

Matthew Bobrowsky
Mikko Korhonen
Jukka Kohtamäki

USING PHYSICAL SCIENCE GADGETS & GIZMOS

GRADES 3-5

PHENOMENON-BASED LEARNING



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ABOUT THE AUTHORS

MATTHEW BOBROWSKY, PHD

Dr. Matt Bobrowsky has been involved in scientific research and science education for several decades. Currently at Delaware State University, he previously served as Director of the Physics Demonstration Facility at the University of Maryland—a collection of over 1,600 science demonstrations. Also at the University of Maryland, Matt was selected as a Faculty Mentor for the Fulbright Distinguished International Teachers Program, where he met Mikko Korhonen.

Matt has taught physics, astronomy, and astrobiology both in the classroom and online. He has written K–12 science curricula and serves on the Science Advisory Committee for the Howard County Public School System in Maryland. Matt has conducted countless professional development workshops for science teachers and special presentations for students, speaking on a variety of topics beyond physics, such as the scale of the universe, life in the universe, misconceptions about science among students and the public, the process of science, and science versus pseudoscience.

He is often asked to be an after-dinner speaker or keynote speaker at special events. Matt is a “Nifty Fifty” speaker for the USA Science & Engineering Festival and a Shapley Lecturer for the American Astronomical Society. Matt has received a number of awards for teaching excellence from the University of Maryland, including the Stanley J. Drazek Teaching Excellence Award (given to the top 2 instructors out of ~800) and the Board of Regents’ Faculty Award for Excellence in Teaching (given to the top 3 instructors out of ~7,000). Matt’s teaching is always innovative because he uses pedagogical techniques that are based on current science education research and known to be effective.

In his research, Matt has been involved in both theoretical and observational astronomy. He developed computer models of planetary nebulae—clouds of gas expanding outward from aging stars—and has observed them with telescopes on the ground as well as with the Hubble Space Telescope. One of the planetary nebulae that Matt investigated is the Stingray Nebula, which he discovered using Hubble.

MIKKO KORHONEN

Mikko Korhonen obtained a master's degree from Tampere Technical University in Finland, where he studied physics, mathematics, and pedagogics. Since then, he has been teaching physics, mathematics, and computer science at various schools in Finland. He has also developed a number of educational programs that brought some of his students to top scientific facilities in the world, including the Nordic Optical Telescope (NOT) observatory in La Palma, Spain, the CERN laboratory at the Franco-Swiss border, and the LATMOS laboratory in France. Most recently, some of his students have attended the Transatlantic Science School, which Mikko founded.

Mikko has written numerous other educational publications, including a book of physics experiments, manuals of physics problems with answers, an article on mathematics and logic for computer science, and two books with Jukka Kohtamäki on using toys to teach physics, one at the middle school and one at the high school level.

Mikko has obtained numerous grants and awards for his school and students, including awards from the NOT science school and the Viksu science competition prize, as well as individual grants from the Finnish National Board of Education and the Technology Industries of Finland Centennial Foundation, and grants for his "physics toys" project. His students are also award winners in the Finnish National Science Competition. Mikko received one of the Distinguished Fulbright Awards in Teaching, which brought him to the University of Maryland for a semester, where he worked with Matt Bobrowsky. Most recently, Mikko received the award of Distinguished Science Teacher in 2013 by the Technology Industries of Finland Centennial Foundation.

JUKKA KOHTAMÄKI

Jukka Kohtamäki obtained his master of science degree from Tampere University of Technology in Finland and since then has been teaching grades 5–9 at the Rantakyla Comprehensive School, one of the largest comprehensive schools in Finland. Jukka has participated in long-term professional development teaching projects and projects involving the use of technology in learning, as well as workshops that he and Mikko Korhonen conducted for Finnish science teachers. His writing includes teaching materials for physics and computer science, and he has written two books with Mikko on using toys to teach physics, one at the middle school and one at the high school level.

Jukka is a member of the group under the National Board of Education that is writing the next physics curriculum in Finland. He is also participating in writing curricula in chemistry and natural science (which is a combination of biology, geology, physics, chemistry, and health education). His goals are to get students engaged in lessons, to have them work hands on and minds-on, to encourage creativity in finding solutions, and to get students to discuss natural phenomena using the "language of physics." In 2013, Jukka received the Distinguished Science Teacher Award from the Technology Industries of Finland Centennial Foundation.

