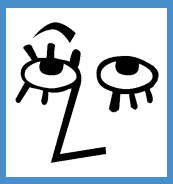

eye openers exploring optical illusions

MUSEUM OF VISION

eye openers
exploring optical illusions

MUSEUM OF VISION

THE MISSION OF THE MUSEUM OF VISION IS TO

EDUCATE PEOPLE ABOUT THE EYE AND VISION.

The Museum has a variety of resources for people who are curious about our most important sense—vision.

•

A collection of over 10,000 vision-related objects, dating from the 300 BC to the present

•

Interactive public outreach programs for children

•

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For more information, contact:
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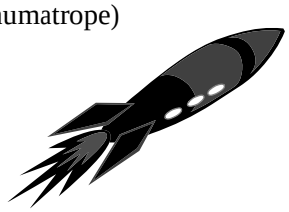
655 Beach Street, San Francisco, CA 94109-1336

EYE OPENERS

contents



INTRODUCTION

Optical illusions are pictures that play tricks on your eyes and confuse your brain. They are an enjoyable way of learning about the science of vision as well as a playful reminder that our assumptions about the visual world can sometimes be deceptive.

The optical illusions in this book illustrate three fascinating aspects of the human visual system: binocular vision, the eye-brain connection, and persistence of vision. Can you believe your eyes? Not always. You will discover that some optical illusions trick us because we have two eyes (binocular vision). Others are the result of our brain remembering one thing while our eyes are seeing another (the eye-brain connection). Still other illusions happen because we think we still see an object after it has disappeared from view (persistence of vision).

How to use this book. The first chapter of this book is an introduction to the eye and the human visual system. Each of the following three chapters focuses on binocular vision, the eye-brain connection, and persistence of

CONTINUED

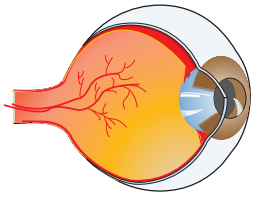
vision. They contain optical illusion demonstrations and activities designed to help students understand these concepts.

Who is this book for? This book is designed for multiple uses, including classrooms, home schools, and museum programs. While some of the optical illusions in this book can be appreciated by children of all ages, the book is targeted to students in the fourth, fifth and sixth grades. These children will best be able to grasp the fundamental principles of vision discussed here.

We hope that *Eye Openers: Exploring Optical Illusions* provides an enjoyable learning experience and stimulates interest in the science of vision.

NOTE TO THE EDUCATOR

This chapter includes background information on the eye and the human visual system. The activity sheets can be xeroxed and handed out as references, or they can be used as overheads in a classroom discussion.



HOW WE SEE

THE EYE AND THE HUMAN VISUAL SYSTEM

There are many ways in which we experience and interpret the world around us. Have you ever thought what your world would be like if one of your five senses was lost or impaired? Consider not being able to smell a rose, or taste a sweet orange, or hear a dog bark, or see a beautiful sunset. Our senses fill our world with delightful sensations. Let's take a closer look at one incredible sense: vision.

Vision is a complex sense. The eyes inform a complex visual system that makes billions of calculations every second. In fact, seventy percent of the body's sense receptors are found in the eyes.

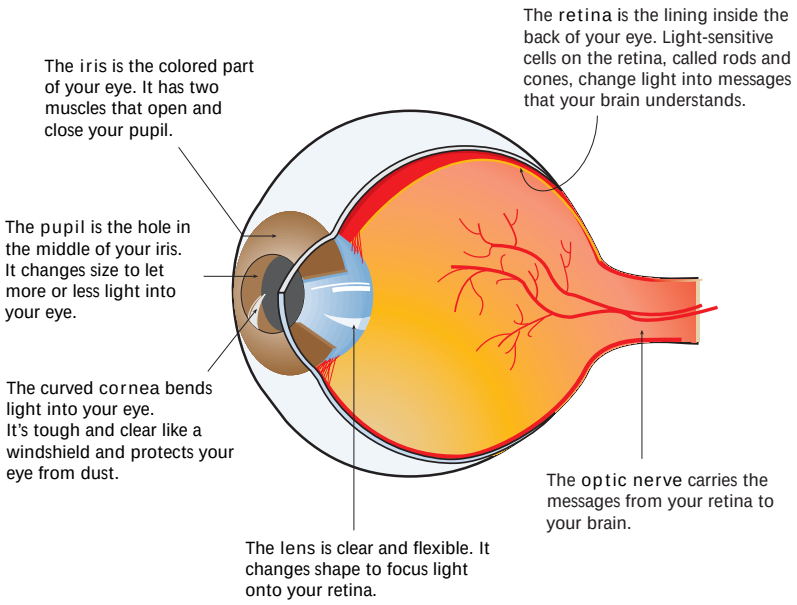
Important though our eyes are, there is another critical component needed to help us see — our brain. Without it, vision would not be possible for us. In fact, it's the brain that drives our visual system. In this chapter, you will learn about the eye's anatomy and how the human visual system works.

1

WHAT'S IN THIS CHAPTER?	key concepts	activity	activity
	Parts of the Eye How Do You see? How Does the Eye Focus?	Name the Parts	Draw Your Eye

key concept

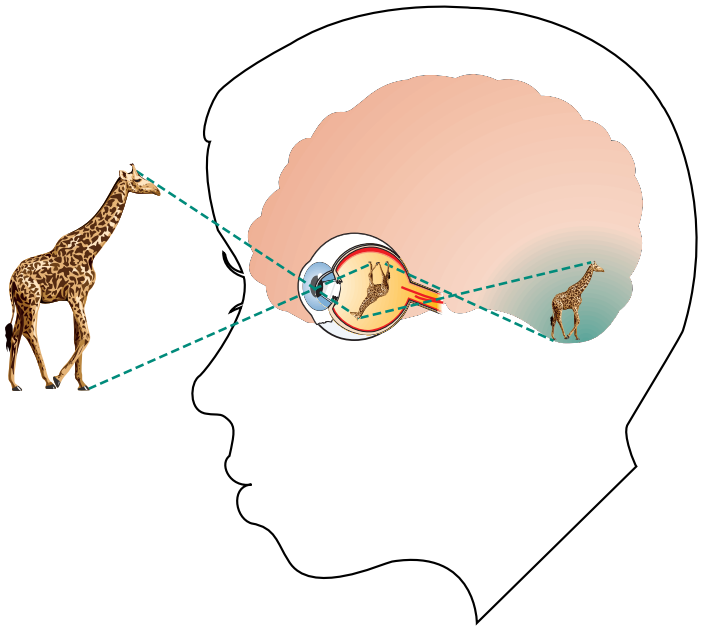
parts of the eye



key concept

how do you see?

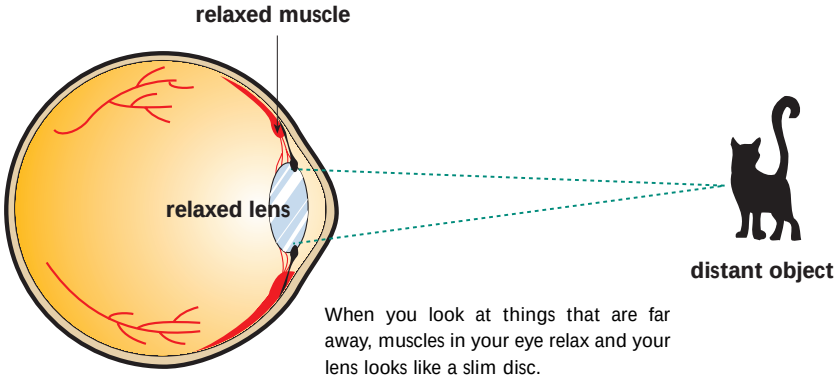
- First, light bounces off objects all around you and enters your eye.
- Then the light passes through your pupil and lens to the retina at the back of your eye.
- In the retina, the light makes an upside-down and backwards picture.
- The retina contains light-sensitive cells (called rods and cones) that change the picture into messages that your brain understands.
- The optic nerve carries these messages to your brain.
- Finally, your brain reads the messages and tells you what you're looking at.



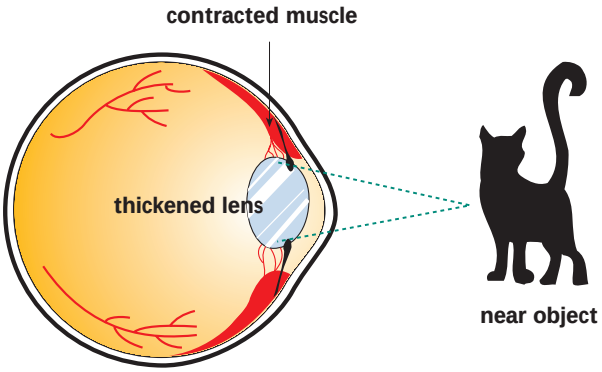
key concept

how does the eye focus?

- You focus light with your cornea and lens.
- Your curved cornea bends light into your eye.
- Your lens changes shape to bring things into focus.



When you look at things that are far away, muscles in your eye relax and your lens looks like a slim disc.



