Playing with Time

Lake Core Bench

EDUCATOR'S GUIDE

Science Museum *of* Minnesota®

Playing with Time

Explore the unseen world of natural change—events that occur too quickly or too slowly for people to perceive. Much of scientific inquiry is involved with how things change. After playing with time, you and your students will come away with a new appreciation for the world beyond your usual perceptions.

Playing With Time will help your students understand more about:

- The unseen world of natural change.
- The limitations of human perception and the tools which investigate changes that lie beyond human senses.
- How these investigations have expanded our understanding of the natural world.

Playing With Time connects with a number of disciplines, for example, climatology, astronomy, botany, genetics, phenology, geology, cosmology, and even microbiology.

This guide contains:

- An overview of exhibit areas and components.
- The super timescale which you also will see throughout the exhibition as a guide to the range of change.
- Connecting with the classroom:
  - Previsit preparation suggestions
  - After the field trip
  - Alignment with national science standards
- Field trip activity page templates ready to copy or adapt for your students or chaperones
  - Chaperones: K–4
  - Students: K–4 Time Explorers; grades 5–8 Observing Change; grades 9–12 Observe Change and Play with Time!
- Resources

When you visit *Playing With Time:*

- Share expectations, plans, and schedules for the visit with students and chaperones.
- Do some preparation activities before your visit. Use suggestions in this guide and the resource list for more ideas.
- Divide your class into small groups to work together in the exhibition.
- Review this guide to connect *Playing With Time* to your curriculum.

Hands-on stations

Natural objects that have recorded change

High-speed photography

Time-lapse videos

Animations of natural phenomena occurring over vast timescales—from billionths of seconds to billions of years

The *Playing With Time* exhibition is a co-production of the Science Museum of Minnesota and Red Hill Studios, with major funding support from the National Science Foundation.

Science Museum of Minnesota · RED HILL STUDIOS · NSF

Exhibition Components

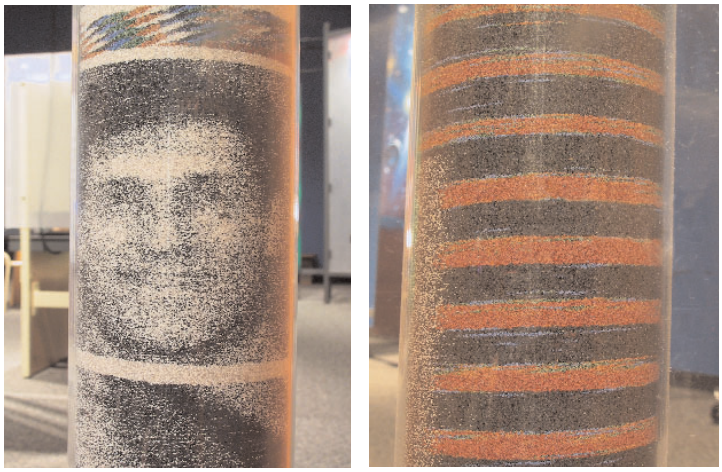
Super-sized Timescale. This giant graphic of a timescale—the thermometer-like measuring stick for how quickly or slowly things change—introduces a key idea of the exhibit: that many events happen at scales too slow or too fast for humans to see on their own. Small timescales appear throughout the exhibit to remind you of this important concept.
Reflectory. An eight-minute presentation of seven video monitors portrays the unseen world of natural change. Reflect on the changes in the world around you.

Time Tools

Funny Faces. A high-speed camera captures you shaking your head or blowing "raspberries," then plays the video back in slow-motion to create funny—and very interesting—effects.
Popcorn Popper. Pop your own popcorn, record this super-fast event with a high-speed camera, and then play it back and see how that tiny hard kernel explodes into a white fluffy cloud.
Water Drop. A stream of water looks like—well, a *stream* of water. But shine a strobe light on it, and it appears to be lots of distinct drops, one after the other. Find out which is the illusion in this mesmerizing component.
Strobe Wheel. Lights that appear to be on continuously are actually blinking on and off as the electrical current pulses to them. Explore this effect by using a strobe wheel to look at several different light sources.
Strobe Light. At this station you can experiment with a strobe light to see how a sewing machine, an electric toothbrush, and a spinning wheel actually work.
High-Speed Camera Bench. Use a high-speed camera to do experiments with events too fast to see with your naked eyes.
Perception Bench. The human body acts as our first "time tool." How effective is it? Try a variety of experiments to test the ranges of time and change you are able to perceive without additional tools.

