

# Horizons School Matinee Series

## 2011-2012 Educator's Resource Guide

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Horizons Educator's Resource  
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## The Science of Magic

February 13, 2012 - 10 a.m. and 12:30 p.m.

### ABOUT YOUNG AUDITORIUM AT UW-WHITewater

The Young Auditorium is located on the University of Wisconsin-Whitewater campus and serves both the campus and public communities. The auditorium presents the highest quality arts and entertainment programming in a wide variety of disciplines for diverse audiences. There is something for everyone each season at Young Auditorium including touring Broadway shows; classical, jazz, rock, pop and folk music; family entertainment; school matinee performances; world-class ballet and opera;

comedy; and lectures.

The ground breaking for the auditorium in June 1991 was made possible through the Irvin L. Young Foundation. The Foundation, along with the auditorium, honors an individual whose name has long been associated with philanthropy and humanitarianism throughout the state of Wisconsin and around the world. From humble beginnings, without the advantages of a high school or college education, Mr. Irvin Young used his time, talents and strong entrepreneurial spirit to establish a variety of successful businesses. Inspired by a business trip to Africa and the commitments he formed

there, Mr. Young established the Irvin L. Young Foundation in 1949. Mrs. Fern Young continued her husband's benevolence until her death in January 2002. Thousands of people, both at home and abroad, have been positively affected by their kindness. It is our goal that, by bearing Mr. Young's name, we continue in his path of serving Wisconsin residents for years to come.



## Horizons School Matinee Series

The mission of the Horizons program is to support the curriculum of schools by providing culturally diverse programs and outreach opportunities for K-12 students. This will be accomplished through  
1) providing performances

and hands-on, interactive outreach opportunities that cultivate and appreciation for the performing arts among young people that will last throughout their lives and  
2) supporting teachers through professional development opportunities in

the arts. It is our vision that someday every K-12 student in the auditorium's service region will attend a Horizon's performance and/or participate in an outreach event each year.

## Horizons School Matinee Series

Dear Teachers,

Thank you for choosing to attend a Horizons School Matinee Series performance at Young Auditorium. We strive to provide programs that enhance your curriculum and allow you to explore arts integration in the classroom with your students. To help meet that goal, we offer a resource guide for each performance. This resource guide has been designed to help you prepare your students with before activities that help them engage in the performance and after activities that encourage them to evaluate the performance and make relevant personal and academic connections. Within the guide you will find a variety of activities that can be used to enhance the core subject areas as well as the creative arts. Wisconsin Model Academic Standards are listed for each lesson to help you link them to your existing curriculum. The materials in this guide reflect the grade range recommended by the performing arts group. As teachers, you know best what the needs and abilities of your students are; therefore, please select and/or adapt any of the material to best meet the needs of your particular group of students.

It is also part of our mission to provide teachers with support in the efforts to integrate arts in their curriculum and bring teaching artists into the classroom to work directly with students. Please visit our website [www.uww.edu/youngauditorium](http://www.uww.edu/youngauditorium) for more information about Reaching New Horizons: Arts Integration in the Classroom,, our new professional development series for teachers, and the Horizons Outreach Program.

As you prepare for your visit to the Young Auditorium, please do not hesitate to contact our staff. We are happy to assist you in making your trip a positive and memorable experience for your students.

Thank you for your support!  
Young Auditorium





## **RESOURCE GUIDE**

This resource guide is designed to be used in conjunction with the live performance of Bill Blagg's *Science of Magic* show. Utilizing the resources in this guide will help you explore the wonders of magic with students. You will be able to further your students' understanding of the art of magic and the scientific principles/processes displayed in Bill Blagg's *Science of Magic* show. The goal of this guide is to further promote students to think "outside the box" and spawn their curiosity about how science is used to create the impossible!

## **The Man Behind the Magic**

To say that Bill Blagg has had a magical life would be no exaggeration. From the moment he received his first magic kit in 1985, his world was never the same. Bill professionally launched his magic performing career in 1996, at the ripe age of sixteen. Bill became a stand-out in the magic community, due in part to his off-the-cuff personality and his high-energy performance style.

After graduating college with honors, Bill hit the road to perform magic full-time. Today, Bill has one of the largest touring illusion shows in the country. His show has been featured on NBC, CBS and FOX television.

Having a love for both magic and science, Bill combined the two to create his one-of-a-kind, educational show called *The Science of Magic*. The show takes students on a rare, exciting, never-before-seen journey behind the scenes of the magic world. Students discover firsthand how magicians utilize science to create the impossible.

Bill lives in Milwaukee, WI, with his wife Kristin. When he's not performing he can be found at his workshop, working with his dad to create new illusions to thrill his audiences with.

## **Magic & Science**

Both magic tricks and science experiments can leave people scratching their heads in amazement. Sometimes it seems there's not much difference between magic and science. What are magic tricks anyway? Magic tricks are really just illusions. The magician knows the secret of how to do the trick. However, to the audience the trick looks like magic because they don't understand how the trick was done.

Many magic tricks are really just simple science experiments. The magician adds a few magic words and makes you believe that something supernatural and mysterious is happening. Magicians are master showmen and work very hard to fool audiences by using misdirection and manipulating their senses. In the end, there's a scientific explanation for how the trick works that has nothing to do with magic or magic words.

## **Examining Magic**

The fascination with tricks and illusions is universal and timeless. Before you can examine magic in detail, it is helpful to let children discover the broadness of the topic. As you are introducing magic to the group, brainstorm all the different types of activities that might fall under the category of magic.

Making things disappear, appear and change form is described as magic. Seeming to defy the “natural” order of the world (i.e. defying gravity, walking through walls) is called magical. Moreover, amazing feats that stun or surprise us are deemed “magical.” You may soon find your list of magic acts getting quite lengthy!

Next it is helpful to look at some synonyms for magic. Illusions, tricks, stunts, and deceptions are all used to describe magic acts. Discuss with the children why something might be called a stunt, whereas something else is an illusion. Decide how broadly you would like to define the category of magic. Work with the children to create a working definition for the topic of magic.

## **Pre-Show Discussion Topics**

Use the following questions to start classroom discussions prior to attending *The Science of Magic*:

- What is MAGIC?
- Name some famous magicians.
- What is your favorite magic trick?
- Does anyone know how to do a magic trick?
- If you could learn how to do one magic trick, what magic trick would you like to learn? Why?
- Do magicians have magical powers or do they use science to fool us?
- Where do magicians learn how to do magic?

## Post-Show Discussion Topics

Use the following questions for classroom discussion after attending *The Science of Magic*:

- **How do magicians create magic tricks?**

*They use the steps of the scientific method. They develop a theory (hypothesis) then they test it. If it fails they change one variable and test it again. They repeat this process over and over until they get their theory to work.*

- **Do magic tricks always work?**

*No. Just like scientists, magicians must keep experimenting to find ways to make illusions work. Some ideas NEVER work and others take YEARS to create!*

- **How do magicians use mirrors to make magic?**

*They use mirrors to reflect light to make a person think they are seeing something (a mirror image) that is not really there.*

- **What type of mirror did Bill use to make things disappear in the magic box?**

*Plane mirror*

- **Can a solid pass through a solid?**

*No. When molecules are tightly packed together they form a solid. In a solid the molecules can't move or separate in order to allow another solid to pass through.*

- **Since a solid can't scientifically pass through another solid, how did Bill pass through the plate of metal?**

*Bill used misdirection and controlled the perspective on the sheet of metal to create the illusion of him passing through it.*

- **What can you do with an object when you find its center of gravity?**

*Make it balance*

- **After everything Bill taught us during the show do you think (teacher's name) was really floating in mid-air at the end of the show?**

*Mention the passing of the metal hoop as proof of no supports, etc. Use this question to spawn creative methods of how the teacher was floating.*

**Activity:** *Create experiments to test the student's hypotheses on how they think the teacher floated. Were their hypotheses correct? Why or why not?*

## Terms

**Illusion:** something that produces a false impression of reality

**Misdirection:** focusing attention on one thing in order to distract attention from another

**Perspective:** the way objects appear to the eye

**Levitate:** to float in air

**Center of Gravity:** the point where the effect of gravity on an object is equal

**Magnetism:** the invisible force that causes items to attract or repel each other

**Attract:** to come together

**Repel:** to push apart

**Mirror:** an object with at least one reflective surface

**Mirror Image:** the image seen when looking into a mirror

**Plane Mirror:** a mirror with a flat surface. Most common type of mirror

**Reflection:** the bouncing of light from a surface

**Refraction:** the change in direction of light as it moves from one transparent substance to another

**Matter:** anything that has mass and takes up space

**Atom:** a tiny particle that all matter is made of

**Molecule:** forms when atoms bond or link together.

**Density:** a term used to compare two substances that occupy the same amount of space but have different amounts of matter

**Solution:** mixing two or more substances together (salt water)

**Scientific Method:** the process used to prove or disprove a hypothesis using experimentation.

**Hypothesis:** an educated guess about the results of an experiment you are going to perform

**Experiment:** a procedure used to test a hypothesis or to make a discovery

## Magic Lesson 1: The Floating Egg

*Sometimes a magician seems to make things float in air. In this project you won't make things float in air, but you will make an egg float in water.*

### **Materials**

Quart (liter) jar, tap water, scissors, ruler, masking tape, ½ cup salt, felt-tip pen, uncooked egg, large spoon

### **The Setup**

1. Fill the jar half full of water
2. Cut a 3" piece of tape and stick it to the outside of the salt container. Use the pen to write on the tape, "Magic Swimming Powder."
3. Place the egg and spoon on the table

### **Magic Science Time!**

1. Tell your audience, "I am going to teach an egg how to swim."
2. Begin by showing the audience that the egg doesn't know how to swim by placing the egg in the jar filled with tap water. The egg will sink to the bottom. Remove the egg from the jar with the spoon.
3. Tell the audience that for the egg to swim you need to add magic swimming powder to the water. Pour the salt in the water and stir with the spoon. Say some magic words!
4. Place the egg in the water. The egg will float!

### **Discussion**

- How did the magic powder help the egg float?
- What was created by mixing the powder in the water?
- Why didn't the egg float without the powder?

### **Explanation**

All matter floats or sinks depending on its density. Less dense substances float on more dense substances. The egg floats in salt water because the egg is less dense than the salt water. However, the egg is denser than tap water, so it sinks.

Salt water is a **solution** that contains both salt and water. A solution occurs when a solid is dissolved in a liquid.

