Dear Educator,

Thank you for booking a tour with the Museum of Glass. We look forward to your visit!

We're sending you this curriculum to help enhance the museum visit for you and your students. These activities have been carefully prepared to go with the exhibit you will visit. You can use them as pre-visit materials or post-visit, but we strongly encourage that you spend some time with the packet before your visit. We've found that students understand and learn so much more if they are prepared before they come.

Along with this packet, we have extensive curriculum and interactive activities on our website about glassblowing and working with hot glass as an art form. Please visit ***www.museumofglass.org*** and click "**Learn**" on our home page. From there, visit the **Virtual Hot Shop**, where your students will get a chance to experience glassblowing by creating a ***macchia***. Participants walk through the process step-by-step until they get a finished work of art! Along the way they can also choose to learn more about glass. You and your students can even watch the Hot Shop Live, by clicking "**Watch**" on our home page and selecting the "**Live Web Streaming of the Hot Shop**" link.

We sincerely hope you enjoy these materials and your visit to the Museum of Glass.

Persistence of Vision

Solid Cinema: Sculpture by Gregory Barsamian

August 14, 2004 - March 13, 2005

EALRs and GLEs

The GLEs cover from grade 3 – 10 unless otherwise noted.

Science:

1. Systems: The student knows and applies scientific concepts and principles to understand the properties, structures and changes in physical, earth/space, and living systems.

  - 1.1.2 Motion of Objects
  - 1.2.1 Structures of Physical Earth/Space and Living Systems

2. Inquiry: The student knows and applies the scientific ideas, skills, processes of investigation, and the nature of science.

  - 2.1.1 Questioning
  - 2.1.2 Planning and Conducting Safe Investigations

3. Application: The student knows and applies science ideas and inquiry to design and analyze solutions to human problems in societal contexts.

  - 3.2.1 All Peoples Contribute to Science and Technology
  - 3.2.2 Relationship of Science and Technology

Arts:

1. The student understands and applies arts knowledge and skills.

  - 1.1 Understand arts concepts and vocabulary.
  - 1.2 Develop arts skills and techniques.

2. The student demonstrates thinking skills using artistic processes.

  - 2.1 Apply a creative process in the arts.

4. The student makes connections within and across the arts to other disciplines, life, cultures, and work.

- 4.2 Demonstrate and analyze the connections among the arts and other content areas.
- 4.4 Understand that the arts shape and reflect culture and history.
- 4.5. Demonstrate the knowledge of arts careers and the knowledge of arts skills in the world of work.

Persistence of Vision and Animation

One of the most amazing things about the sculpture of Gregory Barsamian is their apparent animation. Even though the sculptures are made of many smaller still sculptures, with the help of your eyes and brain and the phenomenon of persistence of vision, all of the smaller elements work together to create an exciting moving work of art.

Persistence of vision is also the phenomenon behind the motion of animation and even the picture on your television. The perceptual processes of the brain and retina in the eye retain images for a split second. When the human eyes are presented with several still images quickly in succession, the brain will take those images and blend them together causing the illusion of motion. Perceptually, the eye-brain system is still interpreting information from the first picture at the same time that it is interpreting new information from the second picture. Two other closely related phenomenons are beta movement and the phi phenomenon. For more about these, see the teacher resources pages at the end of the curriculum.

Consequences and Uses of Persistence of Vision

Discuss examples of this effect:

- Movies: These work the same as animation, only with photographs. Motion pictures display 24 still images per second, but each is shown two or three times, so the resulting frame rate is 48 to 72 per second, which is sufficient to produce the illusion of continuous motion and avoid the flicker that characterized old fashioned movies. The old time movies, displayed at lower rates, flickered, and movies were thus referred to as “flicks.”

- Flipbooks: Images are drawn on the pages of a book. When we flip through the pages, we perceive the images undergoing smooth motion, and animation occurs.

- TV: The image on the screen is scanned at a rate corresponding to 60 frames per second.

Two principle effects based on the persistence of vision are (a) the superposition of images to create a false stationary image and (b) the blending of a series of images to create the appearance of continuous motion. Both of these effects take advantage of the fact that the mind retains the images for a brief period of time. If we use a stroboscopic viewing method, such as a strobe light or hand strobe, we can break up the continuous blurred vision that we normally experience when an image is speeding by, into separated flashes of sight.