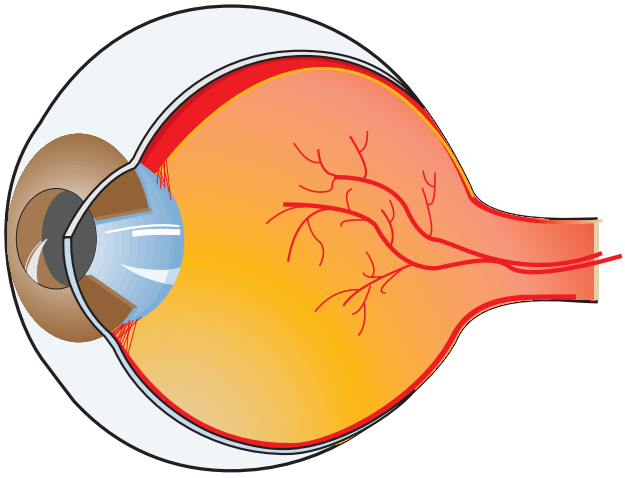
When you look at things that are close, muscles in your eye contract and make your lens thicker.

activity

name the parts

Can you name the parts of the eye? Color and identify the different parts of this eye cross section (answers on page 8).

Iris
Retina
Lens
Pupil
Cornea
Optic Nerve



eye fact

When we ask, "What color are your eyes?", we are really asking, "What color are your irises?" What color are your's? What color irises' do your friends have?

activity

draw your eye

Draw a picture of your eye (you might look in a mirror) and include these parts:

Pupil **Iris** **Eyelashes** **Eyebrow**

BINOCULAR VISION

Humans see the world with two eyes. This is called binocular (bi-NOC-u-lur) vision, (bi means two, ocular means eye). However, since our eyes are about two inches apart, each eye sees a slightly different view. Our brain combines the views from our two eyes and enables us to see things in 3-D.

3-D vision helps us see depth. With 3-D vision we know where things are in space. We can reach for a book or catch a ball.

Do you have to have two eyes to see depth? It helps, but even people who see with only one eye can sense depth. That's because their brain picks up visual clues from the world around them and learns how to see 3-D.

2

WHAT'S IN THIS CHAPTER?

activity

different views

RECIPE

DESCRIPTION	Teacher-led demonstration
PURPOSE	To show students that each eye sees a slightly different view
LENGTH OF ACTIVITY	5 minutes
MATERIALS	none

CONTINUED

different views

activity

STEPS

Read the following instructions to your students:

1. Close one eye.
2. Hold one arm straight out in front of you.
3. Point with your finger at something in the room — it could be a corner where the ceiling and walls meet, or a flag, or a poster.
4. Don't move your finger!
5. Now switch eyes.
6. Did it look like your finger moved? That's because each eye sees a slightly different view.

activity

hole-in-your-hand

RECIPE

DESCRIPTION	Students will create an optical illusion with an every-day object.
PURPOSE	To show that each eye sees a slightly different view, and that the brain puts the two views together to form one image.
LENGTH OF ACTIVITY	15 minutes
MATERIALS	• 1 cardboard tube (paper towel or toilet paper roll works well) OR 1 piece of paper per student (which the student will roll into a tube.)

CONTINUED

hole-in-your-hand

eye fact

When you look through the tube and see a hole in your hand, you are seeing an optical illusion. You looked through the tube into the distance with your left eye, and you looked at your right hand with your right eye. Your brain took what your left eye saw and what your right eye saw and put them together into one picture — a hole in your hand!

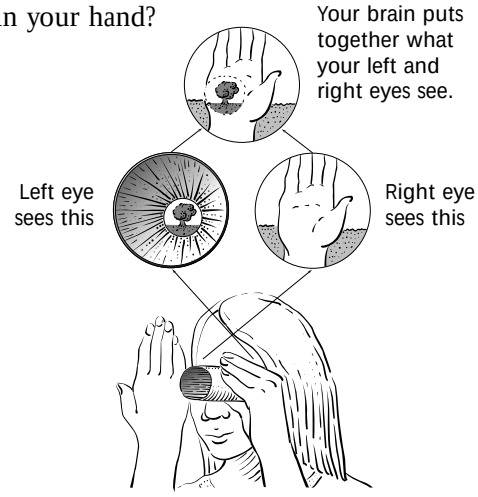
activity

STEPS

- Give each student a cardboard tube, or instruct the student to roll up a piece of paper and make it into a tube.
- Read the following instructions to your students:

1. Hold the tube in your left hand and place it in front of your left eye. (Look through the tube as though you were looking through a telescope.)

2. Keep both eyes open and look at an object in the distance. (You can pick an object in the classroom for the students to look at.)
3. Hold your right hand in front of your face, with your palm facing you.
4. Put the edge of your right hand (pinkie-finger side) next to or touching the tube.
5. Do you see a hole in your hand?



NOTE TO THE EDUCATOR

If the students have trouble seeing the hole in their hand, have them slide their right hand up or down the tube until they see it. If their right hand is too close to their eye, they won't see the hole.

activity

find your blind spot

RECIPE

DESCRIPTION	Students will make a simple prop and use it to find their blind spot.
PURPOSE	To show students how to find their blind spot.
LENGTH OF ACTIVITY	20 minutes
MATERIALS	• One 3” x 5” index card (or other stiff paper) per student • black markers • 1 ruler per student

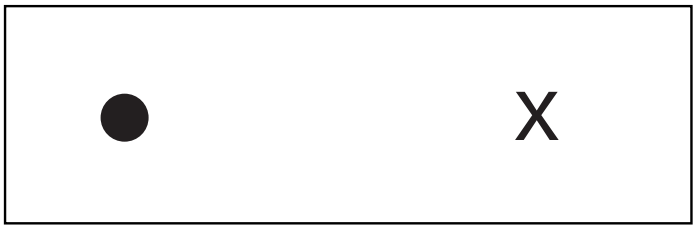
CONTINUED

activity

find your blind spot

STEPS

1. Make a dot and an X on the index card as shown:



2. Hold the card at eye level about an arm's length away. Make sure the X is on the RIGHT.

3. Close your RIGHT eye.

4. Look directly at the X with your LEFT eye. Notice that you can also see the dot.

5. Focus on the X, but be aware of the dot, as you slowly bring the card towards your face. At some point the dot will disappear, and then reappear. That's your blind spot.

6. Now close your LEFT eye and look directly at the dot with your RIGHT eye. This time the X will disappear and reappear as you bring the card slowly toward your face.

CONTINUED

find your blind spot

activity

NOW TRY THIS (optional)

1. Draw a straight line across the card, from one edge to the other, through the center of the X and the dot.

2. Do the activity again.

3. Notice that when the dot disappears, the line appears to be continuous, with no gap where the dot should be. Your brain automatically "fills in" the blind spot with what it thinks should be there.

eye fact

At the back of your eye is your retina. Your retina is made up of light-sensitive cells which send messages to your brain about what you see. Your blind spot is located at the place where your optic nerve joins your retina. (See illustration of the eye in Chapter 1 of this book.) There are no light-sensitive cells in this area, so this part of the retina can't see. When you hold the card so the light from the dot falls on this spot, you can't see the dot.

Most of the time you don't notice your blind spot. That's because the blind spot from one eye doesn't line up with the blind spot from the other eye. Each eye supplies the missing eye's information. And sometimes your brain fills in the missing spots with what it thinks should be there.

THE EYE-BRAIN CONNECTION

3

Seeing happens in the brain. Your eyes take in information from the world around you in the form of light. That information is then sent to the brain, which makes sense of what your eyes are seeing. (See illustration of the human visual system in Chapter 1 of this book.)

Sometimes your eyes see things that your brain doesn't understand. These are optical illusions — pictures that play tricks on your eyes and confuse your brain. Besides being fun, optical illusions can help us to better understand vision. They demonstrate just how closely our eyes and brain work together to help us see.

Scientists have studied the phenomenon of optical illusions and they still don't completely understand or agree on how they work. However, many scientists believe that some optical illusions fool us when the information taken in by our eyes conflicts with how our brain interprets that information. The brain can't make sense of what the eyes are seeing, so it falls back on its previous experience. It turns the unfamiliar into something familiar.

WHAT'S IN THIS CHAPTER?

activities

7 OPTICAL ILLUSIONS

#1: Train Tracks
#2: Rotating Staircase
#3: Barrel
#4: Kissing Lovebirds
#5: Smiling Frogs
#6: Two Straws
#7: Two Flowers

activity

7 optical illusions

RECIPE

DESCRIPTION	Students will look at seven optical illusions and discuss them with the teacher and their classmates.
PURPOSE	To introduce students to the phenomenon of optical illusions.
LENGTH OF ACTIVITY	30 minutes
MATERIALS	• 1 set of photocopied optical illusion sheets per student (7 in each set; see masters on the pages that follow) • rulers • pencil or pen (optional)

STEPS

Distribute photocopies of the following seven optical illusions sheets to each student. See page 29 for notes on all the optical illusions.