*“The most beautiful thing
we can experience is the
mysterious. It is the source
of all true art and science.”*

— Albert Einstein

AN INTRODUCTION TO PHENOMENON-BASED LEARNING

The pedagogical approach in this book is called phenomenon-based learning (PBL), meaning learning is built on observations of real-world phenomena—in this case of some fun toys or gadgets. The method also uses peer instruction, which research has shown results in more learning than traditional lectures (Crouch and Mazur 2001). In the PBL approach, students work and explore in groups: Exercises are done in groups, and students' conclusions are also drawn in groups. The teacher guides and encourages the groups and, at the end, verifies the conclusions. With the PBL strategy, the concepts and the phenomena are approached from different angles, each adding a piece to the puzzle with the goal of developing a picture correctly portraying the real situation.

PBL is not so much a teaching method as it is a route to grasping the big picture. It contains some elements that you may have seen in inquiry-based, problem-based, or project-based learning, combined with hands-on activities. In traditional science teaching, it's common to divide phenomena into small, separate parts and discuss them as though there is no connection among them (McNeil 2013). In our PBL approach, we don't artificially create boundaries within phenomena. Rather, we try to look at physical phenomena very broadly.

PBL is different from project-based or problem-based learning. In project-based learning, the student is given a project that provides the context for learning. The problem with this is that the student is not necessarily working on the project out of curiosity but simply because they are required to by the teacher. To avoid having students view the project as a chore or just a problem that they have

to solve, we employ PBL: The student's own curiosity becomes the driver for learning. The student explores not by trudging through a problem to get to the correct answer but by seeing an interesting phenomenon and wanting to understand what's going on. This works because interest and enthusiasm do not result from the content alone; they come from the students themselves as they discover more about a phenomenon. Personal experience with a phenomenon is always more interesting and memorable than a simple recitation of facts (Jones 2007; Lucas 1990; McDade 2013).

The goal in project-based learning is for the students to produce a product, presentation, or performance (Moursund 2013). PBL does not have that requirement; students simply enjoy exploring and discovering. This is the essence of science, and it is consistent with the philosophy of the *Next Generation Science Standards* (NGSS). Rather than simply memorizing facts that will soon be forgotten, students are doing real science. They are engaged in collaboration, communication, and critical thinking. Through this, students obtain a deeper understanding of scientific knowledge and see a real-world application of that knowledge—exactly what was envisioned with the NGSS. This is why, at the end of each chapter, we provide a list of relevant standards from the NGSS, further emphasizing our focus on the core ideas and practices of science, not just the facts of science.

The objective of PBL is to get the students' brains working with some phenomenon and have them discussing it in groups. A gizmo's functions, in most cases, also make it possible for teachers to find common misconceptions that students may harbor. It is important to directly address misconceptions

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because they can be very persistent (Clement 1982, 1993; Nissani 1997). Often the only way to remove misconceptions is to have students work with the problem, experiment, think, and discuss, so that they can eventually experience for themselves that their preconception is not consistent with what they observe in the real world.

We must also keep in mind that students can't build up all the scientific laws and concepts from scratch by themselves. Students will definitely need some support and instruction. When doing experiments and learning from them, the students must have some qualitative discussions (to build concepts) and some quantitative work (to learn the measuring process and make useful calculations). Experience with combining the two reveals the nature of science.

PBL encourages students to not just think about what they have learned but to also reflect on how they acquired that knowledge. What mental processes did they go through while exploring a phenomenon and figuring out what was happening? PBL very much lends itself to a **K-W-L** approach (what we **K**now, what we **W**ant to know, and what we have **L**earned). K-W-L can be enhanced by adding an H for "How we learned it" because once we understand that, we can apply those same learning techniques to other situations.

When you first look at this book, it might seem as if there is not very much textual material. That was intentional. The idea is to have more thinking by the students and less lecturing by the teacher. It is also important to note that the process of thinking and learning is not a race. To learn and really get the idea, students need to take time to think ...

"Most of the time my students didn't need me; they were just excited about a connection or discovery they made and wanted to show me."