- A hand strobe breaks up our vision by restricting us to viewing through the slits of a rotating wheel. The time between our observations is determined by the speed at which the wheel is rotated and by the number of slits on the wheel.

- A strobe light restricts our vision by giving bursts of light at fixed intervals. Each time the strobe light flashes, it is like catching a glimpse through the slit of a hand strobe.

The images our eyes see are distinctly separate, but the brain's ability to retain the image smoothes them together and prevents us from seeing the dark spots in between, as long as the images are changing at a fast enough rate. The frequency at which the flickering ceases and continuous motion is perceived is called the *critical flicker frequency*. This frequency varies with the illumination level, but is typically around 30-40 Hz. Note that fluorescent lights flash on and off 120 times per second, but this lighting usually appears continuous.

Persistence of vision came into popular use around 1825 with the invention of a parlor toy called the *thaumatrope*, which means "turning marvel" or "wonder turner." The *thaumatrope* is said to have been invented by astronomer Sir John Herschel, however London physicist Dr. John A. Paris made this toy popular. A disk with a picture on each side is spun rapidly (using strings attached to each side). When the disk is spun quickly enough, the two pictures appear to combine into one image. Probably the most well-known example of this is a bird on one side and a cage in the other. When the disk is spun the bird appears to be inside the cage. During the Victorian era, they were also often found to include riddles or short poems with one line on each side. These precursors to film started to fade from popularity as more complex versions, and eventually films came into being.

Build your own Thaumatrope!

Materials (per participant):

- two disks of card stock (should be the same size with a two holes punched opposite each other, one on the left and one on the right)
- two rubber bands
- tape or glue
- pencil
- and markers, crayons or colored pencils.

Once the device is made, you will flip the disk around and around to wind up the rubber bands—like you would with a toy airplane propeller. Then, holding the ends of each wound rubber band, pull gently outward and watch the disk spin. You'll be amazed!

1. Taking the two disks, line up the holes on one disk with the holes on the other. Tape or glue the two disks together like this.
2. Tie one rubber band through each hole. You will end up with a circle with a rubber band sticking out from the left hole and a rubber band sticking out from the right hole.
3. On the front, draw half of what you want the finished picture to looks like (for example, the bird).
4. Flip the disk over and draw the other half of the finished image (for example, the cage). NOTE: you want to flip the disk top to bottom so the first image (now face down on the table) will be upside down while you're drawing the second image.
5. Wind up the rubber bands, pull gently and watch the illusion!

Connecting a Sequence of Images: Animation

While the *thaumatrope* is fun, the images are not usually ones that imply motion. If a series of sequential images is viewed at the proper rate, the images appear animated by the persistence of vision phenomenon. Because the images remain on the retina of the eye, the gaps between frames are not noticed and continuous motion is perceived.

The *phenakistoscope* (meaning "deceiving viewer") was invented in 1832 simultaneously by Belgian Joseph Plateau and the Austrian Simon von Stampfer. The *phenakistoscope* was much like the hand strobe explained above.

According to Wikipedia, "one variant of the phenakistoscope was a spinning disc mounted vertically on a handle. Around the center of the disc was drawn a series of pictures corresponding to frames of the animation; around its circumference was a series of radial slits. The user would spin the disc and look through the moving slits at the disc's reflection in a mirror. The scanning of the slits across the reflected images kept them from simply blurring together, so that the user would see a rapid succession of images with the appearance of a motion picture. Another variant had two discs, one with slits and one with pictures; this was slightly more unwieldy but needed no mirror. Unlike the zoetrope and its successors, the phenakistoscope could only practically be used by one person at a time."

Create and View an Animation with a Hand Strobe and Mirror

Materials:

- hand strobe for each student or group (pre-made or made in class, instructions to follow)
- access to a mirror for each group
- small sticky notes (1.5" x 2")
- pencil
- and markers, crayons or colored pencils

Animation can be accomplished by attaching a sequence of images to the hand strobe then viewing the images in a mirror, looking through the slits of the hand strobe as it spins. Because each image is at a fixed position relative to the observation slits, the image will always be at the proper position to be viewed, no matter how many slits are used or what speed the strobe is rotated. If the disk is rotated *too* slowly, the observation frequency will be below the critical flicker frequency and the animation will become choppy.