CONTINUED

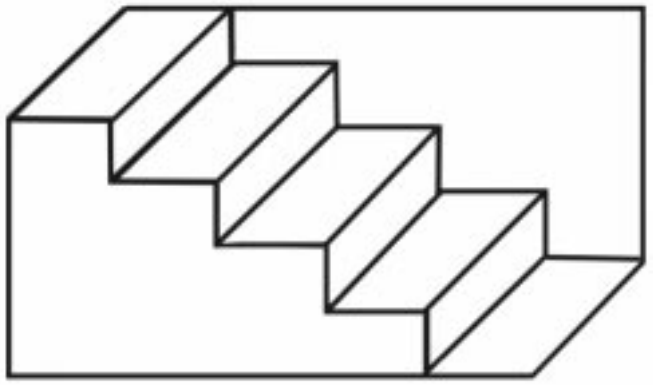
activity

#1 train tracks

• What seems to be happening to the train tracks in this picture?

activity

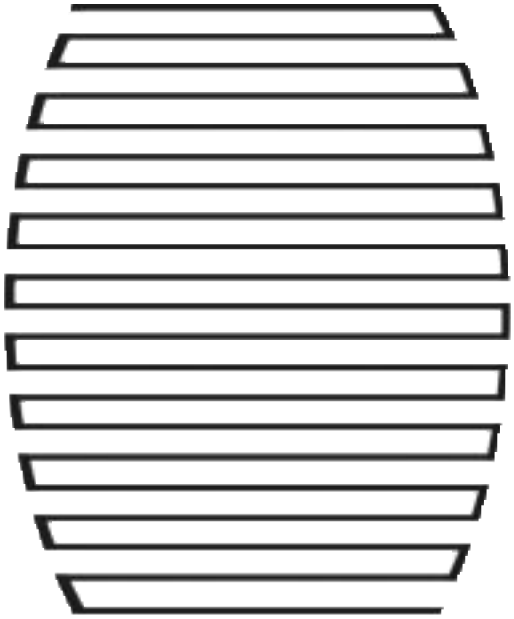
#2 rotating staircase



- What do you see when you look at this picture? A staircase running from left to right or an upside-down staircase?
- Put the paper on the table in front of you and spin it slowly in a circle. What happens to the staircase?

activity

#3 barrel



- What do you see when you look at this picture?
- Do you see eleven separate bars or one continuous line?
- Trace the line with a pencil or your finger.
- What did you discover?

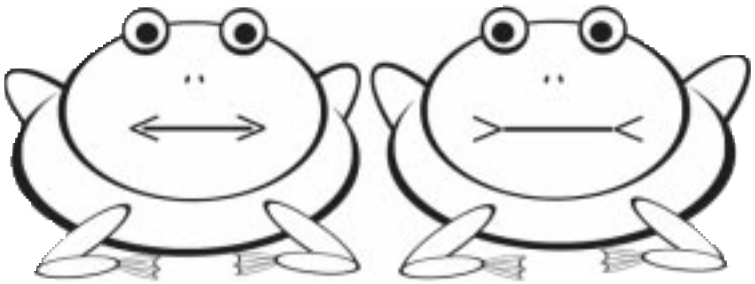
activity

#4 kissing lovebirds

- Hold the drawing of the lovebirds at arm's length.
- Stare at the blank spot between the lovebirds' beaks.
- Slowly bring the paper closer to your face.
- Do you see the two birds kissing?

activity

#5 smiling frogs

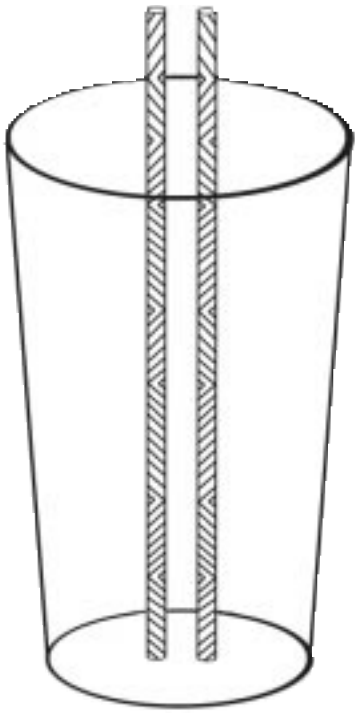


OPIE CLEO

- Which frog has the longest mouth, Opie or Cleo?
- Measure each smile with a ruler.
- What did you discover?

activity

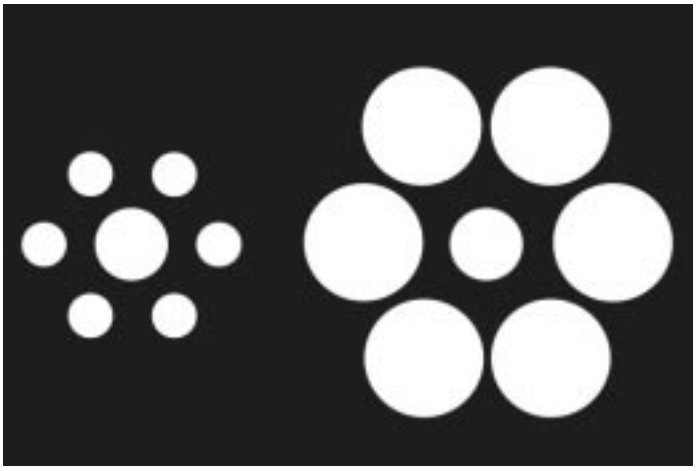
#6 two straws



- Hold the drawing of two straws at arm's length.
- Are the straws straight or crooked? (Most people see crooked straws.)
- Lay the ruler along the length of the straw — is the straw straight or crooked?
- Now hold the drawing flat, like a tray, and put it right under your nose.
- How do the straws look now? (The straws should appear straight.)

activity

#7 two flowers



- Look closely at the two clusters of circles.
- Now look at the two middle circles.
- Which one is bigger?
- Measure across the middle (the diameter) of each circle.
- What did you discover?

OPTICAL ILLUSION NOTES

1. TRAIN TRACKS

The train tracks appear to come together in the distance. In reality, they don't come together. Although our eyes tell us that the train tracks are converging, our brain knows that they're parallel, and that parallel lines never converge.

2. ROTATING STAIRCASE

The staircase seems to flip around as the paper is turned. You can see the staircase two different ways, but you can only see it one way at a time.

3. BARREL

Your brain sometimes sees eight separate bars, and other times sees one continuous line when you look at this picture.

4. KISSING LOVEBIRDS

As you bring the drawing closer to your face, the birds' beaks appear to get closer and closer together, until finally, just in front of your nose, they appear to be touching.

5. SMILING FROGS

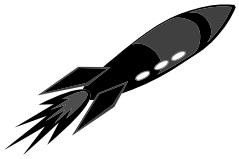
Both mouths are the same size. Cleo's mouth seems bigger because our eyes follow the lines going away from the mouth at either end. Opie's mouth seems to be smaller because the lines at either end direct our eyes towards the center of the mouth.

6. TWO STRAWS

Patterns can make straight objects appear crooked.

7. TWO FLOWERS

Both circles are the same size. The surrounding circles make the circles seem to be different sizes. When the inner circle is surrounded by smaller circles, it seems large. When the inner circle is surrounded by larger circles, it seems small.



PERSISTENCE OF VISION

Persistence of vision is the eye's ability to keep seeing an image of an object for a fraction of a second after the object has disappeared from view. The image of an object stays on your retina even after you've stopped looking at it. Your eye and brain actually retain a visual impression for about 1/30th of a second.

The principle of persistence of vision is used in making motion pictures and animated cartoons. Movies are made up of a series of separate pictures, flashed on the screen at a speed of 24 per second. When you're watching a movie, each image lingers on the retina long enough to merge with the next image, and you have the illusion of motion (hence the name: motion pictures.) You don't even notice that the movie screen is dark half the time!

In this section, you will make two motion toys that will demonstrate the principle of persistence of vision.

4

WHAT'S IN THIS CHAPTER?

activity

Make a Spinning Disc (Thaumatrope)

activity

Make a Flipbook

eye fact

Spinning discs, or thaumatropes (tho-ma-tropes), are one of the earliest motion toys. They were invented in 1827 by Dr. J.A. Paris. The name thaumatrope comes from the Greek, and means "wonder turner."

Thaumatropes work according to the principle of persistence of vision. When you spin the thaumatrope, the two separate drawings on opposite side of the same disc, seem to blend into one image.

activity

make a spinning disc

RECIPE

DESCRIPTION	Students will learn about persistence of vision by making a spinning disc or thaumatrope — an early motion toy.
PURPOSE	To introduce students to persistence of vision.
LENGTH OF ACTIVITY	45 minutes
PREPARATION TIME FOR INSTRUCTOR	20 minutes Instructor should make a spinning disc or thaumatrope in advance to use in a demonstration for the students.
MATERIALS	• index cards or heavy stock paper • compass, drinking glass or template for approximately 3" diameter circle • 2 pieces of string per student, each about 15" long • hole punch • scissors • pencils • crayons, markers, colored pencils • thaumatrope for demonstration

CONTINUED

make a spinning disc

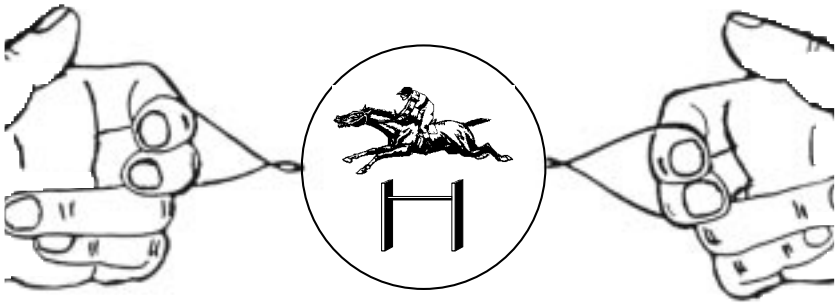
activity

PRE-ACTIVITY STEPS

FOR INSTRUCTOR

Students will have a clearer understanding of this activity if you prepare a sample spinning disc or thaumatrope in advance.

1. Xerox the thaumatrope master found on page 34.
2. Cut out the two circles and glue them on two different sides of an index card or piece of card stock. Be sure that one image is right-side-up and the other is up-side-down or the trick won't work.
3. Cut out the circles.
4. Cut two pieces of string about 15" long.
5. Punch a hole in either side of the card.
6. Tie a string through each hole.
7. Wrap the string around each hand (see illustration).
8. Wind the toy up by flipping the disc over and over, making twists in the strings.
9. Pull the strings to make the toy spin.