How the Earth Changes

Dynamic Planet. Go forward or backward in time and explore the Earth's slow changes in a large-screen computer interactive.
Lake Core Bench. Using a high-powered video microscope, do the detective work of scientists: look for tiny grains of pollen found in a lake-bottom core as evidence of long-ago and ongoing climate changes.
Stratograph. This beautiful sculpture creates colorful "cores" (tall, cylindrical, layered samples), using grains of sand. The Stratograph tracks visitor activity and mimics the natural cores around it found in nature—lake, ice, and and coral cores.



Stratograph Sand Paintings

Exploring Earth Changes. This computer kiosk invites you to explore changes including volcano eruptions, forest regrowth, and glacier migrations.
Erosion Objects. Get hands-on and feel the effects of various very slow changes like erosion and weathering through this array of man-made and natural objects.
Coral Core X-ray. See a real coral core and "read" the changes that occurred in that coral's environment by using an interpretive overlay.
Frozen in Time. A life-size photo of an actual ice core is the centerpiece of this investigation of how scientists learn about the last 700 years of climate changes.

How the Universe Changes

Cosmic Challenge. A fun, fast-paced computer game tests what you know about how the sun, moon, stars, and universe change over time.
Expanding Universe Plates. How scientists have gathered evidence for the slowest change of all, the expansion of the universe.
Exploring Solar Changes. A hands-on computer kiosk lets you explore how the sun changes, demystifying sun spots, solar flares, and stellar formation and evolution.
Blink Comparitor. For most of the 20th century scientists learned about changes in the universe by comparing pictures of the night sky with a "blink comparitor." Make your own discoveries with this tool.

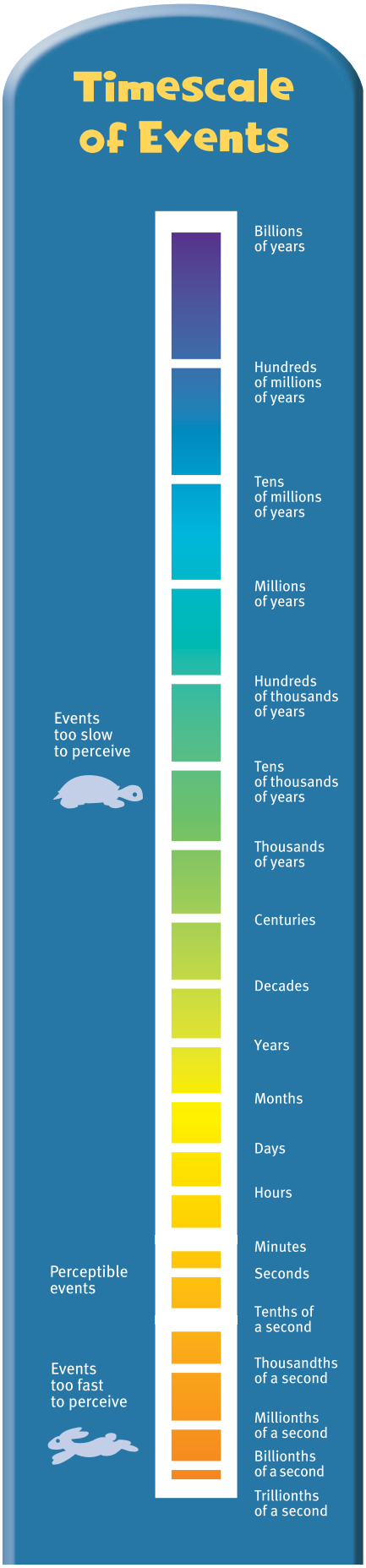
How Life Changes

Blocks of Time. Put six plastic blocks, covered with pictures of sequences of human body changes, in the correct order.
Plant Dance. By swaying and growing and reaching for the sun, plants "dance" through the hours and days as they grow. In this activity, you can don your own fabric leaves and dance and sway alongside time-lapse footage of plants. These memorable duets are made possible through the use of a camera and green-screen technology.
Which Took Longer? With a series of 20-second video clips, this computer game tests your knowledge of how long certain events really take to occur, from mushrooms sprouting to people aging.