- The teacher will now pass out the mirrors, and each group will experiment with them. Have the students start by placing just one sticky note with a single dot drawn on it on the strobe and then observing it in the mirror. The dot will move around in a circle (12 steps) as they spin the strobe.

Now have the students consider what happens if they put 12 images around the circle (evenly spaced).

- Use sticky notes to draw a simple animation sequence and attach them to the strobe, one in each space between the slits. Possible ideas for animation sequences include the hands of a clock (12 hourly positions), a stick figure with arms and legs moving, a ball bouncing, etc. Note that letters and numbers in the images will appear reversed due to the reflection in the mirror. View the images in the mirror and the animation will be automatically synchronized. Notice also that the animations can be run forward or backward depending on whether the hand strobe is spun clockwise or counterclockwise.

To Create Your Own Hand Strobes

Materials (per participant):
- photocopied templates on heavy card stock
- thumbtack
- tongue depressor or large craft stick
- scissors

Although you can purchase pre-made hand strobes from science supply companies such as Sargent-Welch, it is also possible to make your own. The key importance here is to have evenly-spaced slits to look through. This curriculum includes a template in the Teacher Resources section at the end, though feel free to experiment on your own!

1. Carefully cut out the disk, including the slits.
2. Lay the craft stick on the table, carefully placing the center of the disk on top inch of the stick.
3. Gently press the thumbtack through the center of the disk into the craft stick. The thumbtack does not need to go all the way through the stick. There needs to be some space for the disk to spin freely.

At this point you can either draw directly onto the strobe, but if you'd like to experiment more, or keep your strobes reusable, draw your sequences on small sticky notes instead.

The Zoetrope

Invented just two years later in 1834 by George Horner is the *zoetrope*, one of the most widely known optical toys. Wikipedia says "a *zoetrope* is a device consisting of a cylinder with slits cut vertically in the sides. Beneath the slits, on the inner surface of the cylinder, is a band which has either individual frames from a video/film or images from a set of sequenced drawings or photographs. As the cylinder spins, the user looks through the slits at the pictures on the opposite side of the cylinder's interior." The *zoetrope* works the same way the *phenakistoscope* does, but the viewer does not need a mirror to see the motion.

Although the *zoetrope* and *phenakistoscope* are not widely used today, Gregory Barsamian is not the only artist using persistence of vision today. The most recent development is the *linear zoetrope,* which consists of an opaque screen with slits, just like the original cylinder. Instead of spinning a cylinder, the viewer must move past the display quickly to see the motion.

According to Wikipedia, “in September 1980, independent filmmaker Bill Brand installed a type of *linear zoetrope* he called the "*Masstransiscope*" in an unused subway platform in Brooklyn, New York. It consisted of a linear wall with 228 slits in the face. Behind each slit was a hand-painted panel. Riders in subways moving past the display saw a motion-picture within.”

“Joshua Spodek, as an astrophysics graduate student, conceived of and led the development of a class of linear *zoetropes* that saw the first commercial success of a *zoetrope* in over a century. A display of his design debuted in September 2001 in a tunnel of the Atlanta subway system and showed an advertisement to riders moving past. That display is internally lit and nearly 300 meters long. Its motion-picture was about twenty seconds long.”

“His design soon appeared in subway systems elsewhere in North America, Asia, and Europe. Joshua has also participated in a renaissance in *zoetrope* related art and other noncommercial expression.”

How to Make a Zoetrope

Instructions by Ruth Hayes (with permission)

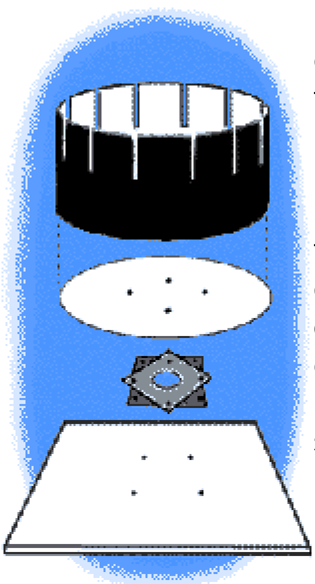
Materials:

- PVC pipe, Sonotube, or ice cream bucket
- lazy susan bearing, pre-bought lazy susan, or turntable
- craft knife or jig saw
- black matte paint
- bright white paint
- strips of paper (the same length as circumference of your chosen tube)
- pencil
- markers or crayons

You can make a zoetrope easily and inexpensively from any cylindrical tube. A good choice is 12" schedule 40 PVC pipe (in Seattle, available from Sherman Supply, 622-4801 @ about $11 per foot) or 12" unwaxed Sonotubes (used in casting concrete columns, available in Seattle from Charles Watts, 783-8400 @ about $3 per foot). You will need a lazy susan bearing (3C bearings cost about about $1 each) available from builders' supply stores.