—*Jamie Cohen (2014)*

and then think some more—so be sure to allow sufficient time for the cognitive processes to occur. For example, the very first experiment (using a toy car) can be viewed in just a few minutes, but in order

for students to think about the phenomenon and really get the idea, they need to discuss the science with other group members, practice using the "language of science," and internalize the science involved—which might take 20 minutes. During this time, the students may also think of real-life situations in which the phenomenon plays a significant role, and these examples can be brought up later during discussions as an entire class.

HOW TO USE THIS BOOK

This book can be used in many ways. It can be used as a teacher's guide or as material for the students. In the hands of the teacher, the introductions and the questions can be used as the basis for discussions with the groups before they use the gadgets, that is, as a motivational tool. The teacher can ask where we see or observe the phenomenon in everyday life, what the students know about the matter prior to conducting the activities, and so on. The explorations can also be used to spark curiosity about a particular area of science and to encourage students to explore and learn.

Exactly how you present the material depends a lot on your students. Here's one approach: Have students work in groups. Studies have shown this to be a good way for them to learn. Have the students discuss with each other—and write down in their science notebooks—what they already

know about the gadget and about the phenomenon it demonstrates. If they don't yet know what phenomenon the gadget shows, you can just have them carry out the steps provided for exploring that gadget. As they perform the exploration, they should write questions they think of about the gadget or the science involved. If the students are having trouble with this, you can get more specific and ask them, for instance, what they would need to know in order to understand what's going on; or ask where else they have seen something like this. Having students formulate questions themselves is part of PBL and also part of an inquiry approach. Asking questions is also how scientists start out an investigation. Be sure to give the groups plenty of time to attempt to answer their questions themselves.

It's great to let the students pursue the questions they raise and to encourage investigations into areas that they find interesting. This is part of "responsive teaching," and also part of PBL. If, after a good amount of time, the students are unable to come up with their own questions, you can start to present the questions in the book—but resist the temptation to just have students go down the list of questions. That is more structure than we want to have in view of our goal of presenting learning as exploration and inquiry. A good use of the questions would be to help guide your interaction with the groups as they explore a phenomenon.

Students can then work in groups to answer the questions, doing more experimentation as needed. The important point is that they won't learn much by simply being told an answer. Much more learning takes place if they can, through experimentation and reasoning, come up with some ideas themselves. Students may come up with an idea that is incorrect; rather than immediately correcting them,

guide them toward an experiment or line of reasoning that reveals an inconsistency. It is not a bad thing if the students' first ideas are incorrect: This allows them to recognize that, through the process of science, it is possible to correct mistakes and come away with a better understanding—which is one of the main points of PBL.

While the student groups are investigating, you, the teacher, should be moving among them, monitoring conversations to determine whether the students are proceeding scientifically, for example, by asking questions or discussing ways to answer the questions—perhaps using the gadget, through debate, or even by doing web searches. This monitoring is part of the assessment process, as explained further in the Learning Goals and Assessment section.

After students have made a discovery or figured out something new, have them reflect on the mental process they went through to achieve that discovery or understanding. This reflection—sometimes referred to as metacognition—helps students recognize strategies that will be helpful for other challenges in the future. The combination of guidance and metacognition is consistent with a modern learning cycle leading to continuous increases in students' content knowledge and process skills.

LEARNING GOALS AND ASSESSMENT

The most important learning goal is for students to learn to think about problems and try a variety of approaches to solve them. Nowadays, most students just wait for the teacher to state the answer. The aim here is for students to enjoy figuring out what's going on and to be creative and innovative.

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Combining this with other objectives, a list of learning goals might look something like this:

By the end of these lessons, students will

- think about problems from various angles and try different strategies;
- demonstrate process skills, working logically and consistently;
- collaborate with others to solve problems;
- use the language of science;
- reflect on the thinking processes that helped them to acquire new knowledge and skills in science; and
- view science as interesting and fun.

You will also notice that there are no formal quizzes or rubrics included. There are other ways to evaluate students during activities such as these. First, note that the emphasis is not on getting the “right” answer. Teachers should not simply provide the answer or an easy way out—that would not allow students to learn how science really works. When looking at student answers, consider the following: Are the students basing their conclusions on evidence? Are they sharing their ideas with others in their group? Even if a student has the wrong idea, if she or he has evidential reasons for that idea, then that student has the right approach. After all members of a group are in agreement and tell you, the teacher, what they think is happening, you can express doubt or question the group’s explanation, making the students describe their evidence and perhaps having them discuss it further among themselves. Student participation as scientific investigators and their ability to give reasons for their explanations

will be the key indicators that the students understand the process of science.