## Magic Lesson 2: The Broken Pencil

*In this trick you'll use water and light to perform an interesting illusion.*

### **Materials**

A glass, tap water, pencil

### **The Setup**

1. Fill the glass about two-thirds full of tap water.
2. Place the glass of water and pencil on the table.

### **Magic Science Time!**

1. Hold the pencil in front of you. Tell the audience, "I am going to break the pencil by simply sticking it in this glass of water."
2. Hold the pencil upright in the water so that the tip is about halfway between the surface of the water and the bottom of the glass. Make sure the pencil is near the back of the glass, away from the audience.
3. Move the pencil back and forth in the water, keeping it upright. Ask them what they see. It will appear as though the pencil is broken when in the water.
4. Remove the pencil from the water

### **Discussion**

- Did the pencil really break when it was placed in the water?
- If not, then why did it look like the pencil was split in half?

### **Explanation**

This trick works because of **refraction**. Light travels in straight lines, but when it travels from one transparent substance to another the light rays bend. This is refraction. When light travels from a more dense transparent substance, such as water, to a less dense substance, such as air, the light refracts, or bends noticeably. Light travels at different speeds in substances with different densities.

Light reflected from the pencil appears to the audience to be in one place when it travels to their eyes through the air, and in another place when it is refracted through water.

## Magic Lesson 3: Disappearing Penny

*Here's another effect that uses light and water to produce a mind-boggling effect.*

### **Materials**

Quart (liter) jar with lid, tap water, penny, helper

### **The Setup**

1. Fill the jar with tap water. Put the lid on the jar.
2. Place the jar and penny on the table in front of you.

### **Magic Science Time!**

1. Get a helper from the audience to assist you.
2. Have your helper examine the penny and confirm that it's a real penny.
3. Have the helper place the penny on the table. Ask "Can you see it?"
4. Place the jar filled with water on top of the penny.
5. Say a few magic words and wave your hands over top of the jar.
6. Have the helper look through the water from the side of the jar and see if the penny is there or gone. What is the answer?

### **Discussion**

- Where did the penny go?
- Why can't the helper see the penny through the clear water?

### **Explanation**

When light travels from air to water, light bends toward the normal, a line perpendicular to the surface. Traveling from water to air, light bends in the opposite direction, away from the normal.

This trick works because at a certain angle, when light travels from a more dense substance (water), to a less dense substance (air), it no longer refracts but will reflect. **Reflection** is the bouncing back of light from a surface. When the image of the penny comes toward the side surface of the jar at too great an angle, reflection rather than refraction occurs, and the image cannot be seen outside of the jar.

## **Magic Lesson 4: Keeping Dry**

*Air can be used in many magic tricks. Try this trick to learn one way air can amaze!*

### **Materials**

Paper towel, drinking glass, plastic tub or bucket filled with enough tap water to reach the height of the glass

### **The Setup**

1. Place the materials on the table

### **Magic Science Time!**

1. Crumple the paper towel and place it in the bottom of the glass.
2. Turn the glass over and make sure that the paper will stay in place at the bottom of the glass.
3. Slowly lower the upside-down glass into the tub of water. Keep the glass as straight up and down as possible, until the entire glass is under the water.  
*\*Good time for discussion topic #1*
4. Take the glass out of the water and let the water drip off the glass.
5. Turn the glass right side up and remove the paper towel. Let the audience feel the paper towel to determine if it is wet or dry.

### **Discussion**

1. Will the paper towel in the cup get wet? Why or why not?
2. Why didn't the paper towel get wet when it was placed in the water?

### **Explanation**

Air takes up space. The glass is filled with air when it's right side up and when it is upside down. When you turn the glass over and slowly lower it into the water, air remains in the glass.

The water cannot enter the glass because of the air inside the glass. The air creates pressure that is greater than the pressure of the water trying to get in. The towel in the top of the glass stays dry. If you were to tilt the glass on its side in the water, air would exit the glass and form bubbles. Water would then be able to enter the glass and soak the paper towel.

## **Additional Classroom Activities**

Here are some additional ideas to use in the classroom to further explore magic and science!

### **Activity 1: Make Magic!**

- Have students create their own magic tricks. Promote students to develop their own unique magic trick. Guide them through the steps of the Scientific Method to help them in their quest to create their very own illusion.
- If time is of the essence perform this activity as an all class magic trick. Ask students to share ideas of a magic trick they'd like to create. Select one idea and as a class follow the steps of the Scientific Method to make the trick a reality!
- Remember sometimes no matter how many times you try the trick won't work. Be sure to document your experiments and the single variables you change each time. Use those notes to spawn classroom discussion on why the magic didn't work. What else could be tried to make it work? Have students suggest other methods to try. Did they work?

### **Activity 2: Magic Show!**

- Have students select a magic trick from a magic book in the library.  
*\*If you're school library doesn't have any magic books find some magic tricks online to hand out to the students. See credits/resources at the end of this guide.*
- Discuss with students the importance of showmanship when performing magic. Encourage them to use magic words, hand gestures, etc. when performing.
- Instruct the students to practice the trick at home.
- Plan a day to have the students perform their very own magic show.
- Following each trick explain the science that allows the magic to happen.

## **Credits / Resources**

Many of the tricks in this guide were adapted from the references below.

### **Books**

Wiess, Jim (1998). *Magic Science: 50 jaw dropping, mind-boggling, head-scratching, activities for kids*. San Francisco: Jossey-Bass

Shalit, Nathan (1981). *Science Magic Tricks*. New York: Holt, Rinehart and Winston

### **Web Links**

**Card Trick Central** – <http://web.superb.net/cardtrick>

*This website has hundreds of card tricks. They are sorted by ability level and make it easy to find an appropriate one to try.*

**Magical Youth International** – <http://magicyouth.com>

*Magical Youth International is the youth program of the International Brotherhood of Magicians (IBM).*

**Bill Blagg** – <http://www.billblagg.com>

*Official website for Bill Blagg that includes tour dates, biography, videos, pictures and an e-mail group sign up form.*

### **Special Thanks**

Overture Center for the Performing Arts (Madison, WI) – Educational Series (2010).

*\*Excerpts from the self-produced Overture Center Guide have been referenced in this resource guide.*

Simon Shaw – Shaw Entertainment Group. Great Barrington, MA

# Activity: Before the Play

## Perfect Perception

**Grade Range:** 5-8

**WI State Standards:**

*Art and Design Education:* H.8.2 Know how light, shadow, color, distance, and angle of viewing affect sight.

*Science Inquiry:* C.8.6 State what they have learned from investigations\*, relating their inferences\* to scientific knowledge and to data they have collected.

**Curriculum Connections:** Art and Science

**Sources:** [http://alex.state.al.us/lesson\\_view.php?id=12768](http://alex.state.al.us/lesson_view.php?id=12768)

**Objectives:**

- Students will demonstrate an application of optical illusion by reproducing the bird in a cage illusion.
- Students will discover that perception can be fooled.
- Students will extend perception by creating an illusion of his/her own.

**Rationale:** Bill Blagg shows how magic is the use of science to trick the audience. Bill takes the audience through this science and shows them how the science actually works. Bill uses a lot of optical illusions. In this lesson the students will be able to investigate and create their own optical illusions

**Materials:**

- index cards: 1 per student
- plastic mirrors: 1 per student
- crayons or colored pencils
- scissors
- tape or glue
- string (yarn) about a foot for each student
- flip-book (necessary materials would be a small stack of paper or notepad)
- spoon
- glass: 1 per student

**Procedure:**

1. Invite students to talk about a time when they thought they saw one thing and it turned out to be something quite different. Explain that perception and conception may be two different things. What we perceive we see, may not always be what we see. (Use Knowledge In Perception Packet to educate students on illusions.
2. Give each student a mirror. Then ask what they see? Many will answer they see themselves. Ask if they are in the mirror? Many will still answer yes. Explain that they are sitting in the classroom and not in the mirror. Lead the students to discover that while they may perceive themselves to be in the mirror; they are in fact in the classroom. (a small example of an illusion)
3. Next demonstrate the bent spoon in water illusion by placing a spoon in a clear plastic glass of water. Divide students into groups. Have them place pencils in their glasses of water. Students should observe that the spoon and their pencils bend. Explain to them that this is another illusion and it is actually not happening, but the light is refracting.
4. Now that the students have seen and talked about some illusions, they will make illusions of their own. Have students draw a cage in the middle of an index card. On the flip side of the card, have students draw a bird. Attach the card to a pencil or attach string (yarn) to each side of the card. When the card is rotated or flipped the bird should appear in the cage. Let students discover the right way to draw the bird and the cage in order that one is not upside down.

**Attachments:** *Knowledge in Perception and Illusion Handout*

## Knowledge in perception and illusion

Richard L Gregory

From: *Phil. Trans. R. Soc. Lond. B* (1997) 352, 1121–1128  
Department of Psychology, University of Bristol, 8 Woodland Road, Bristol BS8 1TA UK

### Summary

Following Hermann von Helmholtz, who described visual perceptions as unconscious inferences from sensory data and knowledge derived from the past, perceptions are regarded as similar to predictive hypotheses of science, but are psychologically projected into external space and accepted as our most immediate reality. There are increasing discrepancies between perceptions and conceptions with science's advances, which makes it hard to define 'illusion'. Visual illusions can provide evidence of object knowledge and working rules for vision, but only when the phenomena are explained and classified. A tentative classification is presented, in terms of appearances and kinds of causes. The large contribution of knowledge from the past for vision raises the issue: how do we recognize the present, without confusion from the past. This danger is generally avoided as the present is signaled by real-time sensory inputs—perhaps flagged by qualia of consciousness.

### 1. Intelligence and Knowledge

Philosophy and science have traditionally separated intelligence from perception, vision being seen as a passive window on the world and intelligence as active problem-solving. It is a quite recent idea that perception, especially vision, requires intelligent problem-solving based on knowledge.

There is something of a paradox confounding intelligence and knowledge, for one thinks of knowledgeable people as being specially intelligent and yet more knowledge can reduce the intelligence needed for solving problems. The paradox is resolved, when we consider two senses of 'intelligence': active processing of information (as supposedly measured in IQ tests) and available answers (as in 'military intelligence'). These senses of 'intelligence' have been named by rough analogy with creating and the storing of energy as, *potential intelligence* and *kinetic intelligence* (Gregory 1987). The notion is that stored-from-the-past potential intelligence of knowledge, is selected and applied to solve current perceptual problems by active processing of kinetic intelligence. The more available knowledge, the less processing is required; however, kinetic intelligence is needed for building useful knowledge, by learning through discovery and testing. (The analogy is imperfect because knowledge is not conserved. Nevertheless, these terms may be useful though, apart from secret knowledge, 'potential intelligence' is not diminished by use.) When almost complete answers are available, knowledge takes the dominating role. Then 'top-down' becomes more important than 'bottom-up', which may be so for human vision. (Remarkably, there are more downwards fibres from the cortex to the lateral geniculate bodies LGN) 'relay stations' than bottom-up from the eyes (Sillito 1995).)