I made a zoetrope from PVC pipe and a 3C lazy susan bearing in 1979. Since then, this zoetrope has been spun, banged around and exposed to various kinds of abuse from thousands of pre-school, K-12 and college students and I've only had to repair it once after it was damaged in shipping.

For a smaller but simpler zoetrope, use the 10" diameter cardboard ice cream buckets from ice cream stores. If you use one of these, you can glue it straight onto a Rubbermaid lazy susan. Or you can make a motorized zoetrope instead by sticking the bucket on the spindle of an old record turntable (the motorized zoetrope will only turn in one direction, so it's not quite as versatile).



1. Cut the PVC pipe or sono-tube evenly so that its height is at least equal to the radius of the cylinder. A height of 6-8" for a 12" diameter tube is fine. (You don't have to cut the ice cream bucket at all).

2. Slots must be evenly spaced around the cylinder, no more than one-half its height, and no more than 3/16ths of an inch wide (the narrower the slots, the more in-focus the image will appear). Measure the cylinder's outside circumference and divide it by 12. Subtract the width of the slots from that number and you will have the distance between each slot. Cut 12 equidistant vertical slots around the top edge of the PVC or sono tube. You can start by drilling holes at either end of the slot and then use a jigsaw to cut out the piece in between. If you're using an ice-cream bucket, cut the slots about midway up the side using a matte knife.

3. Cut a bottom for the tube. You can use thin plywood, masonite or plexiglass. Either cut it square, or round to fit the cylinder, then nail or screw the two pieces together. Again, if you use the ice-cream bucket, this step is not necessary.

4. Now you have a drum with one closed side and one open side. Cut a piece of wood to make a base for the zoetrope. Carefully center the lazy susan bearing on it and mark places to drill screw holes. Center the bearing on the bottom of the zoetrope drum and mark places to drill screw holes for the other side of the bearing. Screw the bearing into the bottom first, then, using nuts, bolts and lock washers, attach the bearing to the drum. If you squirt some graphite into the bearing before installing it, it will spin faster.

5. Paint the outside of the zoetrope matte black. Paint the inside bright white. A strong overhead light shining into the zoetrope will make your artwork more visible.

<u>Zoetrope Strips:</u>

Make paper strips the length of the inside circumference of the zoetrope, and no wider than the space between the bottom of the zoetrope and the slots. Divide each strip into 12 equal frames.

Keep in mind that your animated sequence will repeat itself in the zoetrope. It's a cycle. The drawing in the first frame follows the one in the twelfth frame directly. The difference between these frames should be small. Don't try to animate a complicated story, just a simple motion, gesture or metamorphosis. Sketch in pencil first, then go back over your lines with a dark pen. Pencil lines are too light to show up against the strobe of the zoetrope.

Think of simple shapes to draw. A dot could get bigger and bigger with each frame. A line could rotate like the hands of a clock or wag back and forth like a dog's tail. A smile on a face could turn into a frown.

Draw the extreme positions of the motion separated by five empty frames. Go back and draw gradual changes in the frames between your key drawings.

To animate a metamorphosis, or one thing transforming into something else, draw your first image in frame one and the image you will transform it into in frame seven. Use the frames in between one and seven to draw the gradual changes of the metamorphosis. You can copy these inbetweens in reverse order in frames eight through eleven to complete the cycle.

You can color your strips. Because of the strobe, pale colors don't show up very well. Use bright, bold ones. Experiment with alternating blocks of color from frame to frame.

After you have made some simple strips, you might want to try more complicated ones. Instead of twelve frames, make a strip with ten, eleven or fourteen frames of equal width. Draw the same simple shape in each frame. Notice that in the zoetrope, the shape seems to move in one direction or the other even though you have not animated it. If you animate a ten frame cycle of someone walking, they will appear to walk from right to left in a clockwise spin, and left to right in a counter-clockwise spin.