The PBL approach lends itself well to having students keep journals of their activities. Students should write about how they are conducting their experiment (which might differ from one group to another), ideas they have related to the phenomenon under investigation (including both correct and incorrect ideas), what experiments or observations showed the incorrect ideas to be wrong, answers to the questions supplied for each exploration, and what they learned as a result of the activity. The teacher can encourage students to form a mental model—perhaps expressed as a drawing—of how the phenomenon works and why. Then the students can update this model in the course of their investigations. Students’ notebooks or journals will go a long way to helping the teacher see how the students’ thinking and understanding have progressed. If there is a requirement for a written assessment, the journal provides the basis for that. As a further prompt for writing or discussion, encourage students to form a “bridge to the future” by asking questions such as “Where could we use this phenomena?” and “How could this be useful?” Students might also want to make a video of the experiment. This can be used for later reference as well as to show family and friends. Wouldn’t it be great if we could get students talking about science outside the classroom?

A few of the questions asked of the students will be difficult to answer. Here again, students get a feel for what it’s like to be a real scientist exploring uncharted territory. A student might suggest an incorrect explanation. Other students in the group might offer a correction, or if no one does, perhaps further experimentation, along with guidance from the teacher, will lead the students on the right course. Like scientists, the

students can do a literature search (usually a web search now) to see what others know about the phenomenon. (Doing web searches also involves learning to recognize when a site is reputable and when it is not.) Thus there are many ways for a misconception to get dispelled in a way that will result in more long-term understanding than if the students are simply told the answer. Guidance from the teacher could include providing some ideas about what to observe when doing the experiment or giving some examples from other situations in which the same phenomenon takes place. Although many incorrect ideas will not last long in group discussions, the teacher should actively monitor the discussions, ensuring that students do not get too far off track and are on their way to achieving increased understanding. We've provided an analysis of the science behind each exploration to focus your instruction.

By exploring first and getting to a theoretical understanding later, students are working like real scientists. When scientists investigate a new phenomenon, they aren't presented with an explanation first—they have to figure it out. And that's what students do in PBL. Real scientists extensively collaborate with one another; and that's exactly what the students do here as well—work in groups. Not all terms and concepts are extensively explained; that's not the purpose of this book. Again, like real scientists the students can look up information as needed in, for example, a traditional science book. What we present here is the PBL approach, in which students explore first and are inspired to pursue creative approaches to answers—and have fun in the process!

PBL IN FINLAND

The Finnish educational system came into the spotlight after the Programme of International

Student Assessment (PISA) showed that Finnish students were among the top in science literacy proficiency levels. In 2009, Finland ranked second in science and third in reading out of 74 countries. (The United States ranked 23rd and 17th, respectively.) In 2012, Finland ranked 5th in science and 6th in reading. (The United States ranked 28th and 24th, respectively.) Finland is now seen as a major international leader in education, and its performance has been especially notable for its significant consistency across schools. No other country has so little variation in outcomes among schools, and the gap within schools between the top- and bottom-achieving students is quite small as well.

Finnish schools seem to serve all students well, regardless of family background or socioeconomic status. Recently, U.S. educators and political leaders have been traveling to Finland to learn the secret of their success.

The PBL approach is one that includes responsive teaching, progressive inquiry, project-based learning, and in Finland at least, other methods at the teachers' discretion. The idea is to teach bigger concepts and useful thinking skills rather than asking students to memorize everything in a textbook.

AUTHORS' USE OF GADGETS AND GIZMOS

One of the authors (M.B.) has been using gizmos as the basis of teaching for many years. He also uses them for illustrative purposes in public presentations and school programs. The other two authors (M.K. and J.K.) have been using PBL—and the materials in this book—to teach in Finland. Their approach is to present scientific phenomena to students so that they can build ideas and an understanding of the topic by

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themselves, in small groups. Students progress from thinking to understanding to explaining. For each phenomenon there are several different viewpoints from which the student can develop a big-picture understanding as a result of step-by-step exploration. The teacher serves only as a guide who leads the student in the right direction. PBL is an approach that is not only effective for learning but is also much more fun and interesting for both the teacher and the students.