Plant Dance

Blocks of Time

Exploring Human Changes. How does a beard grow? Or an embryo develop? Or a nerve cell fire? Explore changes in the human body—both inside and out.
Be a Dog Breeder. Breed virtual border collies in this computer-based activity, manipulating both genotypes and phenotypes.
Evidence of Aging. Check out X-rays of hands, hips, and feet over different ages, showing how our bodies change as we get older.
Rotting Fruit. See a time-lapse experiment without the camera: the decay that occurs on fruits and vegetables left out for weeks.
Painting With Time. Splash on some spring! Streak in some fall! Use a touch screen computer to "paint" the same forest scene with different seasons.



Experience a World of Change

From the blink of an eye to the age of the universe, different events happen at wildly different speeds.

Playing with Time unveils a world of changes that happen too fast or too slow for the eye to see.

Connecting with the Classroom

Field trips are most effective when integrated with your curriculum. Below are activities that can be used as an introduction to *Playing With Time* exhibit topics: change, time, and perceiving change. Many can be used after your trip or as ongoing topic explorations.

Grades K–4

Many things change, but we are unable to see the change directly. For each of the activities below, introduce the changes by asking students to directly observe changes they may notice over a minute or two. Introduce documentation or measurement to highlight change that may be hard to detect in other ways.

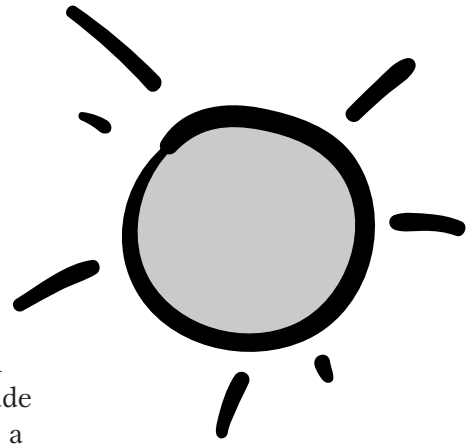
Make a student growth chart for the class.
Have students measure their heights and record them on a class growth chart. Take additional measurements over time (one month, two months and six months later) to show the students' growth throughout the year.

Look at pictures of students as babies to see how they have changed.
Have students bring in pictures of themselves as babies and compare them to their school pictures to show their changes over time. To show more human changes over time, students can bring in different pictures of their relatives (parents or grandparents).

Plant seeds and watch their growth over time.
Have students measure and photograph or draw the plant daily. Make a class chart of results. (This is a good companion to the Plant Dance activity in the exhibition.)

Investigate evidence that the continents have changed shape and position over time.
Have students cut out continents from a map of the earth. Make them into puzzle pieces and try to put together the pieces to form one continent. Scientists think that 200 million years ago the Earth's continents were joined together to form a supercontinent, Pangaea. Discuss what might have happened and why the pieces don't fit together perfectly. (http://kids.earth.nasa.gov/archive/pangaea/Pangaea_game.html gives background information about continental drift.)

Track sunrise and sunset times for two weeks

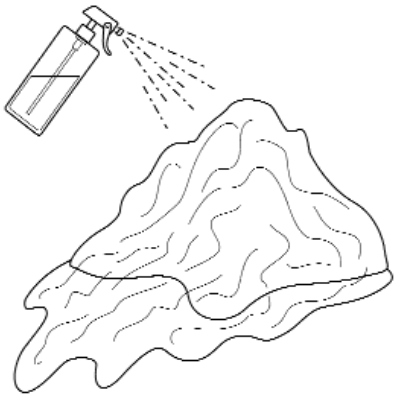


Because the earth moves around the sun and on its axis, we see changes over time in the pattern of daylight hours on earth. If possible, observe and document the direction and size of shadows made by sunlight in school as a whole class over a period of time. Have students track and record the sunrise and sunset times each day for two weeks. This information is usually in the local newspaper if students are unable to see the rising and settings themselves. After all the information is acquired, discuss the relationship of the earth and sun. Make sure to discuss how sunrise and sunset times are affected by the location on earth (for example, at the poles).

Make a flip book.
We can speed up the appearance of change with a simple tool called a flip book. Have students draw a sequence of 12 small (about 3" x 3") pictures changing only one detail on each one. Place the pictures in order and make into a book. Flip through the pictures, sliding your thumb over the edge of the picture and watch the pictures turn into a mini motion picture. (As a post-trip activity, ask students to use one of the changing things they noticed in the *Playing With Time* exhibition; e.g., a plant growing, an eye blinking, a person growing older.)