The zoetrope will transform any drawings into some kind of motion. Sometimes it's fun just to scribble random abstractions on the strips and then watch what kind of effect the zoetrope has on them.

The Flip Book

Although in some respects it might seem simpler, the *flip book* was a later development. Invented around 1868, a *flip book* is a book with a series of sequenced pictures, like the *zoetrope*, the sequence changing gradually from one page to the next. When the pages are turned or flipped rapidly, the pictures appear to animate, just like with the other optical toys discussed above. Sometimes these are found as stand-alone books, but they are often found in the corners of other publications. With a *flip book* the viewer just needs to stare at one location while flipping the pages—the flipping has the same effect as the strobe light in Barsamian's work or the slits in the other toys. In fact, Barsamian has also made a flip-book of some of the pictures of his sculptures!

Make Your Own Flip Book

Materials (per participant):

- small booklets (of at least 10-12 pages) of card stock, pre-made or made in class (instructions to follow)
- Stapler (optional)
- pencil
- and markers, crayons or colored pencils

You can make these books in advance, or have participants make them as part of the exercise.

1. Cut 10-12 rectangles of equal size per flip book (or pass out 10-12 of these to each participant).
2. Stack the rectangles together to make an even stack (if the edges aren't even, the book won't flip properly and will affect the motion).
3. Using a stapler, staple the top and bottom left corners so the staple runs vertically, not horizontally.
4. Using the right half of each page, draw a sequence, one picture on each page. Again, this might be hands on a clock, a bouncing ball, a balloon rising, etc.
5. Once all of the pages are filled, hold the book in your left hand. Using your right hand, flip the right bottom corner and watch the illusion.

Teacher Resources

Gregory Barsamian (American, born 1953)

***Die Falle*, 1998**
Fabric, acrylic paint, urethane foam, steel, motor and strobe light
Collection of the Museum of Glass

The term *Die Falle* is a German expression meaning "the trap"—slang for "bed." The sculpture chronicles a dream within a dream. In it, a small body rises out of the head of a sleeping man. As the dream-figure continues to rise, it becomes a round tire, changes to a square tire and then returns to its original shape before finally coming to rest in a bed shaped like a mousetrap. Then the dream begins again. And again.

Barsamian spent six months in the studio to complete the detailed work on *Die Falle*. It contains over 130 individual pieces and sixteen separate heads, each a self-portrait of the artist. The sculpture is spinning at 50 revolutions per minute.

***Untitled*, 2000**
Steel, acrylic medium, paper, strobe light and motor
Courtesy of the artist

This sculpture conveys the frustration that artists and writers feel when they experience a creative block. Here Barsamian portrays the artist, seated in a photograph on the wall, endlessly throwing failed drafts onto the floor. The figure's increasing frustration is illustrated with each revolution of the sculpture as his unsuccessful attempts at creativity accumulate in a growing pile of paper waste.

Completed over a four-month period, *Untitled* contains almost a hundred individual pieces and is spinning at 38 revolutions per minute.

***The Scream*, 1999**
Urethane foam, steel, motor and strobe light
Courtesy of the artist

The Scream was inspired by the artist's vision of all the clutter the mind stores. Everyone remembers random bits of information—images, television plot lines, song lyrics, and a million other things that we never intended to keep.

Imaginatively portraying what can happen when this mental clutter comes to life, Barsamian created a portrait of his own head in the act of screaming. The mouth opens and continues to open until it turns itself completely inside out, revealing the clutter inside.

The Scream, which includes twenty separate, detailed heads, was completed over a four-month period. It spins at 38 revolutions per minute.
Gregory Barsamian combines art, science, humor and a touch of magic in order to explore the subconscious. Through recognizable imagery, Barsamian's art allows the viewer to briefly enter into an unconscious world made visible, which he calls the *waking dream state*. His animated sculptures are inspired by his dreams, but none of them are exact representations of a specific dream. He merges them with his imagination and the everyday to create a dream-like experience.

Barsamian uses relatively simple technology and does not attempt to mask the mechanized features of his work. He prefers that the viewer understand the working dynamics so they can focus on the content of the piece rather than dwelling too long on how the effect is achieved.