Errors of perception (phenomena of illusions) can be due to knowledge being inappropriate or being misapplied. So illusions are important for investigating cognitive processes of vision. Acceptance that knowledge makes a major contribution to human vision is recent, remaining controversial. This applies even more

to the machine vision of artificial intelligence. Perhaps progress in artificial intelligence has been delayed through failure to recognize that artificial potential intelligence of knowledge is needed for computer vision to be comparable to brains.

It was the German polymath, Hermann von Helmholtz (1821–1894) who introduced the notion that visual perceptions are unconscious inferences (von Helmholtz 1866). For von Helmholtz, human perception is but indirectly related to objects, being inferred from fragmentary and often hardly relevant data signaled by the eyes, so requiring inferences from knowledge of the world to make sense of the sensory signals. There are, however, theorists who try to maintain 'direct' accounts of visual perception as requiring little or no knowledge, notably followers of the American psychologist J. J. Gibson (1904–1979) whose books *The Perception of the Visual World* (1950) and *The Senses Considered as Perceptual Systems* (1966) remain influential. In place of knowledge and inference, Gibson sees vision as given directly by available information 'picked-up from the ambient array' of light, with what he calls 'affordances' giving object-significance to patterns of stimulation without recourse to stored knowledge or processing intelligence. The 'affordance' notion might be seen as an extension of the ethologist's concept of innate 'releasers', which trigger innate behavior such as robins responding aggressively to a red patch. This fits Gibson's 'ecological optics'; but how new objects, such as telephones, are recognized without acquired knowledge is far from clear. To maintain that perception is direct, without need of inference or knowledge, Gibson generally denied the phenomena of illusion.

Following von Helmholtz's lead we may say that knowledge is necessary for vision because retinal images are inherently ambiguous (for example for size, shape and distance of objects). and because many properties that are vital for behavior cannot be signaled by the eyes, such as hardness and weight, hot or cold, edible or poisonous. For von Helmholtz, ambiguities are usually resolved, and non-visual object properties inferred, from knowledge by unconscious inductive inference from what is signaled and from knowledge of the object world. It is a small step (Gregory 1968 a, b, 1980) to say that perceptions are hypotheses, predicting unsensed characteristics of objects, and predicting in time, to compensate neural signaling delay (discovered by von Helmholtz in 1850), so 'reaction time' is generally avoided, as the present is predicted from delayed signals. This has recently been investigated with elegant experiments by Nijhawan (1997). Further time prediction frees higher animals from the tyranny of control by reflexes, to allow intelligent behavior into anticipated futures.

It is a key point that vision is not only indirectly related to objects, but also to stimuli. As Helmholtz appreciated (Boring 1950, p. 304), this follows from the law of specific energies, proposed by his teacher, Johannes Muller. It is perhaps better named the law of specific qualities: any afferent nerve signals the same quality or sensation whatever stimulates it. Thus we see colors not only from light but also when the eyes are mechanically pressed, or stimulated electrically. We may regard eyes and the other sense organs as designed by natural selection to allow the universal neural code of action potentials to signal a great variety of object properties, routed to specialized brain regions to create qualities of colour and touch, sounds and so on (colours being generated by a specialized brain module in area V4 of the striate cortex (Zeki 1993). It was clear to Newton in Opticks

different from the flat ghostly images in eyes. Some phenomena of illusion provide evidence for the uses of knowledge for vision; this is revealed when it is not appropriate to the situation and so causes a systematic error, even though the physiology is working normally. A striking example is illustrated in the following section.



Figure 1. Photographs of a rotated hollow mask: (a) and (b) (black hat) show the front and side truly convex view; (d) (white hat) shows the inside of the mask; it appears convex although it is truly hollow; (c) is curiously confusing as part of the hollow inside is seen as convex, combined with the truly convex face. This is even more striking with the actual rotating mask. Viewing the hollow mask with both eyes it appears convex, until viewed from as close as a metre or so. Top-down knowledge of faces is pitted against bottom-up signalled information. The face reverses each time a critical viewing distance is passed, as 'downwards' knowledge or 'upwards' signals win. (This allows comparison of signals against knowledge by nulling.)

## 2. The Hollow Face

The strong visual bias of favouring seeing a hollow mask as a normal convex face (figure 1), is evidence for the power of topdown knowledge for vision (Gregory 1970). (Barlow (1997) takes a more 'reductionist' view preferring to think of this in terms of redundancies of bottom-up signals from the eyes. I would limit this to very general features, such as properties of edge-signalling giving contrast effects, rather than phenomena attached to particular objects or particular classes of objects, such as faces.)

This bias of seeing faces as convex is so strong it counters competing monocular depth cues, such as shading and shadows, and also very considerable unambiguous information from the two eyes signalling stereoscopically that the object is hollow. (There is a weaker general tendency for any object to be seen as convex, probably because most objects are convex. The effect is weaker when the mask is placed upside down, strongest for a typical face. If the mask is rotated, or the observer moves, it appears to rotate in the opposite to normal direction, at twice the speed; because distances are reversed motion parallax becomes effectively reversed. This also happens with a depth-reversed wire cube.)

It is significant that this, and very many other illusions, are experienced perceptually though the observer knows conceptually that they are illusory— even to the point of appreciating the causes of the phenomena. This does not, however, show that knowledge has no part to play in vision. Rather, it shows that conceptual and perceptual knowledge are largely separate. This is not altogether surprising because perception must work extremely fast (in a fraction of a second) to be useful for survival, though conceptual

decisions may take minutes, or even years. Further, perceptions are of particulars, rather than the generalities of conceptions. (We perceive a triangle, but only conceptually can we appreciate triangularity.) Also, if knowledge or belief determined perception we would be blind to the unusual, or the seemingly impossible, which would be dangerous in unusual situations, and would limit perceptual learning.

The distinguished biologist J. Z. Young was a pioneer who stressed the importance of handling knowledge for understanding brain function, and that there may be a 'brain language' preceding spoken or written language. Thus (Young 1978, p.56): 'If the essential feature of the brain is that it contains information then the task is to learn to translate the language that it uses. But of course this is not the method that is generally used in the attempt to understand the brain. Physiologists do not go around saying that they are trying to translate brain language. They would rather think that they are trying to understand it in the "ordinary scientific terms of physics and chemistry"' Cognitive illusions reveal knowledge and assumptions for vision, and perhaps take us ('lose to 'brain language', but they must be understood and also classified. Classifying is important for the natural sciences: it should be equally important for the unnatural science' of illusions. Classifying must be important for learning and perception, for it is impossible to make inductive generalizations without at least implicit classes. It is also impossible to make deductive inferences, as deductions are not from facts or events, but from descriptions (in words or mathematics) of real or imaginary members of classes. Von Helmholtz's 'unconscious inference' for vision was inductive; 'for example inferring distances from perspective and shapes from shading. As there are frequent exceptions certainty is not attainable. Thus atypical shapes give systematic errors, when general rules or specific knowledge are inappropriate for these unusual objects or scenes, as shown most dramatically by the Ames demonstrations such as the Ames window (Ittelson 1952). (This is a slowly rotating trapezoid, the shape of a rectangle as viewed from an oblique angle. It changes bizarrely in size and form as it does not go through the usual perspective transformations of a familiar sect angle, such as a normal window.) Much the same applies to seeing familiar objects in the very different brush strokes of paintings; this is evidently seen by object knowledge and rules, such as perspective, and is normally applied to the world of objects but is activated by the patterns of paint.

## 3. What are Illusions?

It is extraordinarily hard to give a satisfactory definition of an 'illusion'. It may be the departure from reality, or from truth; but how are these to be defined? As science's accounts of reality get ever more different from appearances, to say that this separation is 'illusion' would have the absurd consequence of implying that almost all perceptions are illusory. It seems better to limit 'illusion' to systematic visual and other sensed discrepancies from simple measurements with rulers, photometers, clocks and so on. There are two clearly very different kinds of illusions: those with a physical cause and cognitive illusions due to misapplication of knowledge. Although they have extremely different kinds of causes, they can produce some surprisingly similar phenomena (such as distortions of length or curvature), so there are difficulties of classification that require experimental evidence.

Illusions due to the disturbance of light, between objects and the eyes, are different from illusions due to the disturbance of sensory signals of eye, though both might be classified as 'physical'. Extremely different from both of these are cognitive illusions, due to misapplied knowledge employed by the brain to interpret or read sensory signals. For cognitive illusions, it is useful to distinguish specific knowledge of objects, from general knowledge embodied as rules. Either can be misled in unusual conditions, and so can be revealed by observation and experiment.

An example of misleading specific knowledge is how a grainy texture is seen as wood, though it is a plastic imitation or a picture. More dramatic is how a hollow face or mask is seen as convex (figure 1), because faces are very rarely hollow (Evidently the perceptual hypothesis of a face carries the, not always appropriate, knowledge that it is convex.) Examples of misleading rules are the Gestalt laws of ‘closure’, ‘proximity’, ‘continuity’ and the ‘common fate’ of movements of parts of objects Wertheimer 1923, 1938). When these do not apply illusion can result, because not all objects are closed in form, with close-together parts and continuous edges, or with parts moving together as leaves of a tree in the wind. Exceptional objects are mis-seen when Gestalt laws are applied, and when perspective rules are applied for atypical objects, such as the Ames window and flat projections of pictures.

**4. ‘Ins-And-Outs’**

To the usual terms ‘bottom-up’ signals and ‘top-down’ knowledge, we add what might be called ‘sideways’ rules. Both top-down and sideways are knowledge; the first specific (such as faces being convex), the second being general rules applied to all objects and scenes (such as the Gestalt laws and perspective). These are ‘ins-and-outs’ of vision, which it might be useful to consider, before attempting to explain how the visual brain works, with the scheme presented in figure 2.

