound and scanning electron microscopes, and nanotechnology and its role in technology and healthcare.
- **DIY NANO:** itunes.apple.com/us/app/diynano/id520611568?mt=8
  The DIY Nano app allows students to learn about nanoscale science, engineering, and technology. The app provides free, easy to use, hands-on activities at your fingertips. Each activity includes materials lists, step-by-step instructions, and detailed explanations.
- **Zoom Quiz: A Game of Zoomed in Pictures:** itunes.apple.com/us/app/zoomquizgamezoomedinpictures/id649725468?mt=8
  The Zoom app engages students to examine close-ups of familiar objects, creatures, and animals, identifying them at increasingly difficult levels. It emphasizes scale and magnification.
- **Smart Magnifier:** itunes.apple.com/ua/app/smartmagnifier/id1125991635?mt=8
  Students can enlarge everyday items and lifeforms in their environment, viewing magnified images with great detail. Students can freeze frame magnifications and save them to the iPad camera roll to share with the class.
- **How Big is a Nano?:** explainthatstuff.com/nanotechnologyforkids.html

I. SEEKERBOTS: EXPLORE UNSEEN WORLDS

Explain how objects in the world around us may normally look familiar, but with a closer look, appear odd or even alien. Administer the following close-up image quiz as a whole group: uk.news.yahoo.com/can-you-guess-what-these-extreme-close-up-photos-are-of--150212384.html. How many everyday objects can students identify correctly? Explain that this type of photography is called "Macro," named for the lens photographers use to take close up shots.

Then, using the Smart Magnifier app, students will increase the magnification of photographic subjects. Model how to do this, focusing in on a close-up part of a whole object. Take a walk around and outside of your school. Have students partner up to take shots.

Once back in the classroom, have students upload close-up images to Google Slides (google.com/slides/about/) as a presentation to be shared with peers. Students select an appropriate Google theme and three clues as hints to identify each object. Sounds may be added as clues where applicable. For example, a close up of a cricket's antennae may be hinted at by a chirping sound. Challenge classmates to identify each object, plant, or creature in their presentation. What details made some objects difficult to recognize? Was it difficult to get some shots? Why? If so, what strategies did students need to use?



II. MECHANOBOTS: FIX ANYTHING, EVEN IN THE HARDEST-TO-REACH PLACES

Students will take mechanical and electronic toys apart and reconstruct them with new parts.

A month before this project begins, send a note home asking parents and teachers to donate old electronic toys, remote control cars, dolls, and stuffed animals.

Explain how students will work with a partner to innovate a new toy or gadget by combining the parts of two or more toys. This project may take several 45-minute sessions to complete.

In this activity, the focus is on process over product. How students deal with failure is as much a part of this lesson as any objective. Some refer to this type of resilience under rigor as a "growth mindset," a term coined by psychologist, Dr. Carol Dweck. From the start, the teacher should clearly state the goal, but move out of the role of "sage on the stage" to "guide on the side" as students are given the time and freedom to explore, play, and learn.

Steps for Toy Deconstruction/Reconstruction:

1. Note the objective: To disassemble an existing toy and repurpose it as a new one, mixing parts from two or more toys or gadgets.
2. Students will work with a partner, selecting two or more toys from the stockpile table.
3. Students may use scissors, screwdrivers, seam rippers, pliers, and other tools to disassemble. *Remind students to be careful not to destroy important parts.

Suggestions for deconstruction:

(a) Turn the fur or cloth lining or cover of a stuffed animal inside out.

(b) Remove parts: batteries, receivers, motors, windup, wheels, axle, doll, or toy body parts.

Visit the following website to learn more about Toy Deconstruction/Reconstruction: tinkering.exploratorium.edu/toy-take-apart.

Students will share and explain their new toys and/or gadgets to peers.

III. HELOBOTS : FLY IN GREAT SWARMS; THEY CAN FORM ANY SHAPE

Explain how HeloBots use "swarm intelligence," a term coined by computer scientists, based on the self-organizing cooperation of tiny living creatures like birds, termites, ants, and bees. Scientists program swarms of nanorobots to behave in a similar manner, working together to solve complex engineering problems. Have students watch the Swarm Robot video to provide background knowledge: pbslearningmedia.org/resource/nvmms.sci.eng.swarm/swarmrobotics.

Working together as a group, ask students to behave like HeloBots, using their bodies to solve challenges. To establish the proper framework for this, show students this TedX Talk by Erik Stern and Carl Schaffer called Math Dance: youtube.com/watch?v=Ws2y-cGoWqQ. After watching this video, discuss the terms: combinations, symmetry, and patterns, and how they relate to the activities in this video.