Colliders (erosion) change the Earth
Playing With Time features several activities which show the earth changing over time. Demonstrate erosion changes by collecting soil in a plastic bin or washtub and forming it into a model mountain. Pack the soil as hard as you can, so it's almost like rock (you may need to

spray water on the mountain to achieve this effect). Add some gravel, sand, or rocks within the mountain and place the mountain on a gentle slope. Have students take turns spraying the mountain 10 times each with water (use a spray bottle with the ability to adjust from mist to stream). Tell students that each mist spray represents 10,000 years of rain and observe what happens. If the spray bottle is switched to stream, students may observe faster changes. Compare the results from the model to a real mountain, canyon, and river over time.



For an additional activity, try placing a bar of soap in a sink directly under the drip of a faucet. Observe the changes over time.

Grades 5–8

Growing Mold

How do living things change over time? Mold is a fast-growing living thing that will show changes over a short period of time. The Thinking Fountain web site has an activity called Grow your own mold: http://www.smm.org/sln/tf/b/bread/bread.html. Have students record changes daily by drawing pictures or taking photographs of the mold.

Tree Rings

Scientists look for clues about changes over time in living things. In the size, width, and configuration of annual growth rings, trees give clues not only about their growth and health but also about their surrounding environment. Observing a horizontal slice of a tree trunk, or "tree cookie," is a way to look at the tree's history over time. Using an old Christmas tree or specimens from a local tree trimming company, distribute small, one-inch-thick pieces of a tree's trunk. Have students count the rings to determine the age of the tree and when it started growing and look for special signs within the rings that may help tell a story about the tree. Rings closer together may signify a drought and small dark markings could have happened during a fire. Students can compare rings to each other to see if there are similar patterns in all of the specimens. Develop a timeline for the trees you have observed.

Make a stratograph of a day in the life of a student.

In the *Playing With Time* exhibition, a stratograph is an art installation that uses sand to show changes over time. Have students make their own stratograph by first recording daily activities for a 24-hour period. For example: eight hours of sleep, six hours at school, one hour on the bus time, two hours eating, etc. Then assign each activity a color. Have students color small containers of sand by adding dry tempera paint to match each activity's color. Then students need to translate the amounts of time they spent for each activity into percentages, so they can place the correct amount of sand into a clear plastic cup or tube which will become their stratograph. If the container is 10 centimeters tall, eight hours would be 33% (8/24) or 3.3 cm. Once completed, their stratograph should be layered to show how much time of their day was spent doing each activity.

Grades 9–12

Explore the *Playing With Time* web site

What kinds of changes are shown in the various pages? Before the field trip, brainstorm other natural changes that might be shown in the exhibition.

Get to know a scientist

Using the list of scientists exploring change (see Follow-up Ideas), students can research and write a short biography of one of the scientists. Identify the area of science the scientist investigates. Study of change cuts across discipline boundaries.

Standards

This exhibition and teacher guide are most closely aligned with the following science content standards, as listed in the National Science Education Standards. For more detail about these standards, check http://www.nap.edu/readingroom/books/nses/html/6a.html.

Inquiry

"Inquiry into authentic questions generated from student experiences is the central strategy for teaching science." (National Research Council, 1996, p. 31)

This exhibition and teacher guide are based on the belief of the power of direct student experiences to motivate students and generate new questions for investigation. This guide will help you implement inquiry-based activities in your classroom and museum or science center. The exhibition also showcases examples, tools, and practitioners of scientific inquiry.

Life Science

K–4 Characteristics of Organisms
5–8 Reproduction and Heredity
9–12 Biological Evolution; Interdependence of Organisms

Earth and Space

K–4 Changes in Earth and Sky
5–8 Structure of the Earth system; Earth's History; Earth in the Solar System
9–12 The Origin and Evolution of The Earth System; The Origin And Evolution of The Universe

Science and Technology

5–8 Abilities of Technological Design; Understandings About Science and Technology
9–12 Understandings About Science and Technology

Science in Personal and Social Perspectives

5–8 Natural Hazards
9–12 Natural and Human-Induced Hazards

History and Nature of Science

K–4 Science as a Human Endeavor
5–8 Science as a Human Endeavor; Nature of Science
9–12 Nature of Scientific Knowledge

Constancy and Change—Project 2061

The American Association for the Advancement of Science has developed benchmarks for scientific literacy in its proposals for reform of K–12 science, math, and technology education, which recommend what students should know and be able to do by the time they reach certain grade levels. One of four unifying themes is constancy and change.