SAFETY NOTES

Doing science through hands-on, process, and inquiry-based activities or experiments helps to foster the learning and understanding of science. However, in order to make for a safer experience, certain safety procedures must be followed. Throughout this book, there are a series of safety notes that help make PBL a safer learning experience for students and teachers. In most cases, eye protection is required. Safety glasses or safety goggles noted must meet the ANSI Z87.1 safety standard. For additional safety information, check out NSTA's "Safety in the Science Classroom" at www.nsta.org/pdfs/SafetyInTheScienceClassroom.pdf. Additional information on safety can be found at the NSTA Safety Portal at www.nsta.org/portals/safety.aspx.

Disclaimer: Safety of each activity is based in part on use of the recommended materials and instructions. Selection of alternative materials for these activities may jeopardize the level of safety and therefore is at the user's own risk.

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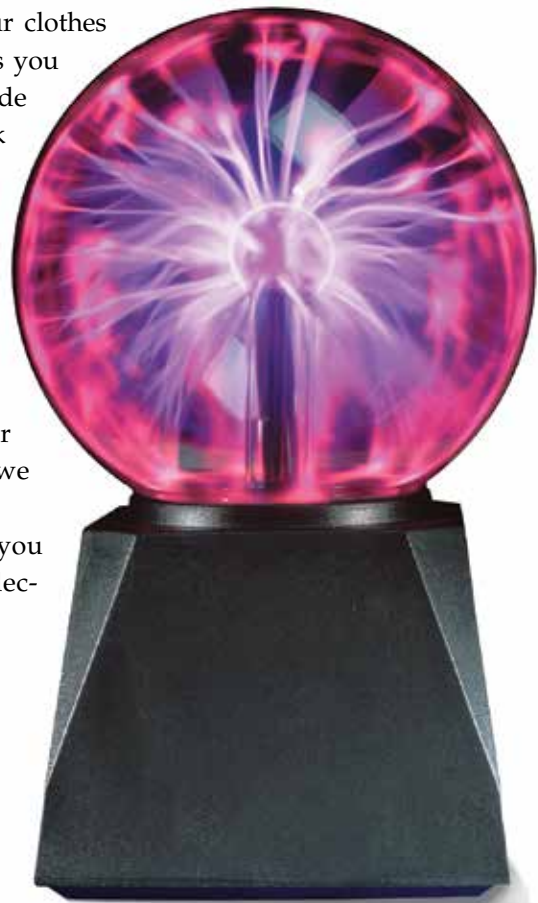
5

ELECTRICITY

Have you ever rubbed a balloon on your clothes or your hair? What happened? Perhaps you noticed that the balloon somehow made your hair stand up. Maybe you could then stick the balloon to a wall or a ceiling. This phenomenon is called *static electricity*.

The same phenomenon occurs when you touch a doorknob and get a shock. This happens because your shoes and clothes gather electric charges. When the difference in charges becomes high enough, you can make a small spark. Clouds can also gather electric charges. They make a big spark that we call lightning.

Now you will do some experiments so you can learn more about static electricity and electric charges.



5

Let's Explore!

**SAFETY NOTE**

Wear safety glasses or goggles.



FIGURE 5.1: Fun Fly Stick

FUN FLY STICK

With the Fun Fly Stick (Figure 5.1), you can make science look like magic. The phenomenon demonstrated here is something you may have experienced before.

1. Learn how the Fun Fly Stick works. Do you see how to turn it on and off?
2. Find the butterfly flyer and put it on the end of the Fun Fly Stick.
3. Press the button on the stick. What happens?
4. Shake the butterfly loose from the Fun Fly Stick. Can you make the butterfly fly around the classroom? What happens if the flying butterfly touches a wall or another student? (Note that you do not have to keep the button pressed while you are making the butterfly fly around.)
5. What keeps the butterfly in the air? Touch the butterfly gently with your finger. Does this give you an idea?
6. Select some other flyers and make them fly. Discuss with others why the flyers do what they do.
7. Next, you can try to make electric wallpaper. Depending on the weather and the kind of wall in your classroom, this might not work—but you can still try. Hold a sheet of paper against a wall and slide the Fun Fly Stick along the paper. Do this as though you were ironing the paper against the wall. Try to make the paper stick to the wall. If it sticks to the wall, talk about why it did.