CONTINUED

make a spinning disc

eye fact

When things move very quickly before your eyes, it's difficult for your brain to keep each picture separate. Your brain actually continues to see one picture for a very brief moment even after the disc has flipped to the other side. This is called *persistence of vision* meaning that the image persists, or continues to be seen, for a split second even after it's actually out of sight.

activity

STEPS

FOR STUDENTS

Have the students:

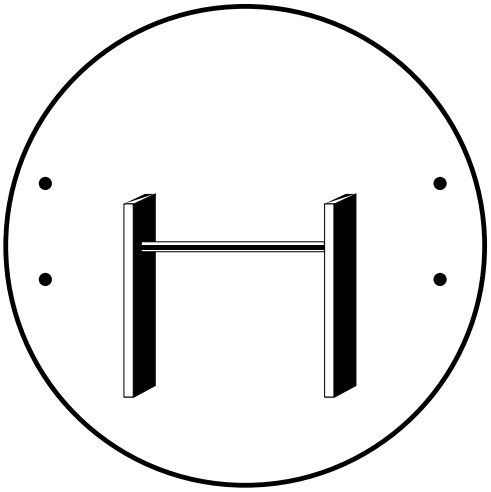
1. Use a compass or drinking glass or circle template to cut out a circle 3" to 5" in diameter from an index card or card stock.
2. Draw the two images *in pencil first* on opposite sides of their cut-out circle. (Remember that one should be right-side-up and the other up-side-down.)
3. Color in the images.
4. Punch a hole in either side of the circular card.
5. Run a string through each hole and tie each piece of string in a loop.
6. Put their hands through the loops of string.
7. Wind the toy up by flipping it over and over, making twists in the strings.
8. Pull the strings to make the toy spin.

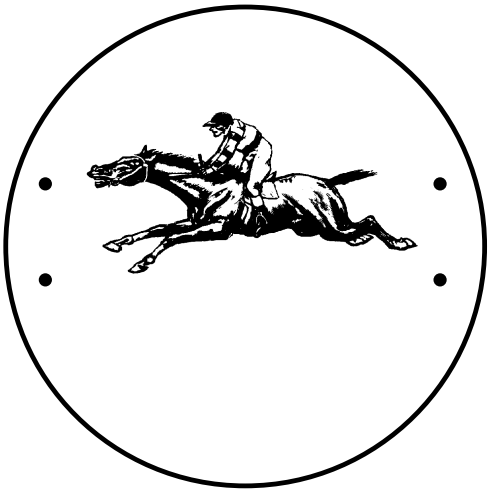
DEMONSTRATION FOR STUDENTS

1. Show the students the thaumatrope you've made.
2. Discuss with them the concept of persistence of vision and how the thaumatrope works.
3. Have the students try the thaumatrope.
4. Brainstorm ideas for possible thaumatropes with the students. (Examples include a frog on a lily pad, a fish in the water, a bird in a nest.)

activity

THAUMATROPE MASTER





activity

make a flipbook

RECIPE

DESCRIPTION	Students will learn about persistence of vision by creating a flip book.
PURPOSE	To demonstrate the role of persistence of vision in animation.
PREPARATION TIME FOR INSTRUCTOR	20 minutes Educator should make a flipbook in advance to use in a demonstration for the students.
LENGTH OF ACTIVITY	40 minutes
MATERIALS	• approximately 20 3”x 4” pieces of paper per student (enough for students to have spares if they make mistakes) • scissors • stapler • markers, crayons, colored pencils

CONTINUED

make a flipbook

eye fact

Movies and cartoons work the same way as a flipbook. A movie projector flashes one still picture after another very quickly onto the screen. Your brain blends one picture into the next one, giving you the illusion of movement.

activity

PRE-ACTIVITY STEPS

FOR INSTRUCTOR

Students will have a clearer understanding of this activity if you prepare a sample flipbook in advance.

• Create a demonstration flipbook

1. Photocopy the "Moon Blink" flipbook master found in this chapter.
2. Cut out each image.
3. Staple each image together at the left-hand margin.

• Prepare flip book pages for classroom activity.

1. Cut paper into approximately 3"x 4" pieces for classroom activity (approximately 20 pieces of paper per student)

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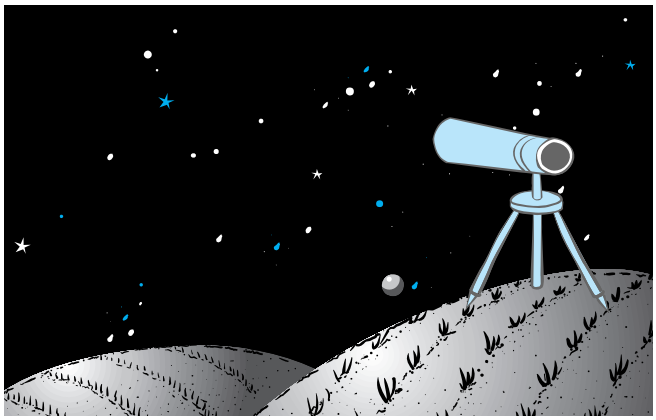

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CONTINUED

make a flipbook

activity

STEPS

DEMONSTRATION FOR STUDENTS

1. Using the flipbook that you made from the master in this activity book, demonstrate how a flipbook works.
2. Discuss with students the concept of persistence of vision, and how the flipbook works.
3. Tell them they are going to make their own flipbooks. Explain that to make a flipbook they'll have to make a series of pictures, each slightly different from the next.
4. Brainstorm ideas for flipbooks (examples: a bouncing ball, stick figure doing jumping jacks, a person opening and closing their eyes, a bird flapping its wings.)

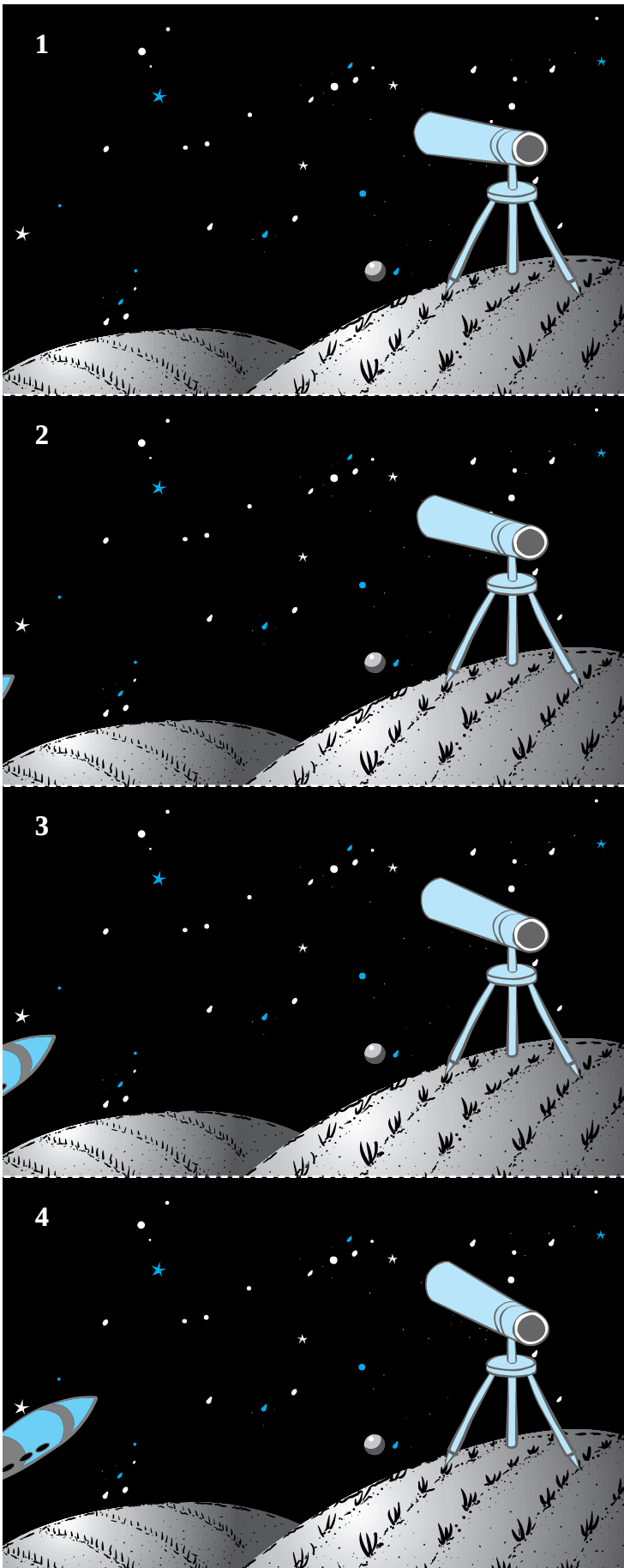
FLIPBOOK ACTIVITY FOR STUDENTS

Have the students:

1. Select about 20 sheets of pre-cut paper.
2. Draw their pictures. Remind them to draw the picture nearer the right-hand side of the paper as the staple will go at the left margin.
3. Put the pictures in order.
4. Staple the pictures at the left margin.
5. Flip through the pages and see the animation.