"Much of science and mathematics has to do with understanding how change occurs in nature and in social and technological systems, and much of technology has to do with creating and controlling change...At every opportunity throughout the school years, the theme of change should be brought up in the context of the science, mathematics, or technology being studied." (http://www.project2061.org/tools/benchol/bolframe.htm. For more specific guidelines per grade level, click on the web site above.)

High Speed Camera

After the Field Trip

Review the field trip in class discussions, writing journal entries, letters, or newsletter articles.

Time Explorers: K–4

Try any of the Connecting with the Classroom activities, especially ones that connect with the class' favorite exhibits or activities the children would have drawn at the exhibition; e.g., the seed growing or growing your own mold.

Observing Change: Grades 5–8

Scientist Stories:

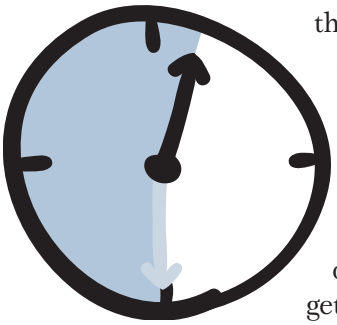
Who	Where	What
Ernst Mach	Germany	flying bullets
Doc Edgerton	MIT	strobes
Arnold Wilkins	England	flickering light
Peter Wilkinson	England	flickering light
Gretchen Anderson	Minnesota	specimen conservation
Food scientists	various	decaying food
Roger Hangarter	Indiana	plant movement
Lonnie Thompson	Denver (lab)	
	Peru/Bolivia	ice cores
Jim Almendinger	Minnesota	lake sediment
Dan Engstrom	Minnesota	lake sediment
Danny Natawidjaja	Sumatra	coral
Kerry Sieh	Sumatra	coral
Arno Penzias	Bell Labs	Big Bang
Robert Wilson	Bell Labs	Big Bang
Henrietta Leavitt	have students look it up	Universe
Edwin Hubble	have students look it up	Universe
Albert Einstein	have students look it up	Universe
Ken Beard	Illinois	Raindrops
Cathy Chuang	Illinois	Raindrops
Jeff Larsen	Arizona	Asteroids/Spacewatch
Clyde Tombaugh	have students look it up	Pluto/blinking apparatus
Kris Balch	have students look it up	High-speed cameras
Engineers at Seagate	have students look it up	High-speed cameras
Paco Underhill	have students look it up	shopping

Investigate one of the scientists further. Write a biography or a magazine-style interview of the scientist.

Describe a change that happens in your life and invent a tool to keep track of or measure those changes.

The Range of Change—refer to student Field Trip Activity pages

Students can chart their findings in the small groups from the field trip or as a whole class. What was the range of short-term changes they found? What kinds of changes did they discover? Were they all from the same area of the exhibition (Life, Earth, or Universe?)



Taking Time: Assign each group an exhibit component or ask each group to choose one. Their responsibility is to get to know this component thoroughly, read all of the text, do all of the activities. As a follow up, each group can present an exhibit critique or written or oral exhibit report to share their experiences with everyone.

Observe Change and Play with Time! Grades 9–12

The Range of Change

Students can chart their findings in small groups from the field trip or as a class. What was the range of changes they found? What kinds of changes did they discover? As they look at the chart of all the changes recorded, what patterns do they notice? Investigate the pattern as a hypothesis.

Evidence of Change

Discuss the evidence gathered to support each hypothesis. Key points from the exhibition are listed below.

- Scientists think that the universe is expanding in all directions. **What evidence supports this statement?** Dark bands in the spectra of galaxies appear shifted toward the red end of the spectrum. The galaxies are all moving away from us and each other at different speeds, so the closer galaxies have a small shift, the farthest galaxies the largest shift.
- Scientists think that glacial ice records climate change. **What evidence supports this statement?** Glacial ice cores show patterns of dust bands, insects, plants, and volcano ash which indicate events in the area throughout time. The exhibition shows an ice core photo from Bolivia (AD 1302–1404).
- Scientists think that 5,000 years ago, northern Minnesota was warmer than today. **What evidence supports this statement?** Prairie grass and oak pollens from lake-bottom sediments indicate warmer environmental conditions that would have supported these plants, unlike the pines and birches of today's environment which grow best in a cool, moist environment.
- Scientists think that plants sense and respond to their environment. **What evidence supports this statement?** Timed photographs of plant growth show changes in position and shapes of plants. Charles Darwin did an early experiment using glass and carbon paper which recorded plant movements.