Then, in small groups of three or four, students will create their own intriguing handshakes performed in unison. How many different combinations of handshakes were they able to design? Next, challenge students to work right hand to right hand. How many different ways are there for people to shake hands, if each person may only use one hand at a time?

Students will work in pairs to choreograph a series of procedures that incorporates symmetry and patterns using body movements, gestures, and claps. Students will teach the class to perform this same procedure in unison.

IV. CHEWBOTS : THEY GOBBLE NASTY, ICKY STUFF… AND MAKE A ROOM SQUEAKY CLEAN

Students will investigate oil spills as an example of an environmental clean up using the Wonder Workshop robot, Dash.

Students will research the impact of an oil spill on the environment using selected websites:

- **Newsela Oil Spills:** newsela.com/search/#/?needle=oil%20spill
  Each Newsela news article ends with a quiz so you can gauge your students' level of comprehension and any areas needing clarification. You can also adjust the reading level of a Newsela article.
- **Containment Methods:** nwf.org/pdf/Kids/oilspill_mini-page.pdf

Then, using the Blockly app for Dash (makewonder.com/apps/blockly), students will work in pairs or trios to solve the 12-Dash puzzles in order to learn how to program Dash using drag and drop block coding.

Students will model a spill containment method they learned about or innovate one of their own using Dash on a grid. The teacher will plot coordinates that designate the perimeter of "the spill" and students will code a program in the "Create New" section of the Blockly app that demonstrates how Dash will act as a Chewbot to clean up the oil spill.

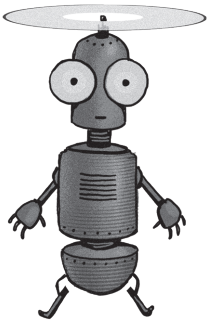
V. MEDIBOTS: THEY KNOW EVERY NOOK AND CRANNY OF THE HUMAN BODY, KEEPING OUT GERMS

Show students the following videos about nanotechnology in medicine:

- **Cancer Fighting Nanorobot:** cbsnews.com/news/cancer-fighting-nanorobot-may-be-able-to-target-tumors-leave-healthy-tissue-alone
- **The NanoRobots Inside You:** youtube.com/watch?v=YdjERhTczAs

Have students play the classic Operation board game. Using creative thinking skills, students will design a game board based on an imaginary character or creature, in which players, as MediBots, will remove the nano-bacteria inside them. Have students visit this Pathogen Modeling website (mrsec.psu.edu/content/pathogenmodeling) to learn more about real-world nano-sized pathogens.

The following link is a Google Slide presentation: tinyurl.com/nano-operation. The first half contains information on open and closed circuits, as well as applied terminology. The second half contains directions on how to make/wire an Operation game board. The board can be based on any theme, but the parts that are being removed should represent a magnification of nano-bacteria that the MediBot must remove to win the game.



Students will share Nano-Operation games with other classes, explaining the role nanorobotics play in medicine. Tell students to allow peers to play their game.

VI. LADY LANCEOBOT: KEEPS WATCH OVER THE GARDEN

In this activity, students will explore various biomes, e.g., desert, antarctica, rainforest, chaparral, etc., and the plant life that live inside them, and study the impact of nonnative species in a new environment.

To provide background knowledge about nonnative plants, have students watch this video on nonnative plant invasion: youtube.com/watch?v=jW5FSZUMzJY. Discuss how Lady LanceoBot might stop the transport of a nonnative plant or seedling into a new biome.

Students will research a plant that is native to one biome and predict its survival in a secondary biome. Discuss how this plant might fare in the new biome. How will it need to adapt to its new environment and weather? Draw a picture of adaptations your plant might need to survive in the secondary biome. Explain your thinking.

Students will share their predictions in a creative presentation. Options for presentation include: multimedia website (wix.com), multimedia poster (canva.com), iMovie, or Google Slideshow.

VII. GUARDOBOTS: USE FORCE FIELDS TO KEEP BEDROOMS SAFE FROM GOBLINS, MONSTERS, AND UNDER THE BEDDERS

In this activity, students will design and construct a dream catcher (pbs.org/parents/crafts-for-kids/dream-catcher) and write a poem that includes his or her personal big and small dreams.

Ask students to read about the mythology that inspired dream catchers on the following website: dream-catchers.org/history-of-dream-catchers.

Have students write down their dreams in a table under two different headings: Small Dreams (NanoDreams) and Big Dreams (GigaDreams). Explain the difference between the prefixes "nano" and "giga."