ALTERNATE ACTIVITY

- Photocopy the Moon Blink master for each student and have the students assemble a Moon Blink flipbook. Students can also color in the images.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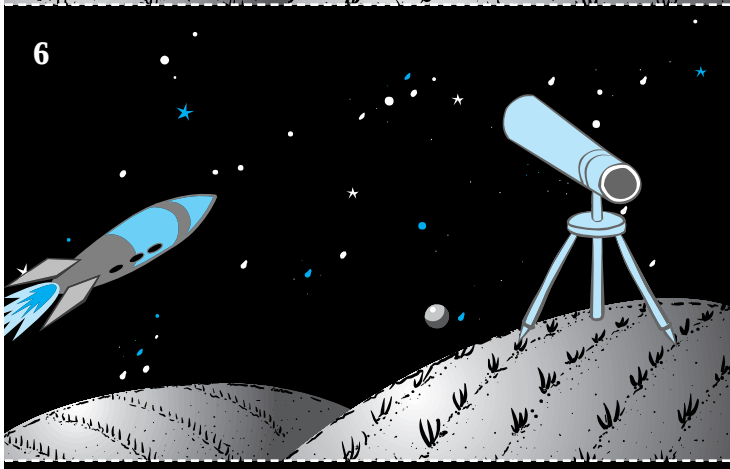
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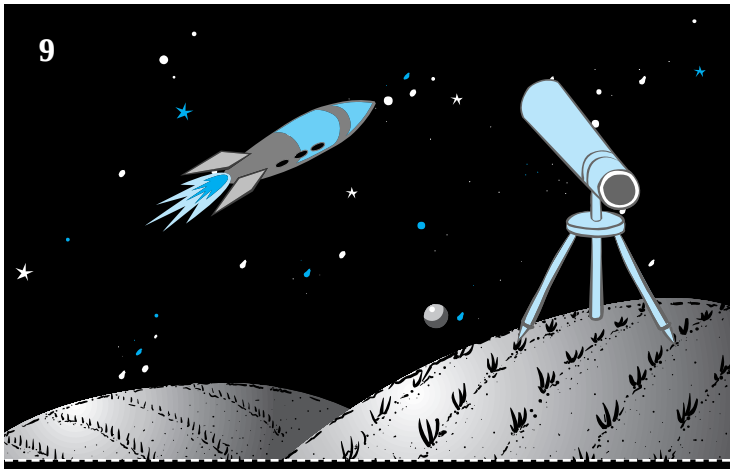
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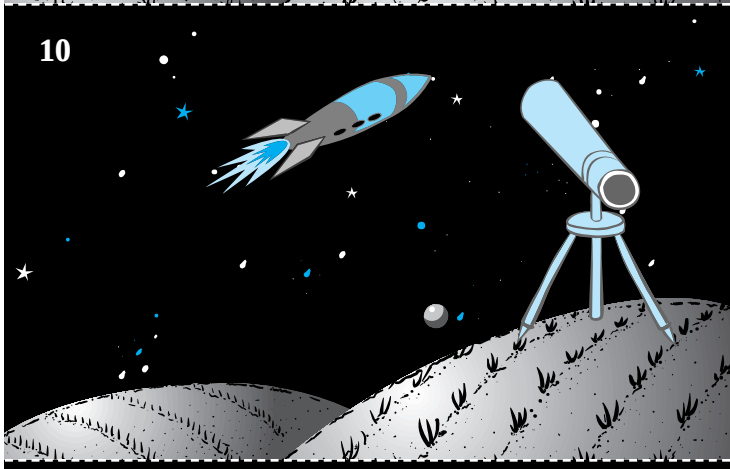
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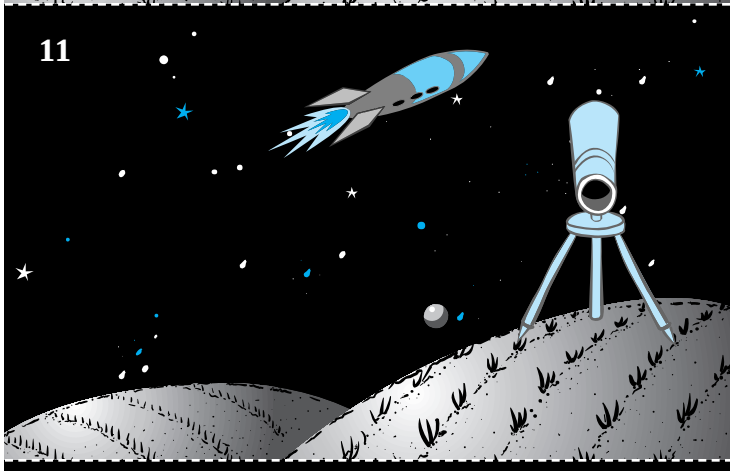
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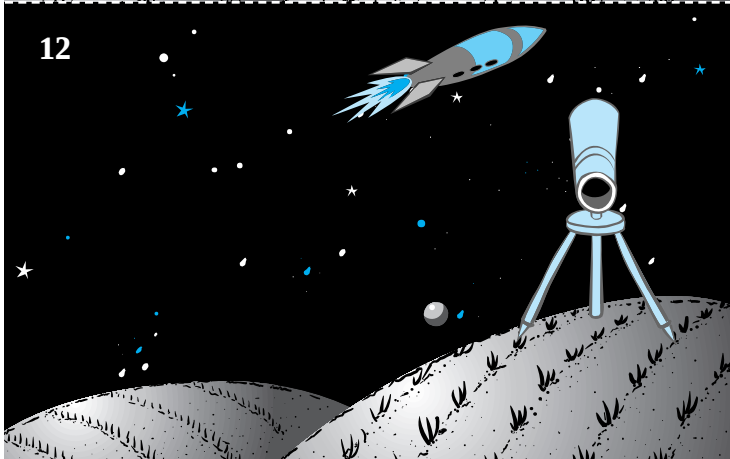
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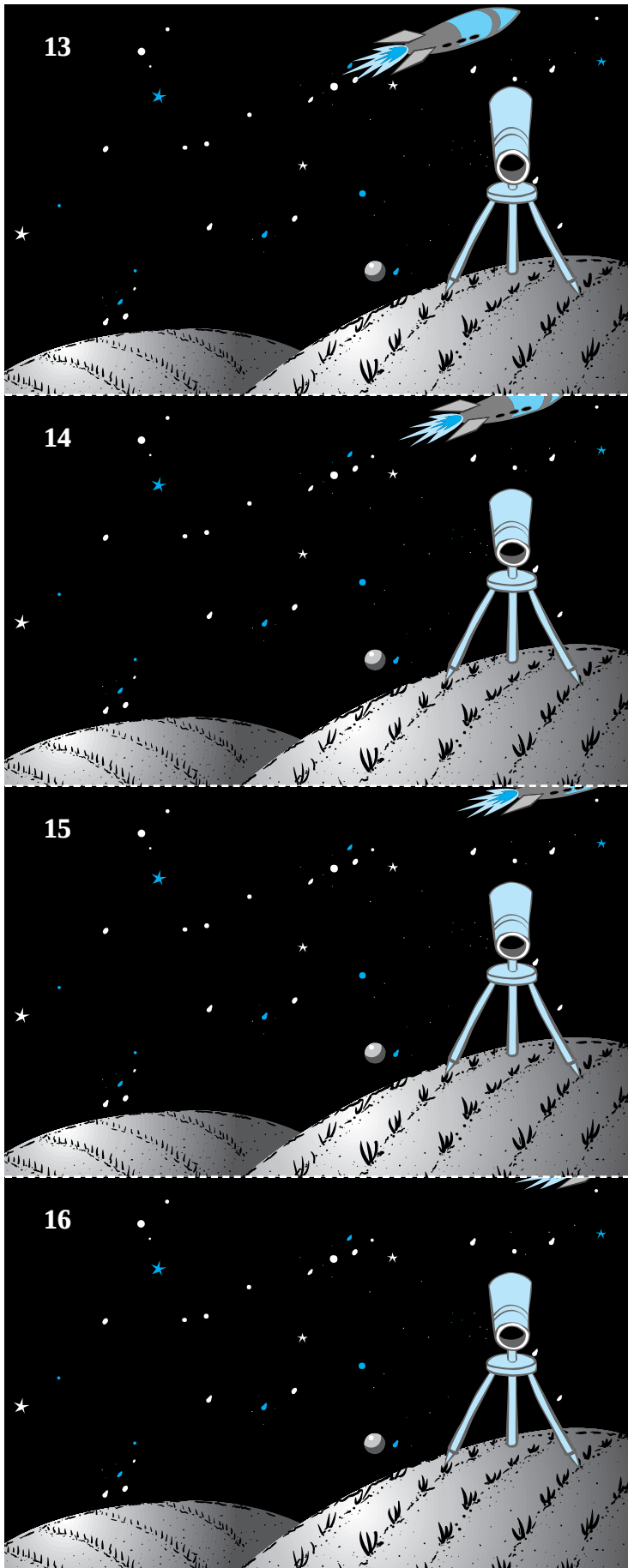