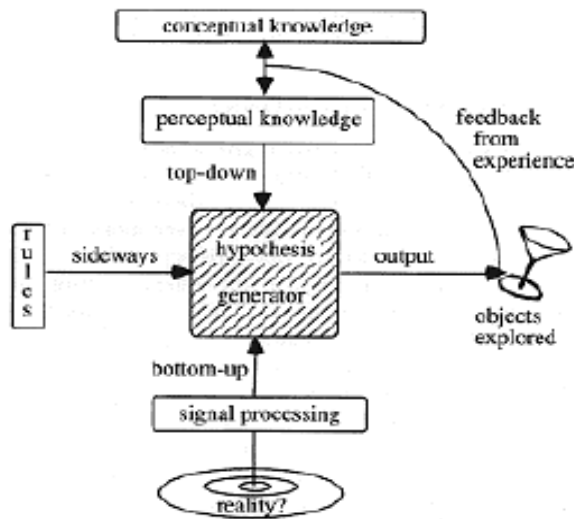


Figure 2. Tentative ‘flat box’ of vision. As usual, signals from the eyes and the other senses are ‘bottom-up’. Conceptual and perceptual object knowledge are shown in separate ‘top-down’ boxes. Knowledge as embodied in the general rules, is introduced ‘sideways’. Perceptual learning seems to work largely by feedback from behaviour.

**5. Classifying Illusions**

Appearances of illusions fall into classes which may be named quite naturally from errors of language: *ambiguities*, *distortions*, *paradoxes*, *fictions*. It may be suggestive that these apply both to vision and to language, because language possibly grew from prehuman perceptual classifications. This would explain why language developed so rapidly in biological time, if based on a take-over from pre-human classification (especially of objects and actions) for intelligent vision (Gregory 1971). Could this be Chomsky’s innate ‘deep structure’ of the grammar of languages (cf. Pinker 1994)? In any case, this is illustrated in table 1.

Table 1. *Illusions and language*

kinds	illusion appearances	sentence errors
ambiguities	Necker Cube	people like us
distortions	Müller-Lyer	he’s miles taller than her
paradoxes	Penrose triangle	she’s a dark haired blonde
fictions	faces-in-the-fire	they live in a mirror

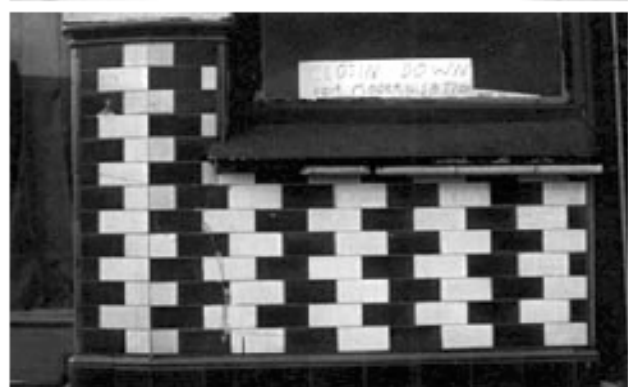
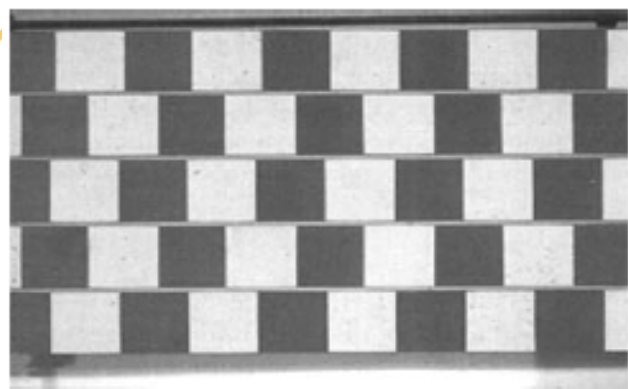
To classify causes we need to explain the phenomena. There is no established explanation for many illusions, but even a tentative classification may suggest where to look for answers amid may suggest new experiments. We need ‘litmus test’ criteria for each example, but so far these hardly exist. There are, however, various experimental tests (especially using phenomena of ambiguity to separate the bottom-tip signal from top-down or sideways cognitive errors), and selective losses of the visual agnosias may help to reveal perceptual classes (Humphreys & Riddock 1987 a, b; Sacks 1985).

We suggest four principal kinds of causes: the first two lying broadly within physics; the last associated with knowledge, and so perhaps with ‘brain language’. The first is optical disturbance intervening between the object and the retina. The second is disturbed neural sensory signals. The third and fourth are extremely different from these, as they are cognitive and so knowledge-based, for making sense of neural signals. (Thus writing is meaningless without semantic knowledge called up by words, organized by syntactic structures of grammar.) Adding the kinds of appearances (named ‘from errors of language as in table 1), we arrive at something like table 2 for classifying visual illusions. One illustrative example is given for each class, under the major division between (physical) optical and neural signal disturbances and (cognitive) general rules and specific knowledge. When any are inappropriate, characteristic phenomena of illusion may occur.

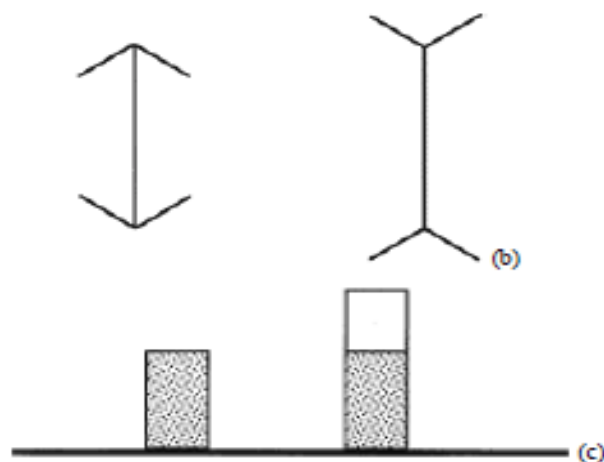
Table 2. *Illusions classified by appearances and causes*

	physics		knowledge	
kinds	optics	signals	rules	objects
ambiguity	1 mist	5 retinal rivalry	9 figure-ground	13 hollow face
distortion	2 mirage	6 Café wall	10 Müller-Lyer	14 size-weight
paradox	3 looking-glass	7 rotating spiral	11 Penrose triangle	15 Magritte mirror
fiction	4 rainbow	8 after-images	12 Kanizsa triangle	16 faces in the fire

No doubt some attributions will be controversial; they are not intended to be set in stone. The task is to develop ‘litmus test’ experimental criteria for assigning the phenomena to their proper classes of appearances and causes. It is entirely possible that different classes will be needed as understanding advances. We reach complicated issues, but some of them are summarized below  
 (i) *Mist*. Any loss of information may increase uncertainty and produce ambiguities.  
 (ii) *Mirage*. Refraction of light between the object and the eyes displaces objects or parts of objects, as for mirages, or a spoon bent in water. (Conceptual understanding does not correct these distortions, though motor performance may adapt, as for diving birds catching fish.)



(a)



(c)

Figure 3. Three distortions. (a) Café wall. This symmetrical pattern produces asymmetrical long wedges. (It seems to violate Curie's principle that states that systematic asymmetry cannot be generated from symmetry. Two processes are involved: local asymmetries of contrast between half-tiles integrate along the rows, to form the asymmetry of the long wedges.) Unlike cognitive distortions this evidently retinal effect depends lawfully on the brightness contrasts. It is a 'neural signal' distortion. (b) Müller-Lyer. The shaft of the outgoing arrow-heads appears longer than for the ingoing heads. These figures give the same retinal images as outside and inside corners (e.g. of a house and a room). They are perspective drawings of corners, but may not appear in depth. The notion is that these perspective depth-cues trigger size sealing inappropriately to the picture-plane. They do appear in depth when the back-ground texture is removed. Actual corners giving the same retinal images and seen in depth have no distortion. The distortion is due to perspective depth triggering constancy sealing. (c) Size-weight. The smaller object feels heavier, though both are the same weight. From knowledge that larger objects are generally heavier, the muscles are set in this expectation, but here it is surprisingly incorrect as the objects have the same weight.

(iii) *Looking-glass*. One sees oneself double: through the glass, as a kind of ghost; yet one knows one is in front of it. So perception and conception separate. (This may be the origin of notions of mind separate from body, i.e. dualism (Gregory 1997).)

(iv) *Rainbow*. An illusion when it is seen as an object, with expectations as for a normal object. (Thus unlike an arch of stone, when approached, it moves away and can never be touched. With this in mind it is not illusory.)

(v) *Retinal rivalry*. Small horizontal separations of corresponding points of the eyes' images are 'fused', and signal depth stereoscopically. At angles greater than about  $1^\circ$  (Panum's limit) fusion breaks down, and perception shifts and changes in bizarre ways.

(vi) *Café Wall*. The rows of 'tiles' (figure 3a) with alternate rows displaced by half a cycle, appear as long alternating wedges. This lacks perspective, or other depth cues. Unlike the distortions of point 10 below, it depends critically on luminances, disappearing when the neutral 'mortar' lines are brighter than the light, or dimmer than the dark tiles. It appears to violate Curie's principle that systematic asymmetry cannot be generated from symmetry; but there are two processes: small wedges are produced by local asymmetry where there is luminance contrast of light-dark half tiles and these small wedges integrate along the rows, to form long wedges (Gregory & Heard 1979).

(vii) *Rotating spiral* (after-effect of movement). The spiral expands yet, paradoxically, does not change size. The adapted motion channel gives conflicting evidence with unadapted position signals.

(viii) *After-images*. These are almost entirely due to local losses of retinal visual pigments, from intense or prolonged stimulation.

(ix) *Figure-ground*. The primary decision: which shapes are objects and which are spaces between objects. This seems to be given by general rules of closure and so on. (These rules cannot always make up the brain's mind.)

(x) *Müller-Lyer* (Ponzo, Poggendorff, Orbison, Hering and many other illusions) seem to be due to perspective, or other depth cues, setting constancy sealing inappropriately, e.g. when depth is represented on the plane of a picture. Scaling can be set bottom-up from depth cues, though depth is not seen, e.g. when countermanded by the surface texture of a picture (Gregory 1963). The distortions disappear when these figures are presented and seen in true depth: corners for the Müller-Lyer and parallel receding lines for the Ponzo, etc. (Gregory & Harris 1975).

(xi) *Penrose impossible triangle*. When a simple closed figure or object, seen from a critical position, has features lying at different distances but that touch in a picture, or retinal image, the visual system accepts a rule that they are the same distance. This false assumption generates a rule-based paradoxical perception.

(xii) *Kaniza triangle* and many other illusory contours and surfaces. Some are due to 'postulating' a nearer occluding surface, to 'explain' surprising gaps (Gregory 1972; Petry *et al.* 1987).

(xiii) *Hollow face*. This illustrates the power of probabilities (and so knowledge for object perception (figure 1).