Then, have students design their own dream catchers and a related poem, which includes their two NanoDreams and two GigaDreams. Require students to incorporate figurative language, e.g., similes, metaphors, alliteration, and personification.

VIII. BINOBOT: SHE SOLVES MYSTERIES WITH HER POWERFUL ROBOEYES

Have students identify small objects on a game board developed by the National Informal STEM Education Network (NISE) called I Spy Nano!: nisenet.org/catalog/programs/i_spy_nano_nanodays_2012.

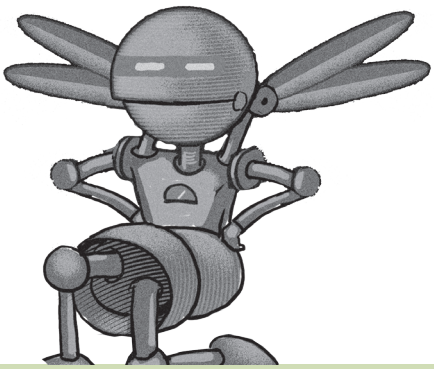
Then, take students outside the classroom to learn about the different ways nano is in the world around us. Using an iPad or other mobile device camera, have students work in pairs or trios to take pictures of tiny objects while on a nature walk outside the school. Have students use either Keynote, Powerpoint, or Google Slides to create their own I Spy Nano games to share with other classes.

IX. NANO-NANOBOT: THEY LIVE IN A WORLD SO MINIATURE, YOU'D NEED A VERY POWERFUL MICROSCOPE TO SEE THEM

Explore the tiny world of BrushBots, experimenting with friction, force, and motion.

Model how to make a Brushbot with students. A list of materials and how-to instructions can be found on the following website: makezine.com/projects/building-brushbot-kits. Ask students to make their own BrushBots using required materials and additional craft supplies to decorate them.

Have students race their BrushBots on plastic tracks from a Matchbox set. Tell students to experiment by bending the direction of their BrushBot's bristles, as well as changing the surface of the race track, e.g., sandpaper, dirt, tile floor. Have students work in pairs to record the time it takes for their BrushBot to travel from point A to point B on different surfaces. After this activity, ask students what adjustments they needed to make in order to improve the performance of their BrushBot.



X. MAKE YOUR OWN DRAWBOT!

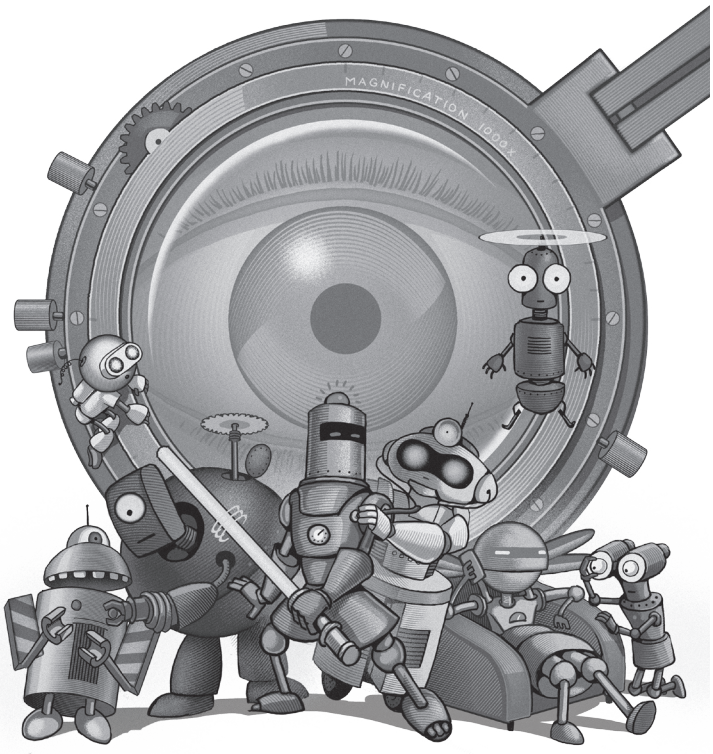
Tell students to reflect on the different types of NanoBots. Which one did they relate to most and why? Encourage students to elaborate on their thinking. "Which talents or interests were not represented by the NanoBots (visual arts, performing arts, music, dance, writing)?" Discuss the importance of the arts and creative thinking in innovation. "Why do you think it's more difficult to program a robot to handle a creative task?