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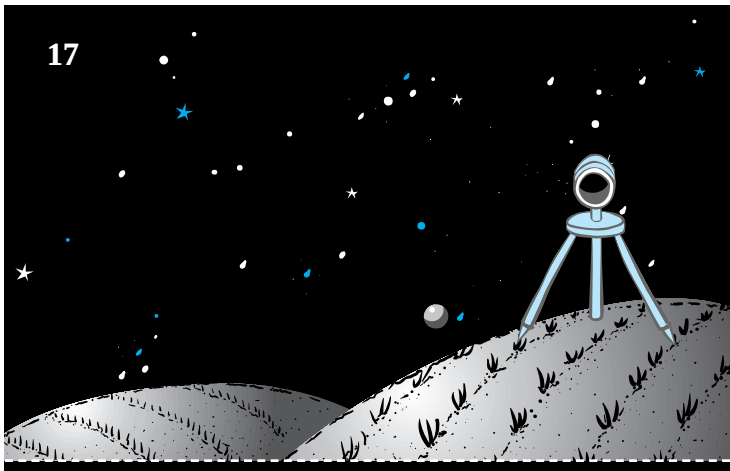
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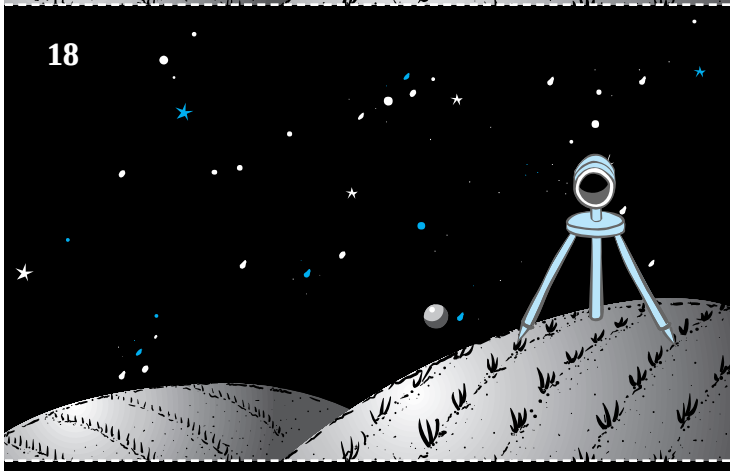
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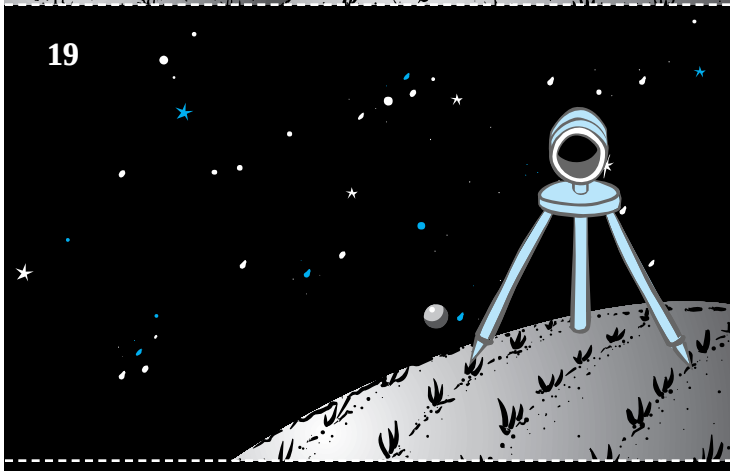
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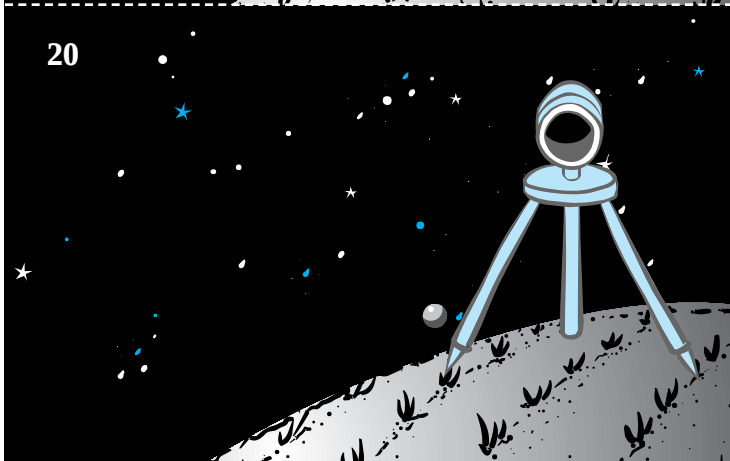
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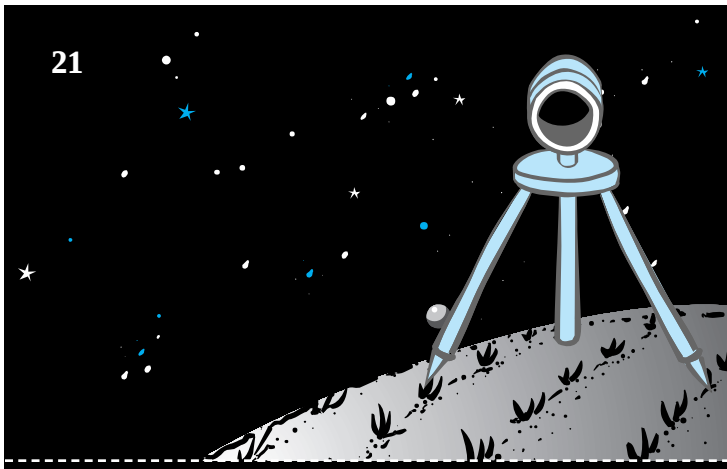
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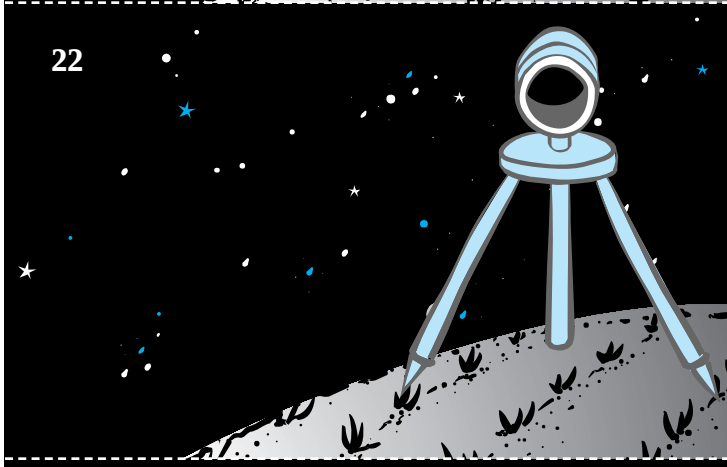
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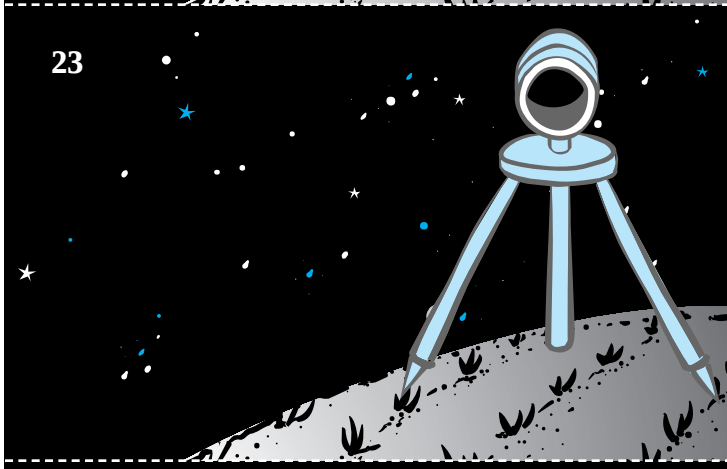