Barsamian studied philosophy at the University of Wisconsin while he supported himself by repairing cars and bicycles. During this time he also studied glassblowing and created a body of work by blowing, casting and slumping glass. After he moved to New York, he began to work instead with metal when he decided to incorporate the elements of time and movement into his work.

Barsamian made his first kinetic sculpture in 1990. As a young artist, he sought to combine his interests in philosophy, dream psychology, art and mechanics. An early and simple optical device—the zoetrope—provided a starting point. The zoetrope was invented over 150 years ago as a nineteenth-century parlor toy. Utilizing a synchronized strobe light, it relies on the principle of persistence of vision, which would later be perfected to produce the motion picture. This principle presents the viewer with images in rapid succession, so an image flashed before the eye is retained in the viewer's mind until the next image appears.

Wikipedia entries for Beta Movement and Phi Phenomenon

“Beta movement is a perceptual illusion, described by Max Wertheimer in his 1912 *Experimental Studies on the Seeing of Motion*, whereby two or more still images are combined by the brain into surmised motion. This is often erroneously referred to as the phi phenomenon, which is a different, related illusion.”

“The classic beta phenomenon experiment involves a viewer or audience watching a screen, upon which the experimenter projects two images in succession. The first image depicts a ball on the left side of the frame. The second image depicts a ball on the right side of the frame. The images may be shown quickly, in rapid succession, or each frame may be given several seconds of viewing time. Once both images have been projected, the experimenter asks the viewer or audience to describe what they saw.”

“Generally, audiences will claim that they saw a ball move from left to right. They did not, in fact, see this, but the cognitive process of perception links the two images in time and causality.”

“The beta phenomenon can also create the illusion of motion toward and away from an audience. When the first image is of a large object, and the second is of a small object (or vice-versa), the audience will generally report that the object moved away from them. Additionally, if the first frame depicts a brightly-colored object against a solid background, and the second depicts the same object but in colors similar to the background, the audience will report that the object moved away from them.”

“**Phi phenomenon** is a perceptual illusion described by Max Wertheimer in his 1912 *Experimental Studies on the Seeing of Motion*, in which a disembodied perception of motion is produced by a succession of still images. In discussions of the perception of film and video it is often confused with beta movement, but it is a distinct phenomenon not directly involved in the perception of motion pictures.”

“The classic phi phenomenon experiment involves a viewer or audience watching a screen, upon which the experimenter projects two images in succession. The first image depicts a line on the left side of the frame. The second image depicts a line on the right side of the frame. The images may be shown quickly, in rapid succession, or each frame may be given several seconds of viewing time. Once both images have been projected, the experimenter asks the viewer or audience to describe what they saw.”

“At certain combinations of spacing and timing of the two images, a viewer will report a sensation of motion in the space between and around the two lines, even though the viewer also perceives two distinct lines and not the continuous motion of objects referred to as Beta movement. The phi phenomenon looks like a moving zone or cloud of background color surrounding the flashing objects.”

Research Resources:

North Carolina School of Science and Mathmatics, Laura Hayes and John Howard Wileman Exhibit of Optical Toys, “Thaumatrope,” “Phenakistoscope,” “Zoetrope,” January 21, 2005, January 26, 2005, <http://courses.ncssm.edu/gallery/collections/toys/opticaltoys.htm>.

Wikipedia, the Free Encyclopedia, “Zoetrope,” “Persistence of Vision,” “Phenakistoscope,” “Beta Movement,” “Phi Movement,” January 2, 2005, January 26, 2005, <http://www.wikipedia.org>.

Hayes, Ruth, “Random Motion: Animation by Ruth Hayes,” August 26, 2004, January 26, 2005, <http://www.randommotion.com/index.html>.

To learn more about Bill Brad’s Masstransiscope, visit:

http://www.bboptics.com/masstransiscope.html

To learn more about Joshua Spodek’s linear zoetropes, visit:

http://www.spodek.net/art.html and http://www.spodek.net/technology.html

To learn more about Gregory Barsamian, visit:

http://www.gregorybarsamian.com

An image of both sides of a thaumatrope.

Here are images of the *phenakistoscopes* or hand strobes of Plateau and Stampfer.

Two images of zoetropes.