Model how to create an ArtBot with students. For directions and materials, follow this link: handmadekidsart.com/art-bot-art-projects-kids. Do a shared writing in which you explain the ArtBot and how its small size is used in art. Example: The ArtBot is used in museums all over the country to touch up old paintings with chipped or peeling paint. It is small enough to patch up the tiniest rip in a canvas or fill in the minutest scratch with paint. Its nano-size makes it perfect for working on old canvases, which may be quite fragile.

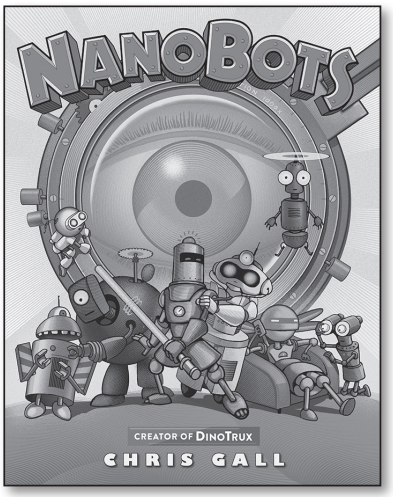
Challenge students to create a tenth NanoBot based on the arts. Have students compose a descriptor about how this tenth NanoBot's tiny size is helpful in carrying out its creative task.

ADDITIONAL RESOURCES ABOUT REAL WORLD NANOBOTS

- How Do You Make a NanoRobot: youtube.com/watch?v=_v9Oqu9wzOs
- NanoBots Small Solutions to Big Problems: cnn.com/videos/tv/2015/01/29/spc-make-create-innovate-nanobots.cnn
- Microbots Clean Up Polluted Water: http://phys.org/news/2016-04-microbots-polluted.html
- Stephen Hawking's Microbot Launched to Alpha Centauri: youtube.com/watch?v=c5wViLRGJSo
- Amazing Ways Nanotechnology is Changing Our World: youtube.com/watch?v=Lqz8PrB39Tc
- NanoBook Report in an Altoid Box: gottoteach.com/2015/03/mint-tin-book-report.html
- Tiny Dancers: http://babbledabbledo.com/steam-project-tiny-dancers-homopolar-motor
- NanoArt: nanoart21.org
- Virtual Electron Microscope: school.discoveryeducation.com/lessonplans/interact/vemwindow.html



ABOUT THE BOOK



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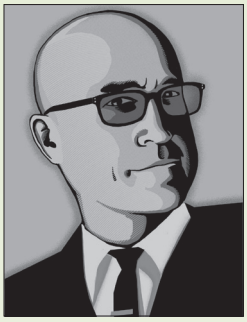
ABOUT THE AUTHOR



Chris Gall is the award-winning author and illustrator of *Dinotrux*, a *Publishers Weekly* Best Children's Book, which inspired a Netflix original TV series, and four other books about these prehistoric monster machines, including *Dinotrux Dig the Beach* and *Revenge of the Dinotrux*. His other picture books include *Dog vs. Cat*, *Awesome Dawson*, *Substitute Creacher*, and *America the Beautiful*. He lives in Tucson, Arizona. Visit him online at chrisgallbooks.com.

ALSO BY CHRIS GALL

All titles listed below, except *America the Beautiful*, are available as an ebook.

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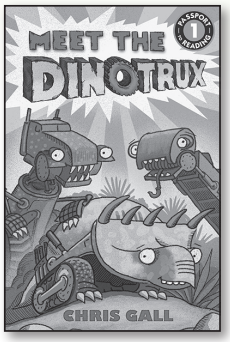

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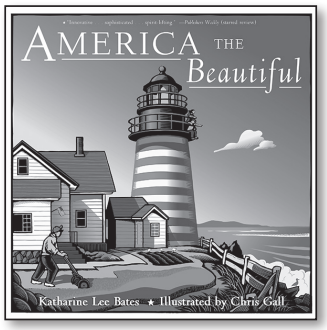

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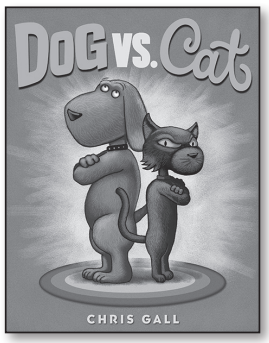

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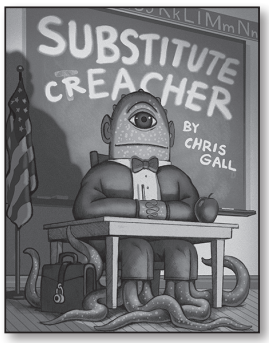

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This educator's guide was written by Julie Dweck, Children's Author and Gifted Specialist Educator.