Learning Science by Doing Science with Simple Materials

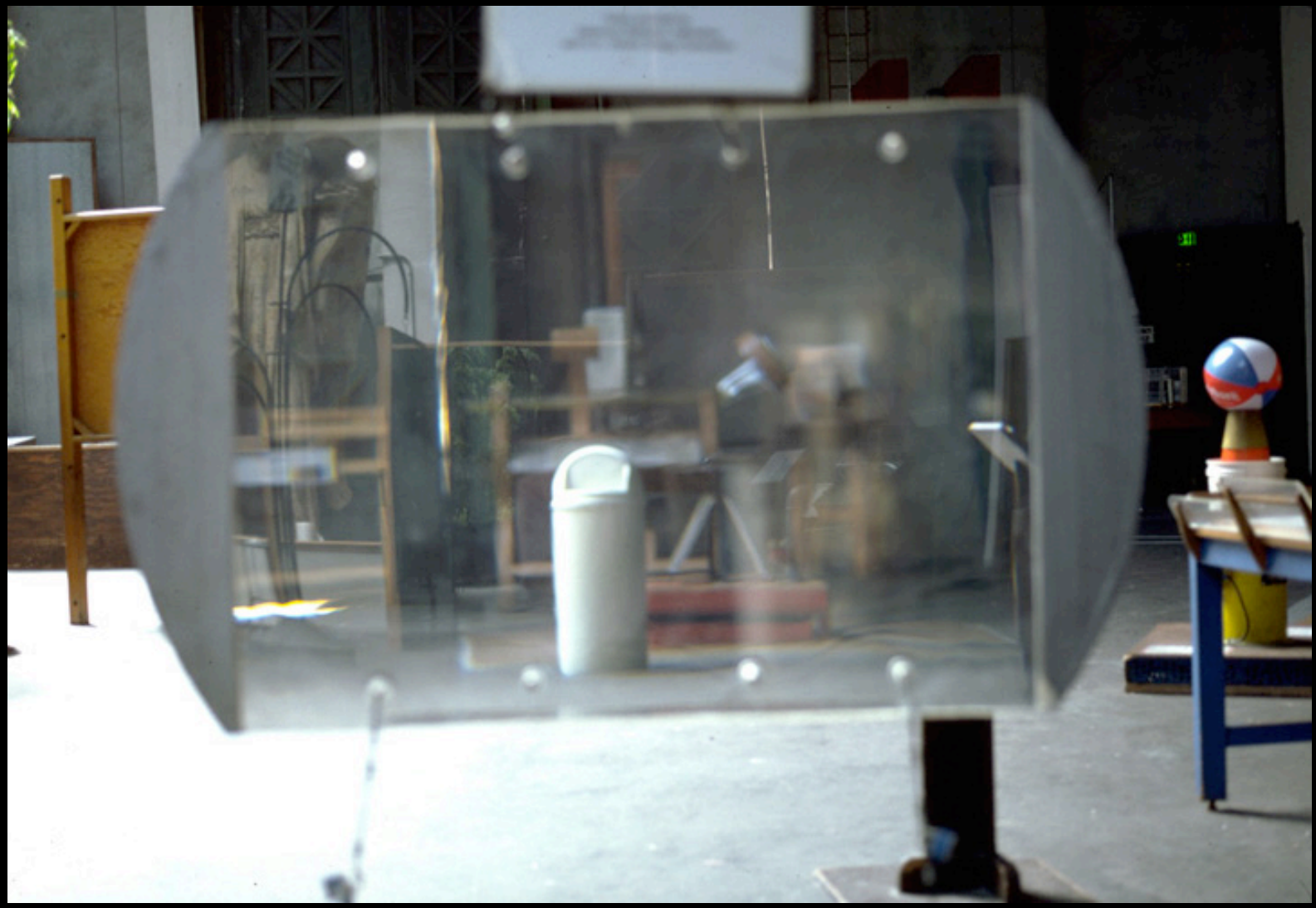
Paul Doherty

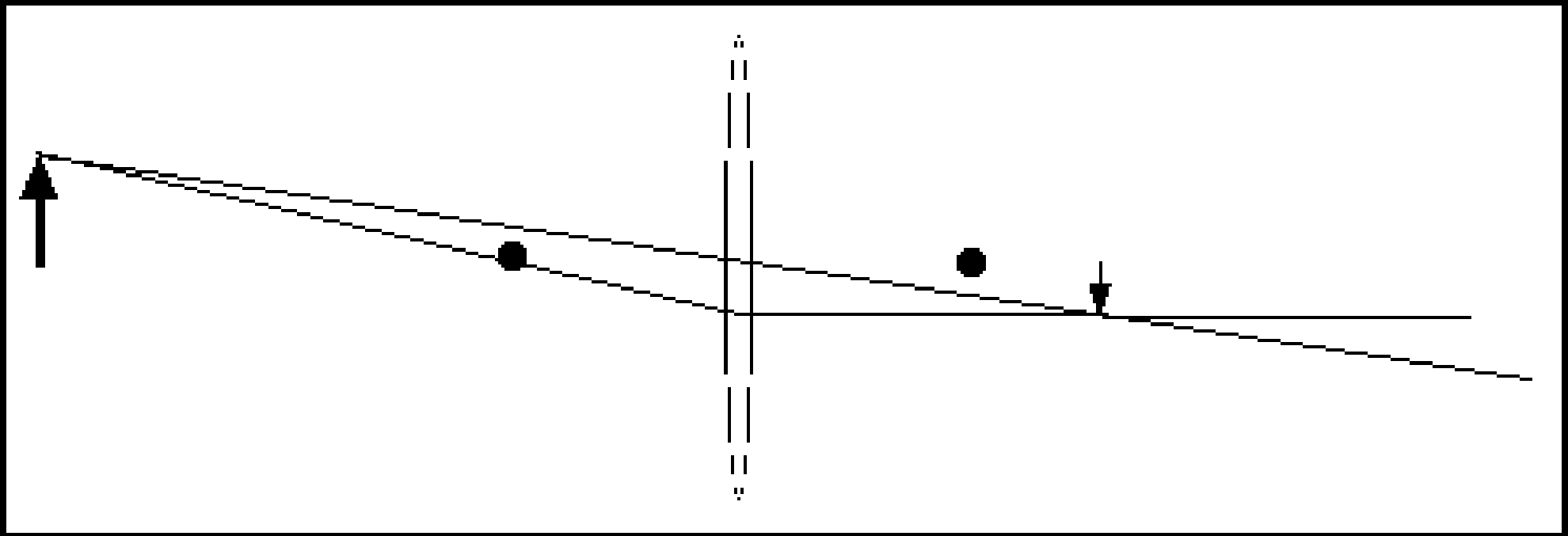
The Exploratorium

The Exploratorium

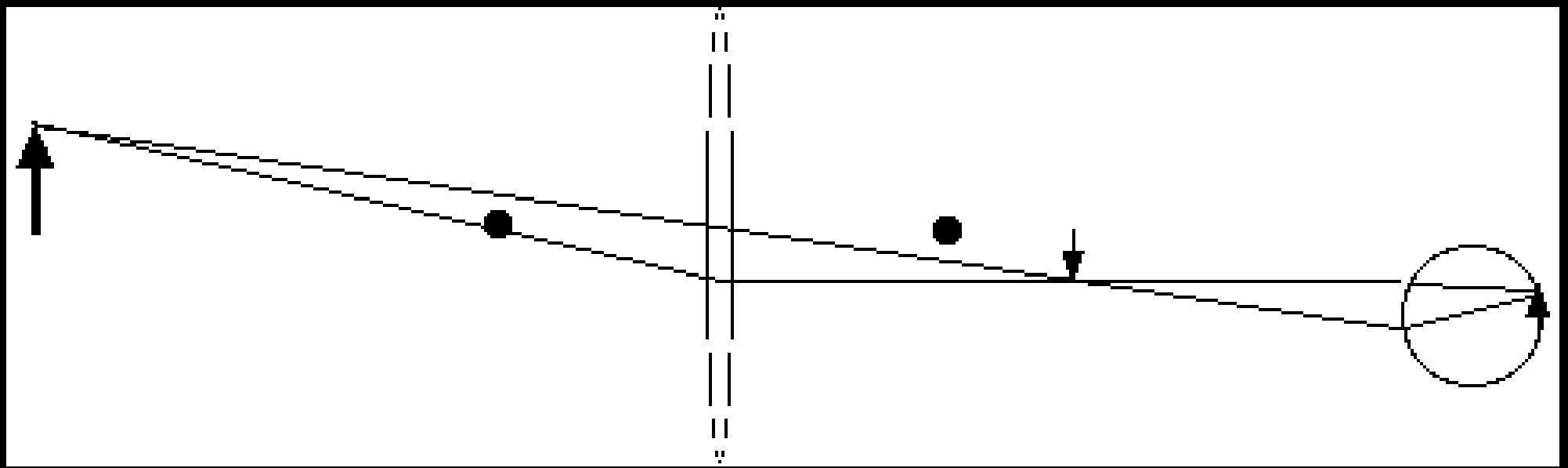
Lens, trashcan, real image