LIGHTNING GLOBE

In the last experiment, you saw how electric charges sometimes repel and sometimes attract each other. There are two kinds of electric charges: positive and negative. When charges are the same kind, such as two positive charges, they push each other apart. When two charges are different kinds, one positive and one negative, they attract each other. In this experiment, you will use the Plasma Globe (Figure 5.2) to explore some more about electric charges and the phenomenon they cause called static electricity.

1. Plug in the globe and turn it on. The gadget has a switch for three different options. Choose the one that keeps the globe on continuously.
2. Explore the Plasma Globe. Touch the top with just one finger.
3. Next, touch the globe with two fingers and then with the palm of your hand. What do you see? Discuss with others what happened and why.
4. Keep one finger on one side of the globe. How does the spark move? Discuss why. How is what is happening in this experiment similar to lightning?
5. Put your finger very close to the surface of the globe. Can you make a small spark between the globe and your finger? If you did that, you might have been able to smell a gas called *ozone*. Sparks of static electricity create ozone.
6. Now let your teacher take a fluorescent light tube and bring it close to the Plasma Globe. Discuss what happened with others in your class.

SAFETY NOTES

- Wear safety glasses or goggles.
- As with all electrical equipment, make sure the lightning globe is clear of any water sources.



FIGURE 5.2: Plasma Globe



FIGURE 5.3: Energy Ball

HAVING A BALL

You have become acquainted with electric charges. In this experiment, the Energy Ball (Figure 5.3) will help you make them go around a *circuit*. A circuit can be a loop or a circle.

1. Find out what the Energy Ball does.
2. Make a circle of students in the classroom. Everyone in the circle must hold hands or touch elbows. Give the Energy Ball to two students in the circle so that each of them touches one of the metal strips.
3. You'll know that your group has made a *closed circuit* when the Energy Ball makes a sound.
4. What can you do to make the Energy Ball stop making a sound? That is called *opening the circuit*.
5. Now close the circuit again. Did the Energy Ball start making a sound again?
6. Discuss with the class the idea of open and closed circuits.
7. How many students can form a closed circuit so that the Energy Ball still works?



SAFETY NOTE

Wear safety glasses or goggles.

FUN FLY STICK

All matter consists of atoms. Atoms are very tiny building blocks for all materials. Everything you see around you is made of atoms. In an atom there is a part at the center called the *nucleus*. Surrounding the nucleus are *electrons* (Figure 5.4). The nucleus has a positive charge. The electrons have negative charges.

If an object has a negative charge, it has been given more electrons. If an object has a positive charge, the object has lost electrons. Electrons can move from one object to another if you rub two objects against each other. When you rub a balloon against your hair, both your hair and the balloon become charged—oppositely charged.

The objects that have opposite charges attract each other. You see this when you bring the charged balloon close to your hair (Figure 5.5). Your hair gets attracted to the balloon and sticks out toward it.

Your charged hair might stick out in other directions too. The charges on your hair are trying to get as far from each other as possible. There might even be enough charges on the balloon and your



FIGURE 5.5: When you bring a charged balloon near your head, it causes your hair to stick out.

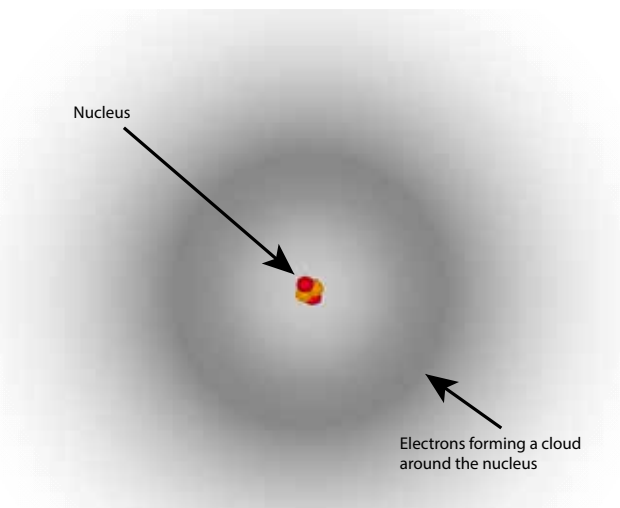


FIGURE 5.4: A helium atom with its nucleus and electrons. The electrons form a cloud around the nucleus.

hair to make the balloon stick to your hair without you holding it (Figure 5.6).