(xiv) *Size-weight illusion*. Small objects feel heavier than larger objects of the same scale weight; muscles are set by knowledge-based expectation that the larger will be heavier, which is generally, though not always true.

(xv) *Magritte mirror*. René Magritte's painting *La reproduction interdite* (1937) shows a man facing a mirror, but the back of his head appears in the glass. This looks impossible from our knowledge of mirrors (Gregory 1997).

(xvi) *Faces-in-the-fire*, ink blots, galleons in the clouds and so on, show the dynamics of perception. Hypotheses are generated that go fancifully beyond the evidence. The Café wall distortion, due to disturbed neural signals, is shown in figure 3a, for comparison with the knowledge rules distortion of the Muller-Lyer distortion (figure 3b) and the specific-knowledge distortion of the size-weight illusion (figure 3c). They may appear similar (all being distortions) but their causes are fundamentally different. We may develop the ‘flat box’ of ins-and-outs (figure 2) to a fuller ‘black box’ (figure 4). These diagrams do not attempt to show anatomical paths or brain regions, but rather, functional ins and-outs of vision. A ‘downwards’ loop is also shown, from the prevailing perceptual hypothesis, affecting bottom-up signal processing. This may be demonstrated by the change of apparent brightness with depth-reversal of the Mach’s corner illusion (figure 5). Though as Barlow points out (personal communication, 1997) this is not necessarily the explanation; it requires experiments.

**6. Qualia**

Most mysterious of all brain phenomena is consciousness, especially how sensations, qualia, are produced and their possible uses. In the account given here, perception depends very largely on knowledge (specific ‘top-down’ and general ‘sideways’ rules), derived from past experience of the individual and from ancestral, sometimes even prehuman experience. So perceptions are largely based on the past, but recognizing the *present* is essential for survival in the here and now. The present moment must not be confused with the past, or with imagination, i.e. as indeed one appreciates when crossing a busy road. So, although knowledge from the past is so important, it must not obtrude into the present. Primitive non-cognitive animals have no such danger of confusion, as their present is simply signaled by real-time afferent inputs.

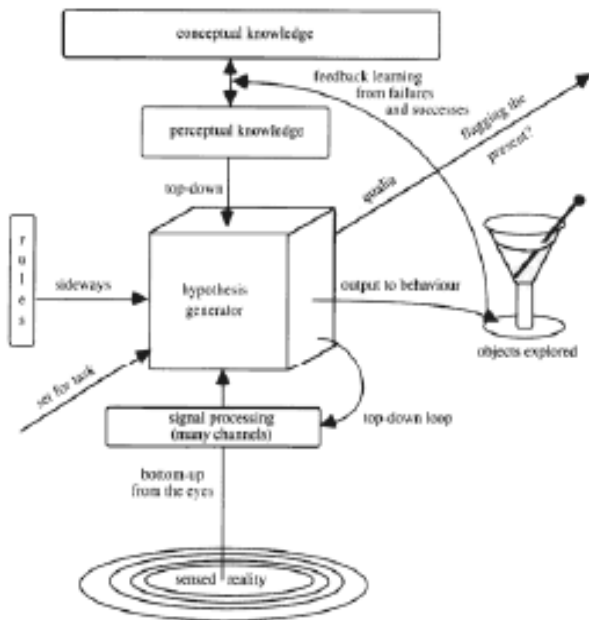


Figure 4. Ins-and-outs: black box of vision. The scheme of figure 2 with additions: set, for selecting needed knowledge; qualia, perhaps for signalling the present.

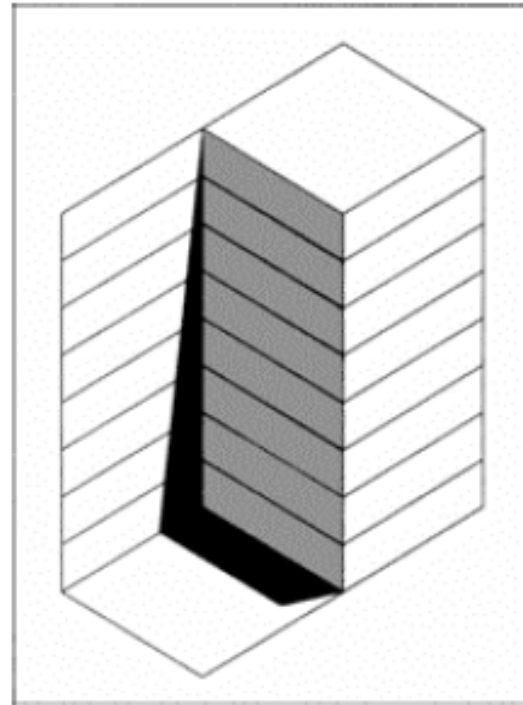


Figure 5. Mach's corner. The dark region changes apparent brightness when the corner flips in or out: it is brighter when in, and so a likely shadow, although there is no physical change (Mach 1897).

Time-confusion is likely only for ‘higher’ animals, especially humans, where knowledge derived from the past dominates present perception. As for primitive (reflex and tropismcontrolled) animals our present is also signalled by real-time afferent inputs, but as input signals have a smaller part to play than knowledge from the past, for cognitive perception, they must be very clearly distinguished. (Exceptions are qualia in dreams and in schizophrenic hallucinations. There are rare cases (Luria 1969) of individuals having such vivid memory that their present is dangerously confused with their past and with imagination. Memories of emotion such as embarrassment can evoke qualia, perhaps from real-time signals from visceral changes or blushing evoked by memory.) As a speculation: are real-time sensory signals—and so the present—flagged by the vividness of qualia?

It is interesting to compare the qualia of seeing, with memory of a scene immediately the eyes are closed. Surely the visual qualia almost if not entirely disappear when the sensory inputs cease. Reversing this simple experiment by opening the eyes following immediate memory, the onset of the visual qualia is so striking that they make the memory pale by comparison. So perhaps consciousness serves to avoid confusion with the remembered past, by flagging the present with the unique vividness of sensory qualia.

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# Activity: Before the Play

## Mystery Box (Hypothesis)

**Grade Range:** 4-8

**Science Inquiry** C.8.9 Evaluate, explain, and defend the validity of questions, hypotheses, and conclusions to their investigations.

**Curriculum Connections:** Science

**Sources:** <http://serc.carleton.edu/sp/mnstep/activities/20162.html>

**Objectives:**

- Students will gain knowledge of what a hypothesis is.
- Students will make a hypothesis after taking observations.

**Rationale:** Bill Blagg uses the scientific method within his performances to teach the audience on how magic is affected by science. He uses the scientific method process to break down a magic trick. Through this lesson students should become familiar with a large part of the scientific method which is creating a hypothesis.

**Materials:**

- Collect Kleenex boxes or small boxes (# depends on how many you want in a group)
- Look through junk drawer to find objects of various sizes to put in the boxes.

**Procedure:**

1. Have students get into groups. The number of students in each group can vary. The students will receive a Kleenex box with objects in the box. Tell students that they should not tamper with the box at all.
2. Talk with the students about what a guess is. Inform the students that most guesses do not have any information backing them up. Then introduce the term hypothesis. Explain that a hypothesis is a developed guess that comes from careful observations.
3. Have students make observations of what is in the box, by using any method other than opening up the box. Have the students write down different things that they have witnessed, such as noise, weight, or shape (if they can feel it).
4. Tell them that these observations will lead to not just a guess but an educated guess such as a hypothesis. At the end of the class period opening the boxes to have students see if their hypothesis was correct. Have them explain why their observations worked or did not work. (See attached worksheet)

**Attachments:** Worksheet for Mystery Box

## *Mystery Box*

Names \_\_\_\_\_

1. What is a guess?

2. How are a guess and a hypothesis different?

3. Observation notes of mystery box.

4. What is your hypothesis of what is in the mystery box?

5. Explain your observations and how they led you to a hypothesis.

# Activity: Before the Play

## Benham's Disk

**Grade Range:** 5-8

**WI State Standards:**

*Art and Design Education:* H.8.2 Know how light, shadow, color, distance, and angle of viewing affect sight.

*Physical Science:* D.4.6 Observe and describe physical events in objects at rest or in motion

**Curriculum Connections:** Art and Science

**Sources:** <http://faculty.washington.edu/chudler/benham.html>

**Objectives:**

- Students will create their own optical illusion.
- Students will understand that the nervous system can cause illusions.

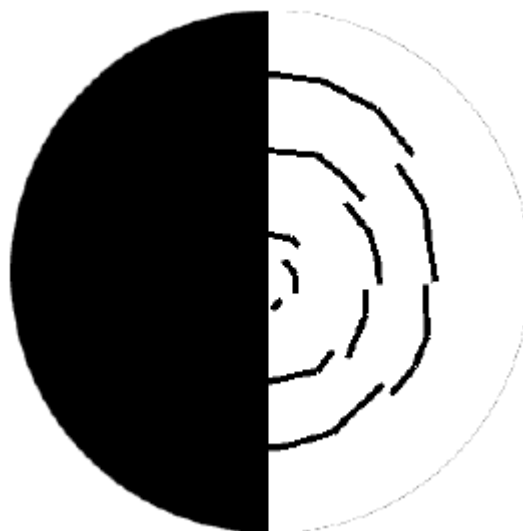
**Rationale:** Bill Blagg shows how magic is the use of science to trick the audience. Bill takes the audience through this science and shows them how the science actually works. Bill uses a lot of optical illusions. In this lesson the students will be able to investigate and create their own optical illusions.

**Materials:**

- Cardboard
- Toothpicks
- Scissors
- Benham Disk cutouts

**Procedure:**

1. Get some cardboard and a toothpick.
2. Draw a circle (with a diameter of at least 4 inches) on the cardboard.
3. Cut out the circle carefully. It is important that the circle is as round as possible.
4. Poke a hole in the center of the circle with the toothpick.
5. Insert the toothpick into the hole. The toothpick should stick out about half an inch. Break or cut the toothpick in half.
6. Twist the toothpick to spin the spinner.
7. Have students paste the black and white template of this disk on the the top of the cardboard.
8. Handout Benham Disk Wksht. Have students fill out the observations of the wksht.
9. Hand out Explanation on Benham Disk and discuss with students.



**Attachments:** Benham Disk Wksht. and Explanation of Benham Disk, Image of Disk.

## Benham Disk

Name \_\_\_\_\_

1. Get some cardboard and a toothpick.
2. Draw a circle (with a diameter of at least 4 inches) on the cardboard.
3. Cut out the circle carefully. It is important that the circle is as round as possible.
4. Poke a hole in the center of the circle with the toothpick.
5. Insert the toothpick into the hole. The toothpick should stick out about half an inch. Break or cut the toothpick in half.
6. Twist the toothpick to spin the spinner.