Discuss or ask students to present the hypothesis they formed in *Playing With Time.* What evidence supports the hypothesis they found?

Reflecting on Change

What kinds of change would students document for a video? Use the *Playing with Time* web site as a guide—http://www.playingwithtime.org/ to make your own time-lapse images or videos. Click on "Toolkit" to get started.

Time Tools

Resources

Books:

Before and After—A Book of Nature Timescapes
Jan Thornhill
National Geographic Books; ISBN: 0792270932; (1997)
Illustrations (with identification around the borders) comparing a variety of habitats now and a few seconds, an hour, a year later.
Appropriate for grades K–3

Simple Experiments in Time With Everyday Materials
Muriel Mandell, Frances Zweifel (Illustrator)
Sterling Publications; ISBN: 0806942983; (March 1998)
Grades 4–8; Experiments to explore time and ways to measure time.

Traces of Time (An Exploratorium Book)
Pat Murphy, Paul Doherty, William Neill (Photographer), Diane Ackerman
Chronicle Books; ISBN: 0811828573; (October 2000)
A beautifully photographed book, which compares a variety of landscapes 10–40 years ago with today, chronicling change in natural landscapes.
Appropriate for secondary, but with adult help the photographs can be used to illustrate or show changes for younger students.

Web sites:
Playing With Time:
http://www.playingwithtime.org/

Building a tree-ring chronology:
http://www.pbs.org/wgbh/nova/vikings/treering2.html

Interdisciplinary change—artists from a variety of cultures look at change
http://www.nelson-atkins.org/tempusfugit/

Scale and change:
www.powersof10.com/powers/time/time.html

Playing with Time

Favorites for younger students

Plant Dance
We don't often see plants move on their own. Challenge children to mimic the plant movements exactly, then describe what they did as "plants."

High-speed camera bench and Funny Faces
Cameras can slow down motion so you can see how things look when they move: water, solids, and us. Follow exhibit instructions to record and play back the motion.

Water Drop Strobe lights can show motion you don't see happening in other ways. Play with the speed of the light flashes to change what your eyes are seeing.

Rotting Fruit You don't always notice change taking place under your nose or on your counter. What other things change like this? Look at the oldest plate. How will this fruit look in a few days?

Dog Breeder Try the game to match up dog color, ear shapes, and size. Change happens over time and across generations. The puppies will show traits of each adult parent. How many generations did you cross?

Ask children to find other things changing, either quickly or very slowly, in the exhibit. Ask children to find a picture of a scientist studying change (there are many in the exhibition). Who are they and what do they study?

Explore time together! Be curious! Find out one new thing about our changing world.

Some concepts may be hard to figure out, but don't worry about understanding the whole idea. Scientists can spend their whole lives studying change!

Dance with the Plants!

Draw pictures of a friend dancing with the plants. Show changes in each picture.

Rotting Fruit

What it looks like today.

What it will look like next week.

Scientist Stories

Many scientists study fast and slow change. Find two scientist stories in the exhibit.

1

Name of scientist

Topic of research

Discovery

2

Name of scientist

Topic of research

Discovery

The Range of Change

Some things change over a very long time and others change very quickly. Find a ***really fast*** change that takes less than one second.