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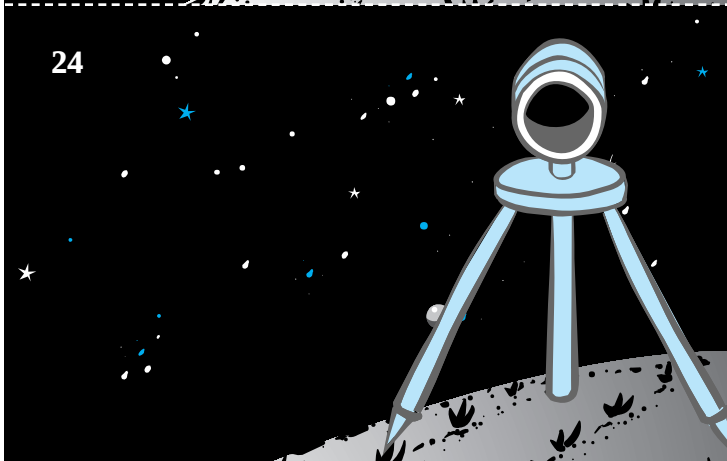
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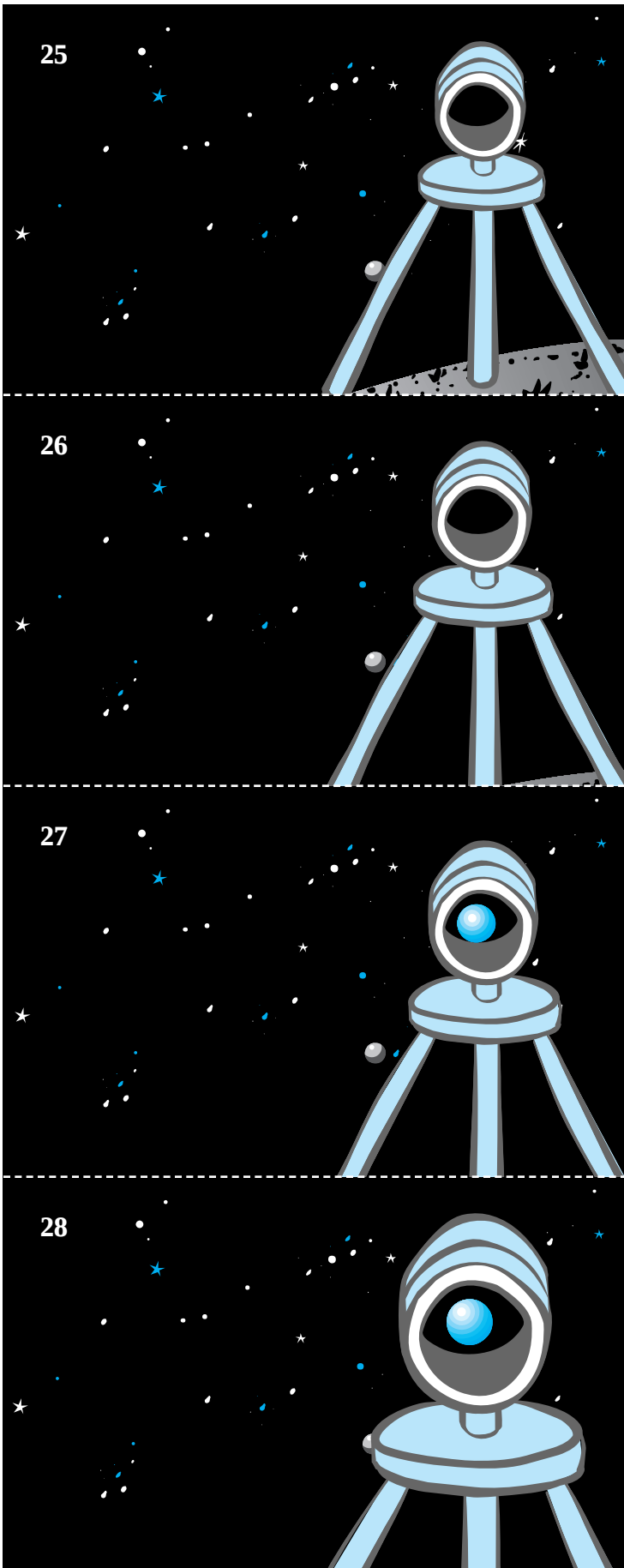
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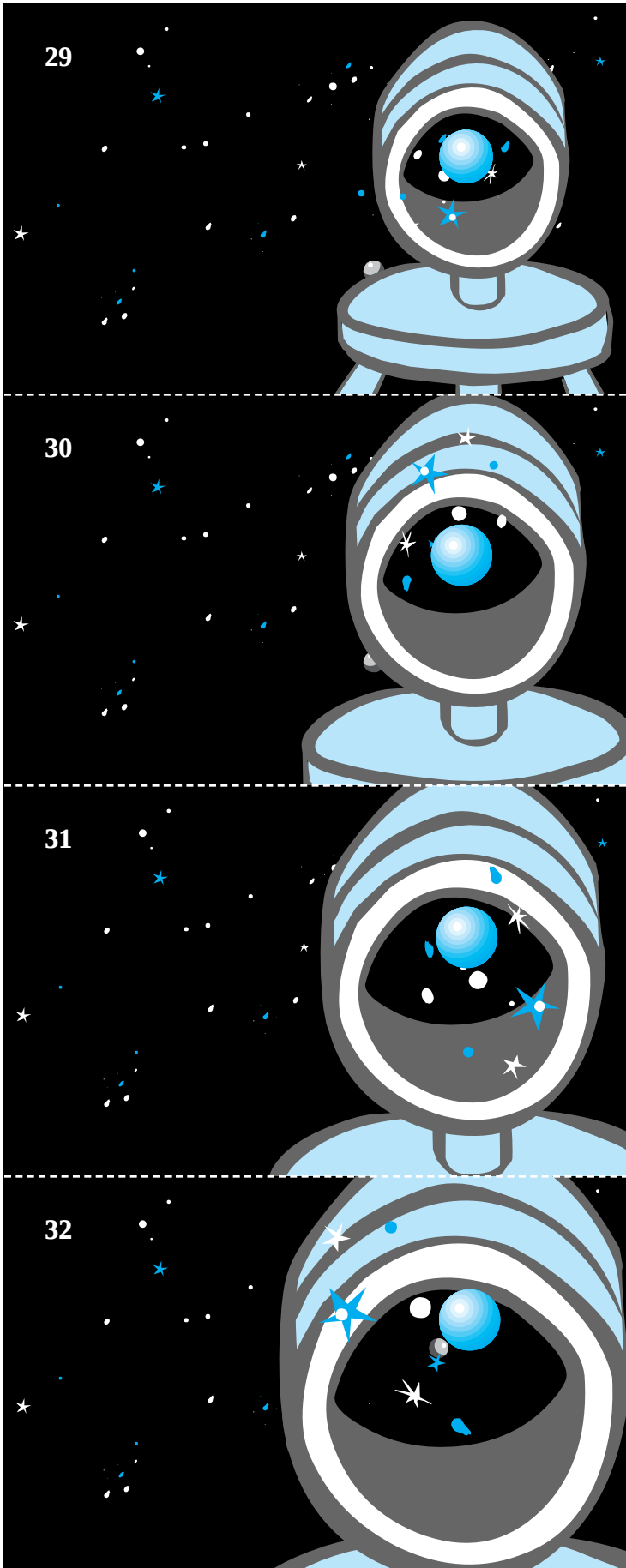
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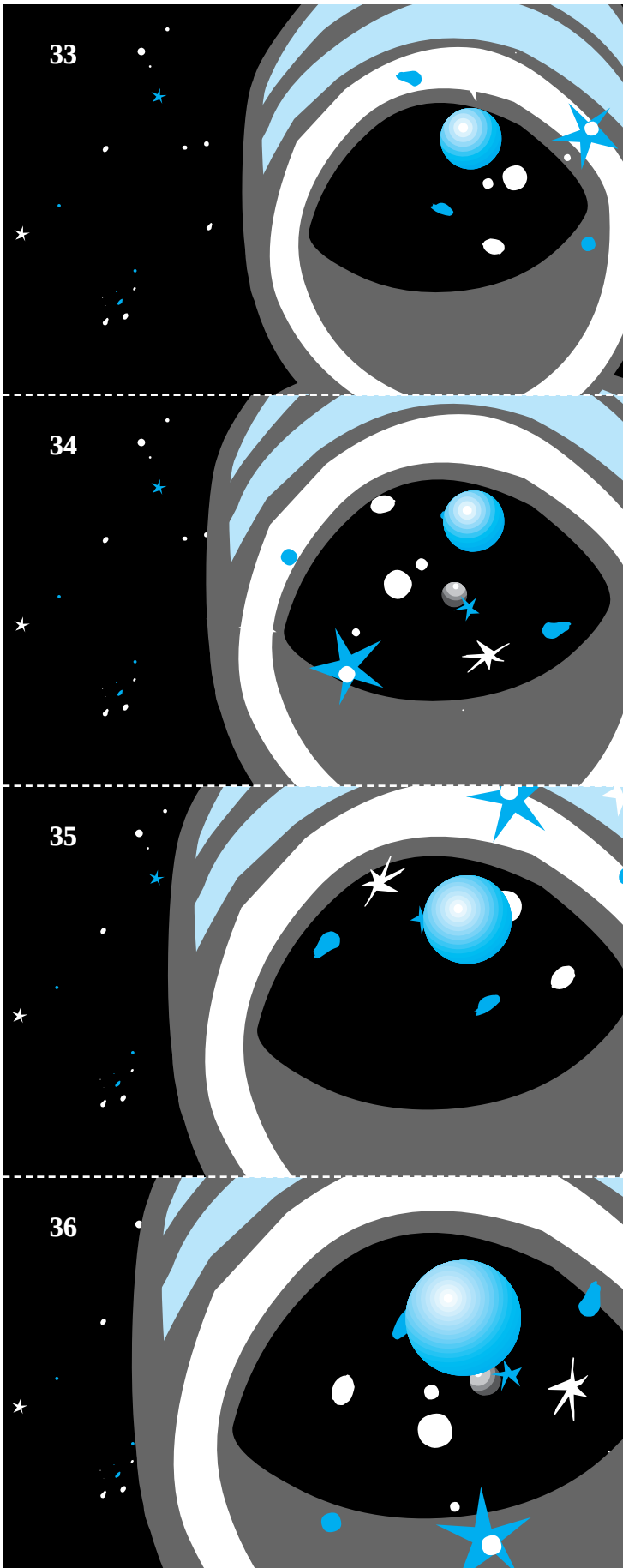
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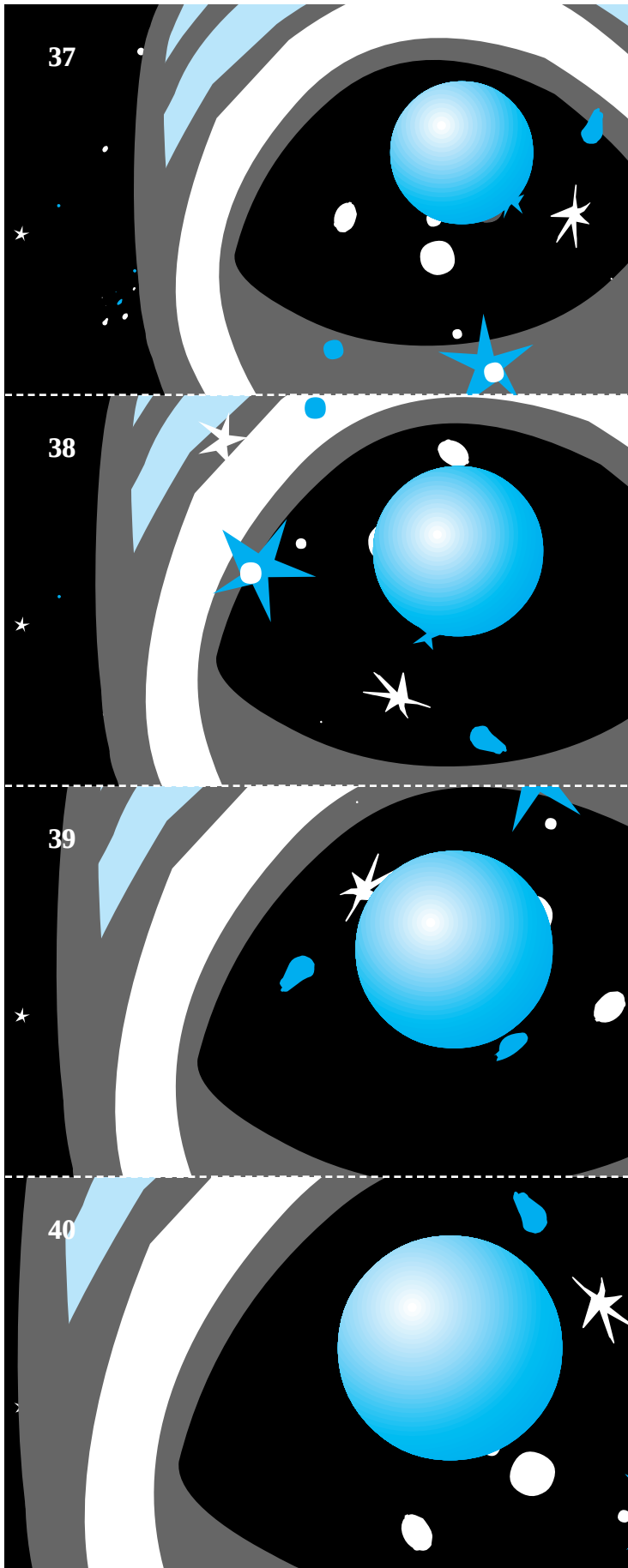
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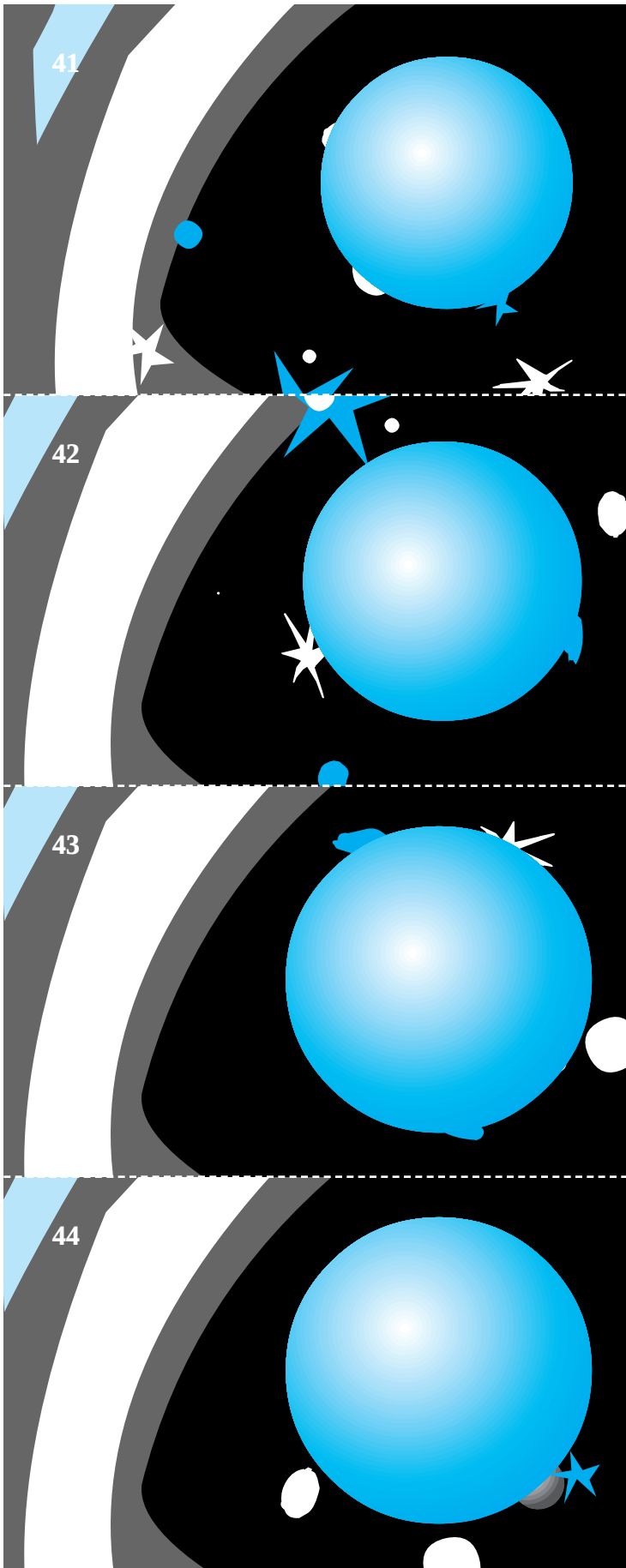
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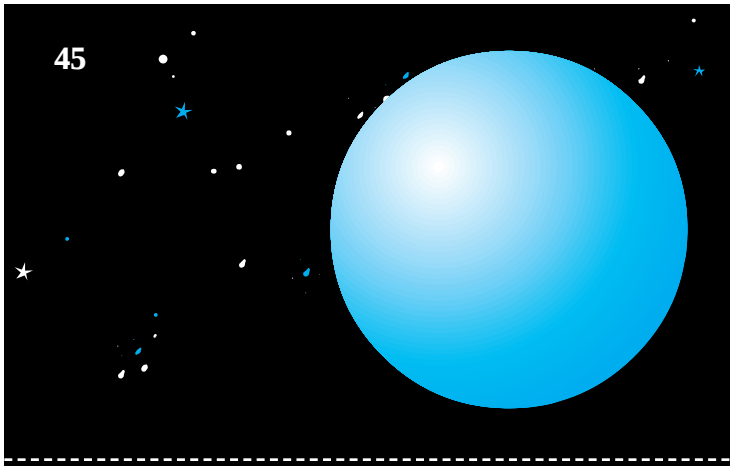