**1. What do you think will happen when you spin the disk?**

**2. What did you observe when you spun the disk? (spin at different speeds)**

**3. Why do you think you observed this?**

## Explanation of Benham Disk

### What's Happening? What Causes the Colors?

The retina of the eye is composed of two types of receptors sensitive to light: cones and rods. Cones are important for color vision and for seeing in bright light. There are three types of cones, each of which is most sensitive to a particular wavelength of light. Rods are important for seeing in low light.

It is possible that the colors seen in spinning Benham disks are the result of changes that occur in the retina and other parts of the visual system. For example, the spinning disks may activate neighboring areas of the retina differently. In other words, the black and white areas of the disk stimulate different parts of the retina. This alternating response may cause some type of interaction within the nervous system that generates colors.

Another theory is that different types of cones take different times to respond and that they stay activated for different amounts of time. Therefore, when you spin the disk, the white color activates all three types of cones, but then the black deactivates them. The activation/deactivation sequence causes an imbalance because the different types of cones take different times to respond and stay on for different times. This imbalance in information going to the brain results in colors.

Neither of these theories explains the colors of Benham's disk completely and the reason behind the illusion remains unsolved.



# Activity

## Optical Illusion Art

**Grade Range:** 3rd – 5th grade

**Standards:**

*Art and Design Education: H.8.2 Know how light, shadow, color, distance, and angle of viewing affect sight.*

*Physical Science: D.4.6 Observe and describe physical events in objects at rest or in motion*

**Curriculum Connections:** *Art and Mathematics*

**Sources:** <http://www.princetonol.com/groups/iad/lessons/elem/patti-opart.htm#Op> and <http://opticalillusionshowtheywork.blogspot.com/>

**Rationale:** Bill Blagg shows how magic is the use of science to trick the audience. Bill takes the audience through this science and shows them how the science actually works. Bill uses a lot of optical illusions. In this lesson the students will be able to investigate and create their own optical illusions.

**Objectives:**

1. Analyze optical illusions.
2. Create original optical illusions.
3. Review geometric shapes and see how the shapes seem altered through the use of colors and lines.

**Materials:**

1. Plain white paper
2. Rulers and circular templates.
3. Markers, pencils, and erasers.

**Procedure:**

1. Begin class by talking about optical illusions. What are optical illusions? Provide the class with examples of optical illusion artwork (<http://www.michaelbach.de/ot/>) or (<http://kids.niehs.nih.gov/illusion/illusions.htm>) .
2. Explain to the class that an optical illusion is a optical phenomenon that results in a false or deceptive visual impression.

3. Next, pass out a sheet of paper to each student and tell them that they will be creating their very own optical illusion.
4. Using the 1-inch wide rulers, have the students trace the width of the ruler along the entire paper, creating vertical lines. Start by lining up your ruler vertically along the short edge of the paper. Trace the side of the ruler from the top to the bottom of the paper. This creates your first vertical column. Continue tracing columns across the entire paper.
5. Have students draw at least 5 different geometric shapes of different sizes on the paper in an interesting design. (Squares, diamonds, stars, rectangles, octagons, triangles, etc.)
6. This is also a great time to review geometric math terms such as: polygons, concave, convex, parallel, perpendicular, etc. During this discussion the class can also talk about the different properties that polygons have (squares- four 90 degree angles with all sides of equal length).
7. After the students have completed their templates, pass out the markers and allow each student to choose one color to use for the project.
8. Explain to the class that the first column will be colored in but no part of any shape in this column will be colored. In the next column, only the shapes will be colored in. This pattern repeats throughout the remaining columns.
9. Example:



Completion Questions:

1. Does it seem as if the original shapes on your drawing are altered or moving?
2. Why might it seem like the lines are distorted or the shapes have changed?

# Activity

## Taste Illusion

**Grade Range:** 3rd – 5th grade

**Standards:**

*A.4.3 When investigating a science-related problem, decide what data can be collected to determine the most useful explanation.*

**Curriculum Connections:** Science

**Sources:** [http://www.abc.net.au/science/surfindscientist/pdf/lesson\\_plan21\\_tasteIllusion.pdf](http://www.abc.net.au/science/surfindscientist/pdf/lesson_plan21_tasteIllusion.pdf)

**Rationale:** Bill Blagg shows how he uses magic as a form science to trick his audiences. Bill takes the audience through this science and shows them how the science actually works. In this lesson the students will be able to investigate the illusions their own mind may play on them without them even knowing.

**Objectives:**

1. Students will see how their senses can be susceptible to illusions based on preconceptions about the color and flavor of foods.

**Materials:**

1. Enough raspberry juice for the entire class.
2. Green food coloring.
3. Two gallons of water.
4. Plastic or paper cups (two for each student).
5. Taste theory sheets.

**Procedure:**

1. Students are to taste and record the flavor of two types of juices, one pink and one green. The responses should be recorded before the secret is revealed. Apart from green food coloring, the juice samples are identical and taste exactly the same.
2. Explain to the class that you have to different types of mysterious juices (one red and one green) and you would like them to figure out what each is made of.
3. Ask all the students to taste each juice and record what they think each is made of without discussing their theories with other classmates.

4. After all the responses are collected, explain to the class that both juices have the same flavor, but one has green food coloring added to it. To make sure the class understands that food coloring does not alter the taste of foods, provide the class with 2 gallons of water. In one gallon, put green food coloring in the container and leave the other gallon of water alone. Allow each student to come up and sample each. This will allow the students to experience how food coloring does not alter the taste.

5. Next discuss with the class the following questions.

- a. What flavors did the class think each colored juice was and why.
- b. Was the class surprised that juices were the same?
- c. What factors contributed to thinking the juices were different?
- d. Are there other foods that the students do not like due to their color? (Different colored noodles?)

Taste Theory Sample Sheet:

Juice Flavor

Write down the flavor of the two juices samples you were asked to taste.

Pink juice = \_\_\_\_\_

Green juice = \_\_\_\_\_



# Activity

## Magic Toothpicks

**Grade Range:** 3rd – 5th grade

**WI State Standards Addressed:**

E.4.2 Show that earth materials have different physical and chemical properties.

D.8.1 Observe, describe, and measure physical and chemical properties of elements and other substances to identify and group them according to properties such as density, melting points, boiling points, conductivity, magnetic attraction, solubility, and reactions to common physical and chemical tests.

D.8.2 Use the major ideas of atomic theory and molecular theory to describe physical and chemical interactions among substances, including solids, liquids, and gases

**Curriculum Connections:** Science

**Sources:** <http://www.kidzone.ws/magic/toothpick.htm> and [http://encyclopedia.kids.net.au/page/su/Surface\\_tension](http://encyclopedia.kids.net.au/page/su/Surface_tension)

**Rationale:** Bill Blagg shows how he uses magic as a form science to trick his audiences. Bill takes the audience through this science and shows them how the science actually works. In this lesson the students will be able to investigate how often magic is done through the use science. Students will be able to see how molecules “like to stick together” and will be able to explore surface tension.

**Objectives:**

1. Students will begin to explore and understand what surface tension is and how water molecules work together.

**Materials:**

1. A box of flat toothpicks.
2. A large pan.
3. Liquid dishwashing soap and water.

**Procedure:**

1. Fill the bowl with water.
2. Dip one end of the magical toothpick in the dishwashing soap. Set aside for now.
3. Make sure the pan you are using is clean and fill it with water.
4. Arrange the flat toothpicks in the water so that they form a pentagon or square. Make sure the ends of the toothpicks overlap so they do not float away from each other. This can be tricky, practice before presenting to the class.
5. Tell the class that you've arranged the toothpicks into a special five sided shape called a pentagon and that you're going to cast a spell on the sixth toothpick so that it will be able to break apart the pentagon

6. Take out the sixth toothpick (the one that was dipped in dish soap) and wave your hand over it while chanting some magical words.

7. Now, dip the magical toothpick into the center of the pentagon (Make sure you dip the soapy end in the water and try to get it as close to the center of the shape as possible). The five toothpicks will fly apart.

8. If you have a non-believer in the class, offer to let them try the trick. Arrange the pentagon in the water again and hand them the magic toothpick. Let them dip it in the center. It won't work!

9. Next explain to the class how the trick works. Tell the class that water is made of tiny particles called molecules. Here you can show the class what water is actually made up of (H<sub>2</sub>O). Each grouping of two hydrogen atoms and one oxygen atom are a molecule.

10. Then explain to the class that water molecules like to stick to each other since they are polarized and that the surface of water has a layer of sticky molecules on it. This is known as surface tension and why the flat toothpicks were able to float on the water.

11. Next, explain to the class that one end of the magical toothpick was actually dipped in dish washing soap. Once the soapy end touched the water, it broke the surface tension and caused the toothpicks to float apart. This effect spreads out in an ever widening ring (like ripples in the water when you throw a rock in a lake). The molecules originally holding the toothpicks break apart. The molecules farther away from where you dipped the toothpick still have their surface tension (for a little longer) so they pull the toothpicks toward them.

12. Once the soap is in the water, the surface tension won't come back. That's why the class member could not recreate the trick. It will only work once and then you have to clean everything up and use new toothpicks to do the trick a second time.

# Activity

## Color Changing Carnations

**Grade Range** 4-6

**WI State Standards Addressed:**

- D.4.4 Physical Science-observe and describe changes in form, temperature, color, speed, and direction of objects and contrast explanations for the changes
- F.4.1 The Characteristics of organisms- Discover how each organism meets its basic needs of water nutrients protection and energy in order to survive.

**Curriculum Connection:** Science

**Sources:** [www.stevespanglerscience.com](http://www.stevespanglerscience.com)

**Objectives:**

- Students will discover how the stem of a flower works to “feed” it
- Students will be able to make predictions about what will occur to the flower.

**Rationale:** Bill Blagg uses the deduction of the scientific method in science to go about performing his magic tricks. By having students hypothesizing and making predictions in science experiments and making inferences and connections about what may occur from what they already know they can do the same with Blagg’s magic tricks.

**Materials:**

- 1 carnation for each student
- 2 cups/vases for each student
- Food coloring (any color)
- Knife
- Scissors
- Water

**Procedure:**

1. Fill each cup half full with water
2. Add 20-30 drops of food coloring to each cup
3. Trim stem with knife/scissors
4. Use knife to split stem in half
5. Place carnation in cups, one split end in one cup and the other split end in the other.
6. Make predictions: Students will answer the questions on their worksheets; “What color will be soaked up first? Will the colors mix to make a new color?”
7. Remember to keep the ends of the stem wet at all times and make fresh cuts on the ends.
8. Check back at the times designated on the worksheet for results; record results; may take 24 hrs
9. At conclusion of experiment, examine the whole plant, including the stem, leaves, buds, and petals. Record findings.