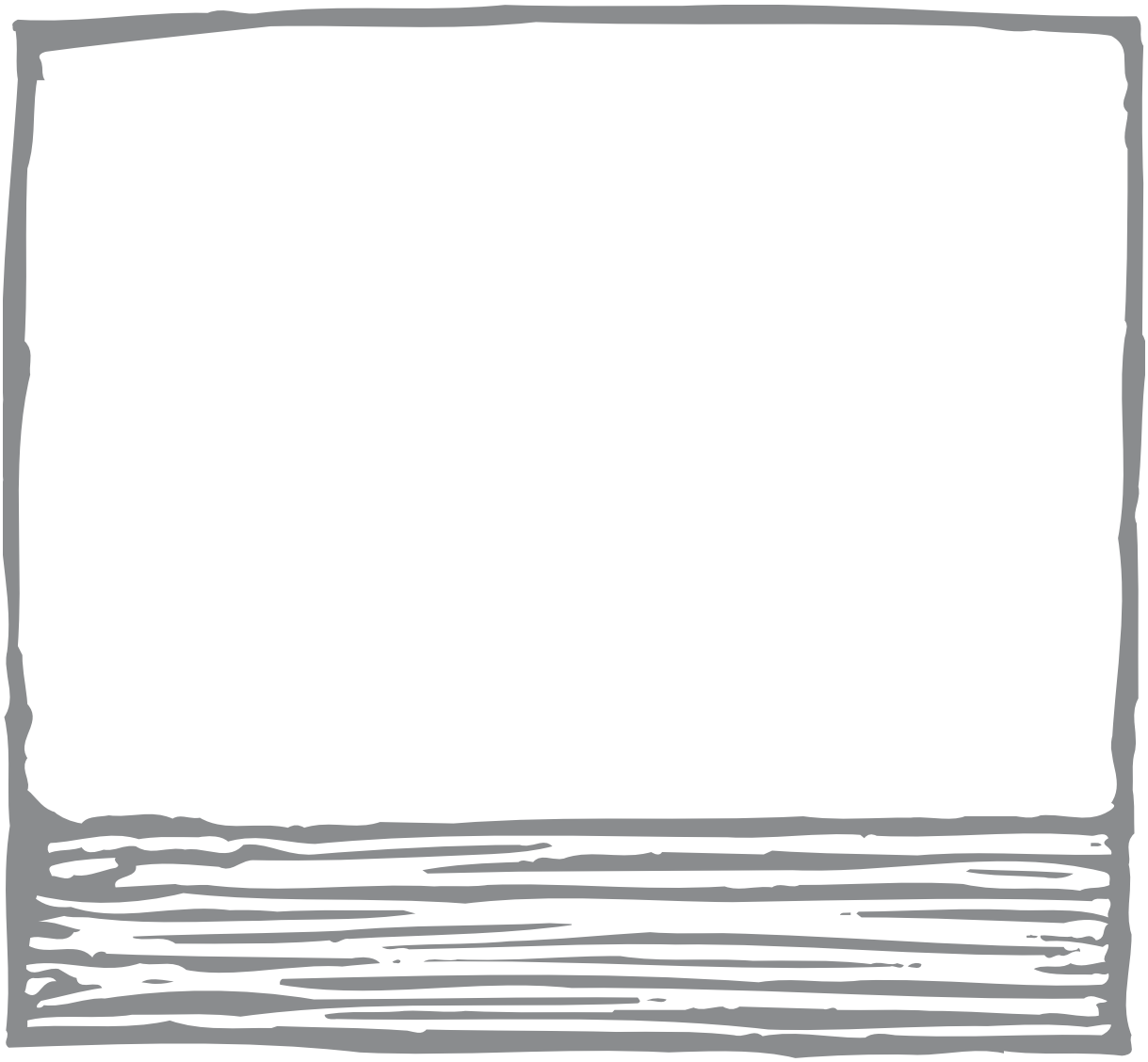
What did you find?

How long did it take?

What is the "longest running show in town"? What change takes the most time?

Taking Time

Get to know ***one*** exhibit component really well.
Read all of the text, do all of the activities related to this one topic.
You will be the expert on this exhibit. Here is a space for your notes:



As you visit other areas of the museum or science center, what evidence of change can you find?

Playing with Time

Student Activity Page

Observe Change and Play with Time!

The Range of Change

Some things happen too quickly to perceive with your senses, others too slowly. Find three examples of change and draw an arrow to show where they would fit on the "timescale":

1)_____

2)_____

3)_____

Reflecting on Change

Watch the multiscreen video presentation.
What kinds of change would you document for a video?

Playing with Time

Student Activity Page

Evidence of Change

From the Big Bang to the Big Strrrrretch

Scientists think that the universe is expanding in all directions.
What evidence supports this statement?

Ancient Ice Tells the Time and Temperature

Scientists think that glacial ice records climate change.
What evidence supports this statement?

Muddy Mystery

Scientists think that 5,000 years ago, northern Minnesota was warmer than today.
What evidence supports this statement?

Plant Dance

Scientists think that plants sense and respond to their environment.
What evidence supports this statement?

Find another hypothesis about change in *Playing With Time.*
What evidence supports the hypothesis you found?