When two things have the same charge, they push each other apart. We say that they *repel* each other. With the Fun Fly Stick (Figure 5.7, p. 46), both the flyers and the stick have positive charges.



FIGURE 5.6: With enough charge, the balloon will stick to your head without you holding it.



FIGURE 5.7: Fun Fly Stick

They got the same charge when they touched each other. Since they have the same kind of charge, they repel each other, and the flyer gets pushed away from the stick. This is why the flyer stays in the air above the stick.

The flyer gets the same positive charge all over it, making it spread out as the different parts try to get as far away as they can from each other.

LIGHTNING GLOBE

The Plasma Globe (Figure 5.8) is a very interesting gadget. It works because of a big difference in charge between two parts of the globe. A big difference in charge is called a *voltage*. (Where there are dangerous amounts of electricity, you might see a sign that says, "Danger. High voltage.")



In the middle of the globe there are many charges that repel each other. They try to move farther from the center to get away from the each other. Putting a finger on the globe creates an easier path for the charges to follow as they move farther away. This is why you see a bigger spark.



FIGURE 5.8: Plasma Globe



FIGURE 5.9: Energy Ball

HAVING A BALL

With the Energy Ball (Figure 5.9), you can explore closed and open circuits. In the experiment, you made a circle with your friends. That made the energy ball work because the circle of people made a way for the electrons to get from one part of the Energy Ball to the other. When someone broke the circle by letting go of hands, the electrons could not move to the other part of the Energy Ball. That's why the ball turned off. It works the same way with all electrical circuits. If the circuit is all connected, the electric charges can move. Then we say that the circuit is *closed*. If there is a break in the circuit, it is called an *open circuit* (Figure 5.10).

The Energy Ball is actually more complicated than that. The electrons that traveled through your friends are not the same ones that lit up the ball. When the Energy Ball detects that electrons

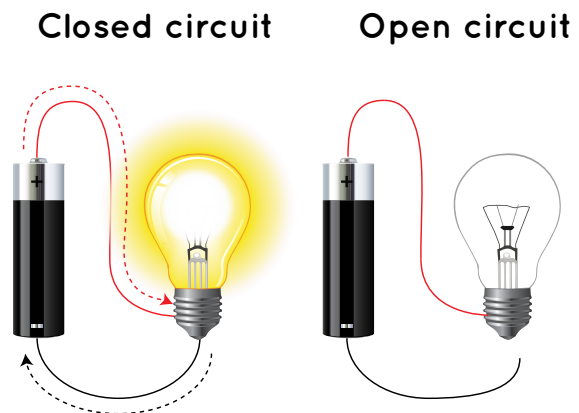


FIGURE 5.10: Closed and open circuits.

are moving from one part of the ball to the other part, it turns on a second circuit to make the light and sound.

Web Resources

Circuits for beginners.

www.bbc.co.uk/schools/scienceclips/ages/6_7/electricity.shtml

A simulation in which students explore why balloons stick to clothes. Images show charges in a sweater, balloons, and the wall.

<http://phet.colorado.edu/en/simulation/balloons>

Explore electric charges around the house with a simulation starring John Travoltage.

<http://phet.colorado.edu/en/simulation/travoltage>

Compare an electric current to the flow of water.

www.cabrillo.edu/~jmccullough/Applets/Flash/Electricity%20and%20Magnetism/Water-Analogy.swf

See how a light switch opens and closes a circuit.

www.cabrillo.edu/~jmccullough/Applets/Flash/Electricity%20and%20Magnetism/Light-Switch.swf

Try to make a circuit to light up a lightbulb.

<http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc-virtual-lab>

See how the Energy Ball works.

<https://sites.google.com/site/sed695b3/projects/discrepant-events/closed-circuit>

Relevant Standards

Note: The Next Generation Science Standards can be viewed online at www.nextgenscience.org/next-generation-science-standards.

PERFORMANCE EXPECTATIONS

3-PS2-3

Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. [Clarification Statement: Examples of an electric force could include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper....]

4-PS3-2

Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

DISCIPLINARY CORE IDEAS

PS3.A: Definitions of Energy

- Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. (MS-PS3-1)
- A system of objects may also contain stored (potential) energy, depending on their relative positions. (MS-PS3-2)
- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3), (MS-PS3-4)

PS3.B: Conservation of Energy and Energy Transfer

- When the motion energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5)
- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-4)
- Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3)

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GRADES 3-5

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