**Directions:** Answer the questions and fill out the chart according to how your flower reacts to the mixture.

**Pre-Experiment Questions**

1. What color will be soaked up?
2. Will the colors mix to make a new color?
3. Will only part of the flower change?

**Post- Experiment Questions**

1. What happened to your flower?
2. Why do you think this change occurred?
3. What did the flower do to the water?
4. Do you think this is how all plants “eat”?

Time Period	Petal Color	Stem Color	Bud Color	Leaf Color
Beginning Of Experiment				
Mid Morning				
Early Afternoon				
End of the School Day				
Following Morning				

# Activity

## Color Changing Bottle

**Grade Range:** 6-8

**WI State Standard(s) addressed:**

- D.8.4 While conducting investigations, use the science themes to develop explanations of physical and chemical interactions and energy exchanges

**Curriculum Connection:** Science

**Sources:** <http://www.practicalchemistry.org/experiments/the-blue-bottle-experiment,269,EX.html>  
<http://chemistry.about.com/od/chemistrydemonstrations/ss/bluebottle.htm>

**Objectives:**

- Students will be able to use science to investigate physical changes and witness illusion.
- Students will be able to make predictions as to what is occurring while shaking the bottle and when the bottle is at stand still.

**Rationale:** Bill Blagg uses the deduction of the scientific method in science to go about performing his magic tricks. By having students hypothesizing and making predictions in science experiments and making inferences and connections about what may occur from what they already know they can do the same with Blagg's magic tricks.

**Materials:**

- tap water
- two 1-liter Erlenmeyer flasks, with stoppers
- 7.5 g glucose (2.5 g for one flask; 5 g for the other flask)
- 7.5 g sodium hydroxide NaOH (2.5 g for one flask; 5 g for the other flask)
- 0.1% solution of methylene blue (1 ml for each flask)

**Procedure:**

1. Half-fill two one-liter Erlenmeyer flasks with tap water.
2. Dissolve 2.5 g of glucose in one of the flask (flask A) and 5 g of glucose in the other flask (flask B).
3. Dissolve 2.5 g of sodium hydroxide (NaOH) in flask A and 5 g of NaOH in flask B.
4. Add ~1 ml of 0.1% methylene blue to each flask.
5. Stopper the flasks and shake them to dissolve the dye. The resulting solution will be blue.
6. Set the flasks aside (this is a good time to explain the chemistry of the demonstration). The liquid will gradually become colorless as glucose is oxidized by the dissolved dioxygen. The effect of concentration on reaction rate should be obvious. The flask with twice the concentration uses the dissolved oxygen in about half the time as the other solution. A thin blue boundary can be expected to remain at the solution-air interface, since oxygen remains available via diffusion.
7. The blue color of the solutions can be restored by swirling or shaking the contents of the flask.
8. The reaction can be repeated several times.
9. Students will then answer the questions on the worksheet about the experiment and then have a discussion with the class.

## Color Changing Bottle Worksheet

**Directions:** Answer the questions below.

1. What happened when the bottle was shaken?
2. What happened when the liquid in the bottle went back to being at rest?
3. What do you think is happening that is making the colors change?
4. Can you think of an example from everyday life that is able to start in one physical state, change to another, and then change back to its original state?

# Activity

## Floating Ping Pong Balls

**Grade Range:** 4-6

**WI State Standard(s) addressed:**

- Position and Motion of Objects: D.4.6 Observe and describe physical events in objects at rest or in motion

**Curriculum Connections:** Science

**Sources:** <http://www.reekoscience.com/Experiments/FloatingPingPongBalls.aspx>

**Objectives:**

- Students will use science to hypothesize what will happen to the ball.
- Students will relate this example to examples that occur in everyday life.

**Rationale:** Bill Blagg uses the deduction of the scientific method in science to go about performing his magic tricks. By having students hypothesizing and making predictions in science experiments and making inferences and connections about what may occur from what they already know they can do the same with Blagg's magic tricks.

**Materials:**

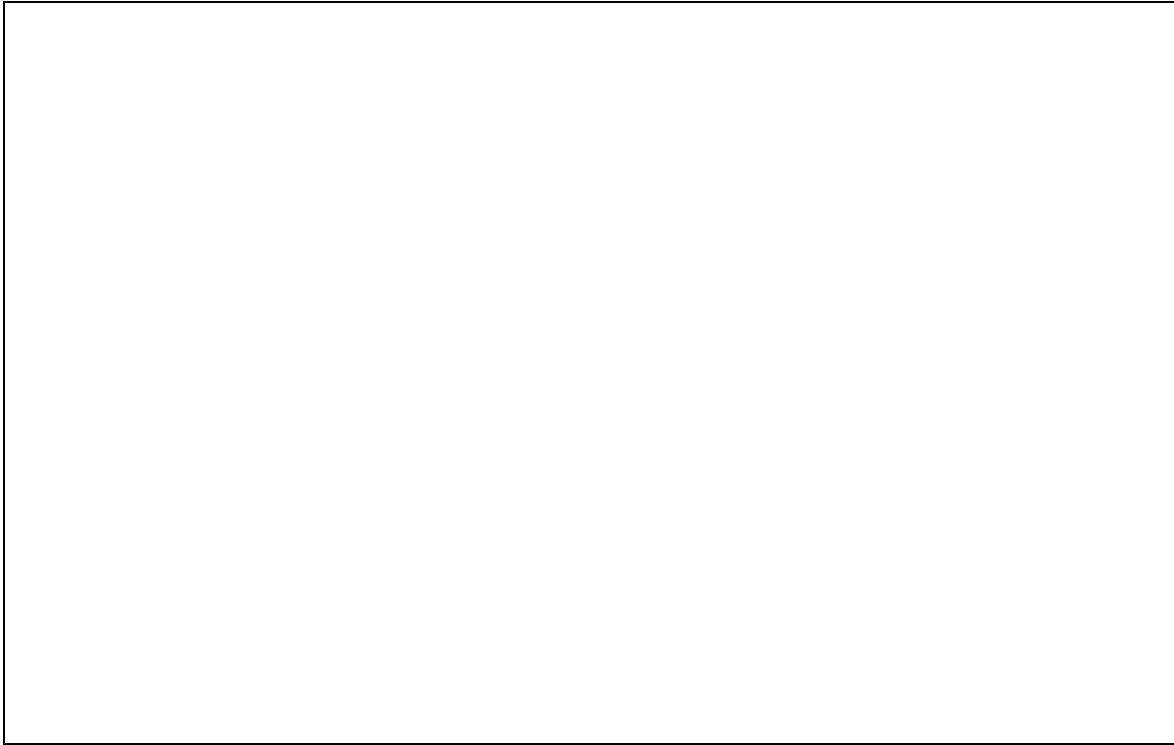
- Ping pong balls
  - Hair Dryer
- Or
- Foam Ball
  - Leaf Blower

**Procedure:**

1. Turn hair dryer on highest setting
2. Point hair dryer upward so air is blowing straight up
3. Gently place ping pong ball above the hair dryer
4. Students observe what is occurring and record observations.

## Floating Ping Pong Balls Worksheet

**Directions:** You saw what occurred when the pressure was on high. What do you think will occur with the pressure is turned to low? Draw and write out your prediction.



What do you think will happen when the hair dryer is turned off?

Where else might you see an example of air pressure?

How might Bill Blagg use air pressure in his magic tricks?

## Reflecting on the Performance

**Write a friendly letter** - As a way to reflect on the play, ask your students to write the Young Auditorium staff a letter. Our staff would love to hear what your students think about the Horizons productions they experience. For your convenience there is a letter template on the next page that is ready for you to reproduce for your students. This activity will provide your students with the opportunity to practice their writing skills by writing a critical evaluation of the Horizons performance for an authentic audience.

**Write a Review** - Create an idea map on the board by asking students to brainstorm everything they remember from the performance. The first part of this activity should be objective; remind students that they will be able to express their opinions when they write the review. Prompt students with the following questions: Was there music involved? If so, was it instrumental or what kinds of songs did they sing? In what different ways did the actors use their voices? What costumes did the actors wear? Did the actors wear masks? How did the different characters move? What did the set on the stage look like? What else can you remember?

- Instruct students to write a review that includes the following components:

- 1) A rating, out of five stars
- 2) One paragraph that objectively describes what you saw and heard at the performance
- 3) For each star in your rating, explain one thing you liked about the performance (e.g. a four star rating equals four things you liked about the show)
- 4) For each star under five, explain one thing you didn't like about the performance (e.g. a three star rating equals two things you didn't like about the show)
- 5) Use at least two of the new vocabulary words from this study guide or the performance in your review
- 6) Use the stages of the writing process to produce your review: pre-writing, draft, review, revise, edit
- 7) Publish your work by sending it to Young Auditorium! (Use the address on the letter template on the next page.) We would love to hear from you, and our education coordinator will write back!

**Create a Theatre Journal** - Download and reproduce the four *Theatre Journal* pages available on the Young Auditorium web site. [www.uww.edu/youngauditorium](http://www.uww.edu/youngauditorium) Copy the pages back-to-back and fold them down the middle into a booklet. There are a variety of writing and drawing activities to stimulate your students' imaginations before and after the play.



Young Auditorium  
Horizons School Matinee Series  
930 W. Main Street  
Whitewater, WI 53190

Dear Horizons:

My name is \_\_\_\_\_

I attend \_\_\_\_\_ School in \_\_\_\_\_  
(city or town).

I just saw \_\_\_\_\_ (name of  
show).