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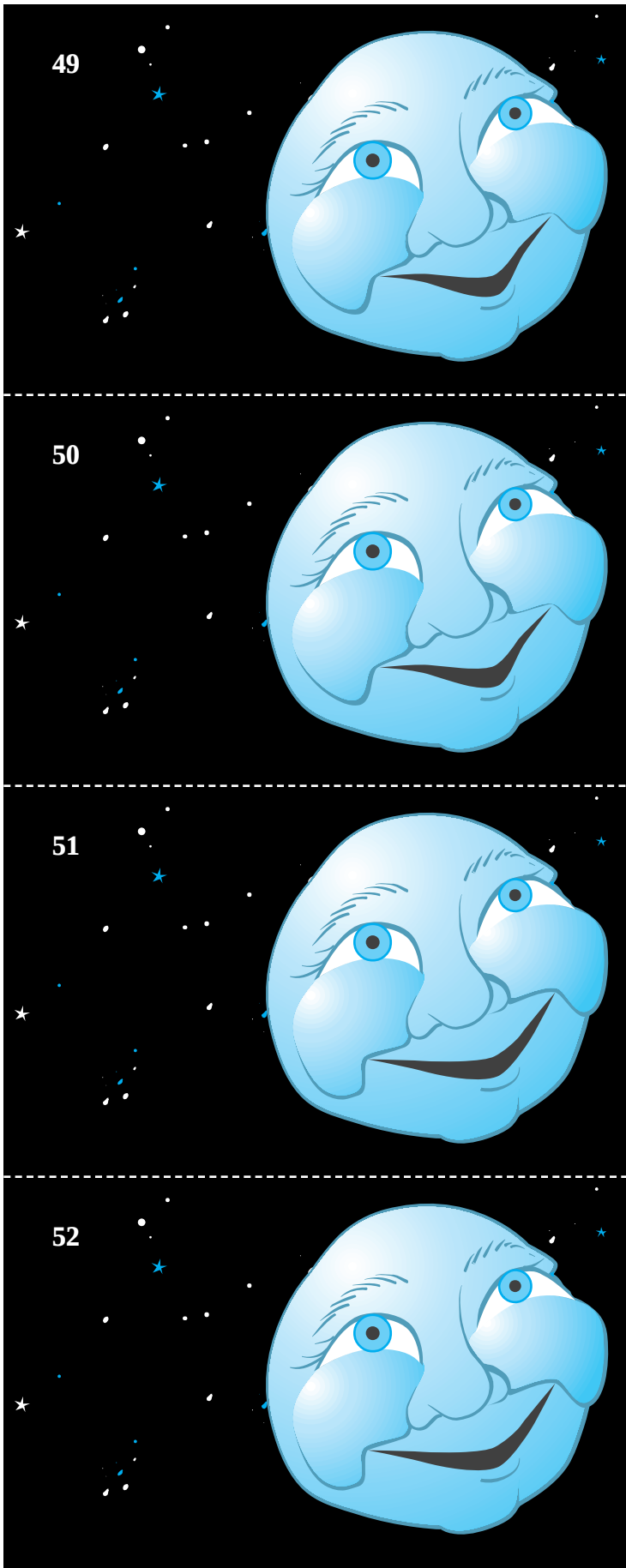
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Web Sites

- The Exploratorium Science Snacks have a number of activities about vision and optical illusions: http://www.exploratorium.edu/snacks

You have been exploring your eyes and vision. The world we experience around us is a rich mixture of all of our five senses. Take a moment to focus and think about your other senses.

What are you hearing? Are you cold or warm? Breathe deeply, what can you smell? Do you taste anything? What are you seeing? Close your eyes and answer these questions.

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