I liked the performance because

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

My favorite part was when

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

One question that I have is

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Signed

\_\_\_\_\_

# Theatre Vocabulary A-Z

**Act:** 1. To perform a role on stage; 2. One of the main divisions of a play or opera, i.e. Act I, Act II

**Actor:** Someone who performs a role on stage

**Applause:** To show approval by clapping the hands

**Apron:** The part of the stage that extends in front of the main curtain

**Audience:** Spectators that listen to or watch a performance

**Backstage:** The part of the stage and theater that the audience cannot see

**Balcony:** A platform inside of a building extending out over part of the main floor, as in a theatre

**Blackout:** A fast shutdown of lights to darkness

**Bow:** To bend the head, body or knee in acknowledgement

**Box Office:** Refers to the ticket office where people can buy tickets for a show

**Cast:** The group of actors or performers in a show

**Catwalk:** A walkway above the stage used to gain access to equipment

**Choreographer:** A person who arranges dances or other movements

**Company:** The cast, crew, and other staff associated with a show

**Costumes:** Clothes worn by the actors on stage

**Crew:** People that perform the technical tasks for a show

**Cue:** The signal for an actor or crew member to do an action

**Curtain Call:** At the end of a performance, the acknowledgement of applause by actors taking bows

**Dialogue:** The spoken text of a play, conversations between characters

**Director:** Person who guides the actors in the development of a show

**Downstage:** The part of the stage nearest to the audience

**Dress Rehearsals:** A full rehearsal in costume, to practice the show as it will be on show night

**Dressing Rooms:** Room in which actors change into their costumes and apply makeup

**Equity:** Short for American Actors' Equity Association, the trade union of actors, directors, designers and stage managers ([www.actorsequity.org](http://www.actorsequity.org))

**Follow Spot:** A hand operated lighting instrument that emits a high intensity beam of light used to follow an actor on stage

**Front of House:** Areas of the theatre in front of the proscenium arch, includes lobby areas open to the general public

**Gel:** Thin, transparent sheet of colored plastic used to color stage lights

**Ghost Light:** A light on a pole that is left on stage when nobody is there so the last person out and the first person in won't fall off the end of the stage in the dark

**Green Room:** Room close to the stage for the actors to meet and relax

**House:** 1. The audience inside the theatre; 2. The seating area inside the theatre

**Intermission:** A brief break between acts of a performance, usually ten to twenty minutes long

**Load In/ Load Out:** Process of moving a production in or out of the theatre

**Matinee:** A performance held in the daytime, especially in the afternoon

**Musical:** A play whose action and dialogue is interspersed with singing and dancing

**Orchestra Pit:** Sunken area immediately in front of the stage, intended to accommodate an orchestra

**Props:** Something other than scenery or costumes that is used in a performance, short for “properties”

**Proscenium:** The frame separating the stage from the audience

**Rehearsal:** A practice session in preparation for a public performance

**Script:** The text of a musical or play

**Set:** The complete stage setting for a scene or act

**Sound Check:** A thorough test of the sound system before a performance

**Stage:** the part of the theatre on which performances take place

**Stage Manager:** A person who is in charge of the stage and the related details of a performance

**Stage Right/ Stage Left:** The left and right of the stage from the point of view of the actor on stage looking at the audience

**Theatre:** A building or area for dramatic performances

**Understudy:** Someone who studies another actor’s part in order to be his or her substitute in an emergency

**Upstage:** The part of the stage furthest from the audience

**Usher:** A person who guides audience members to their seats

**Wardrobe:** The general name for the costume department

**Wings:** The out of view area to the left and right sides of the stage

### **A Lesson in Theatre Etiquette**

A fun way to review theatre etiquette with your students is to have them compare appropriate dress and behavior for the theatre with other activities such as attending a concert, going to a movie, swimming at the beach, going to a sports game, or going to the mall with family or friends. Divide the class into groups and assign each group a different activity. Have the groups list the appropriate dress and behavior for their activity and why. The groups can then briefly role play their activity and present their ideas to the rest of the class. After all groups have presented, discuss how we behave differently for a live theater performance than we do for other activities (such as watching TV or a movie).

Print copies and review the “Courtesy Counts” sheet in this guide with your students.

## Courtesy Counts

Please share this information with your students . . . most children are unfamiliar with proper theatre behavior. Make sure you share these courtesies as a part of their experience, and be sure to select shows appropriate for their age & attention span. Ask students to use the restroom before the performance begins.

**Produce positive energy** . . . Watching a live theatre performance is very different from watching a movie or television show. A live presentation has not been prerecorded with the mistakes edited out. The audience's behavior and reactions can either add or detract from a performance. Each audience member affects those around him/her as well as the performers. Concentrate on helping the performers by producing only positive energy!

**Find your seat** . . . An usher will show you where to sit. Walk slowly and talk quietly as you are seated.

**Keep it clean** . . . Gum, food, and beverages are not allowed in the theatre!

**Quiet on the set** . . . Young Auditorium is known for its excellent acoustics, so if you make a noise others will hear you (including the performers)! Please no talking, humming, unwrapping cough drops and candy, or foot tapping during the performance. Exceptions to this rule include shows that ask for audience participation. Applause and laughter are appreciated and appropriate.

**Unplug** . . . Turn off pagers, cell phones, cameras, and watch alarms during performances. Better yet, leave them at home or school!

**Only use your memory as a recording device** . . . Flash photography and video recording are not allowed during performances because the bursts of light are dangerous to the performers on stage and distracting to other patrons. Please keep recording equipment at home or school, or conceal it in a jacket pocket or purse.

**Respect personal space** . . . Please keep feet on the floor, not on the seat or balcony rail in front of you. Shifting in your seat, wearing hats, or wandering in the aisles is extremely distracting to those around you; please stay in your seat until intermission or the final curtain.

## FOR YOUR INFORMATION (teachers & chaperones)

**PLACE:** All Horizons School Matinee Series performances will be held in Young Auditorium, on the UW-W campus. Musical Encounters concerts are held in the Light Recital Hall in the Greenhill Center of the Arts. You will be escorted from the auditorium to the recital hall if you are attending a concert.

**TIME:** The doors of the auditorium will be opened 30 minutes prior to curtain time. Please arrange your schedule so the buses will arrive with time for seating and a bathroom stop. Late arrivals will not be seated until there is an appropriate pause in the production.

**BUSES:** The east side of Lot 1 is reserved for buses that are staying for the duration of the Horizon's performance. Buses that are not staying will pull into Lot 2 and line up along the curb to drop off and pick up students. Please make sure that your bus driver receives the Bus Driver's Memo available on our website.

**WHEELCHAIR:** All entrances are wheelchair accessible. If you have upper level seats, use the elevator. Main floor seats are on the same level as the lobby. Please inform us at least 4 weeks in advance if you need wheelchair seating or any other special accommodations.

**RESTROOM:** Main floor men's and women's restrooms are located on each side of the auditorium. On the upper level, the women's restroom is on the south side and the men's restroom is on the north side of the building. Please try to limit your restroom visits to before or after the show.

**SEATING:** An auditorium escort has been assigned to your school. The escort will direct you to your seats. All seats are reserved; thus each group must adhere to the seating assignment and may use only the number of seats reserved. Please plan to have chaperones seated with the students under their supervision. Chaperones - please do not bring infants/babies to the school matinee performance. After all the students and respective chaperones have been seated, please settle in and remain seated during the entire show. No one should leave the hall until after the final curtain, except in the case of emergency. Leaving during the performance is exceedingly distracting for both the performers and members of the audience. If students must leave during the performance for any reason, re-entry into the auditorium will be allowed only when there is an appropriate pause in the program.

**CAMERAS/ RECORDERS AND CELL PHONES:** The use of cameras or recorders during any performance is strictly forbidden. Please do not bring them to the program. Cell phones must be turned off for the duration of the program. We encourage you to ask your students not to bring cell phones with them to the theatre.

**FOOD,** drinks, and chewing gum are not permitted in the auditorium.

**EMERGENCY:** Please contact the nearest usher in case of emergency.

**LOST ARTICLES:** Report lost articles to the house manager, or call 262-472-4444.

CONTINUED ON NEXT PAGE

**EXITING:** Please disperse in an orderly manner. Teachers and chaperones have the responsibility of keeping their group together. Ushers are not assigned to oversee your exit from the building.

**BUS PICK-UP:** Your bus pick-up will be the same place as the drop-off.

**LUNCH:** Local fast food establishments and restaurants, as well as UW-W campus dining (262- 472-1161) are happy to accommodate your group for lunch. Please make advanced arrangements to promote efficient service.

**LUNCH SPACE:** Schools may request a place to eat their bag lunches. Young Auditorium can accommodate a very limited number of people eating lunch picnic-style seated on the floor. This must be scheduled in advance. You will receive an admission slip in the mail confirming lunch space, which you must bring along with your lunches. We thank you, in advance, for cooperating in implementing these procedures, giving all audience members the opportunity to sit back, relax, and enjoy the show.

Thank you for coming – we appreciate having you as a part of the Horizons program!

**SPECIAL NOTE:** Please print the Bus Driver Memo/ Map from our website [www.uww.edu/youngauditorium](http://www.uww.edu/youngauditorium) and give it to your driver on the day of the show!

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## Policies

Please note the following policies are in place to ensure enjoyment for all!

The house opens at least one-half hour before the curtain.

A seat must be purchased for everyone attending an event, including teachers, chaperones, and bus drivers.

Timing is everything . . . so don't be late! Performances begin at 10:00 a.m. and 12:30 p.m. so plan to arrive at the theater 30 minutes early.

Patrons arriving late are seated only when there is a suitable pause in the performance.

# Young Auditorium

UNIVERSITY OF WISCONSIN WHITEWATER



930 W. Main Street  
Whitewater, WI 53190  
262-472-4444 (main office)  
262-472-4400 (fax)  
www.uww.edu/youngauditorium

Shannon Dozoryst  
Education and Outreach Coordinator  
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262-472-4400 (fax)  
dozoryst@uww.edu

## Staff

**Ken Kohberger, Director**

**Shannon Dozoryst, Education and Outreach Coordinator**

**Malinda Hunger, Office Manager**

**Leslie LaMuro, Marketing Director**

**Michael Morrissey, Audience Services Coordinator**

**David Nees, Technical Director**

**Ben Strand, Development Director/ Assistant Director**

The Horizons School Matinee Series is funded cooperatively by the University of Wisconsin-Whitewater, participating schools, grants from the Wisconsin Arts Board, Dorothy Remp Elmer Children's Arts Outreach Endowment, Nasco, and Target, and a partnership with the National Endowment for the Arts, in addition to various public and private institutions. Young Auditorium is a non-profit organization under Section 115 of the Internal Revenue Code.

## John F. Kennedy Center Partners in Education Program

The Young Auditorium and School District of Janesville are members of the Partners in Education program of the John F. Kennedy Center for the Performing Arts, Washington D. C. Selected because of their demonstrated commitment to the improvement of education in and through the arts, the Partnership Team participates in collaborative efforts to make the arts integral to education. For more information, please visit <http://www.kennedy-center.org/education/partners>.



NATIONAL  
ENDOWMENT  
FOR THE ARTS

A great nation  
deserves great art.



The Dorothy Remp Elmer  
Children's Arts Outreach Endowment