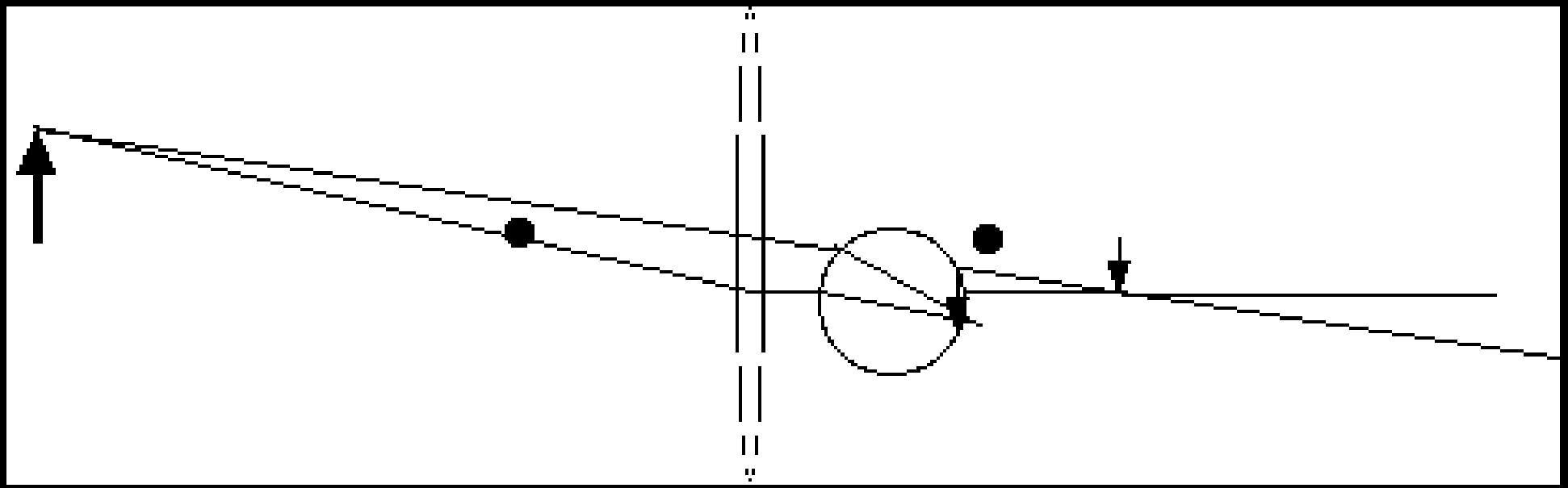
Lens, trashcan, virtual image
The lens and the trashcan did not move!





The scientist must consider the observer.





Scientists must know a narrow range of science to great depth to know the fundamental experiments.

Teachers must know how science in breadth, to relate topics to each other and to the world in general.

Scientists write with great precision so they cannot be misunderstood by other scientists but perhaps so they cannot be understood by the public.

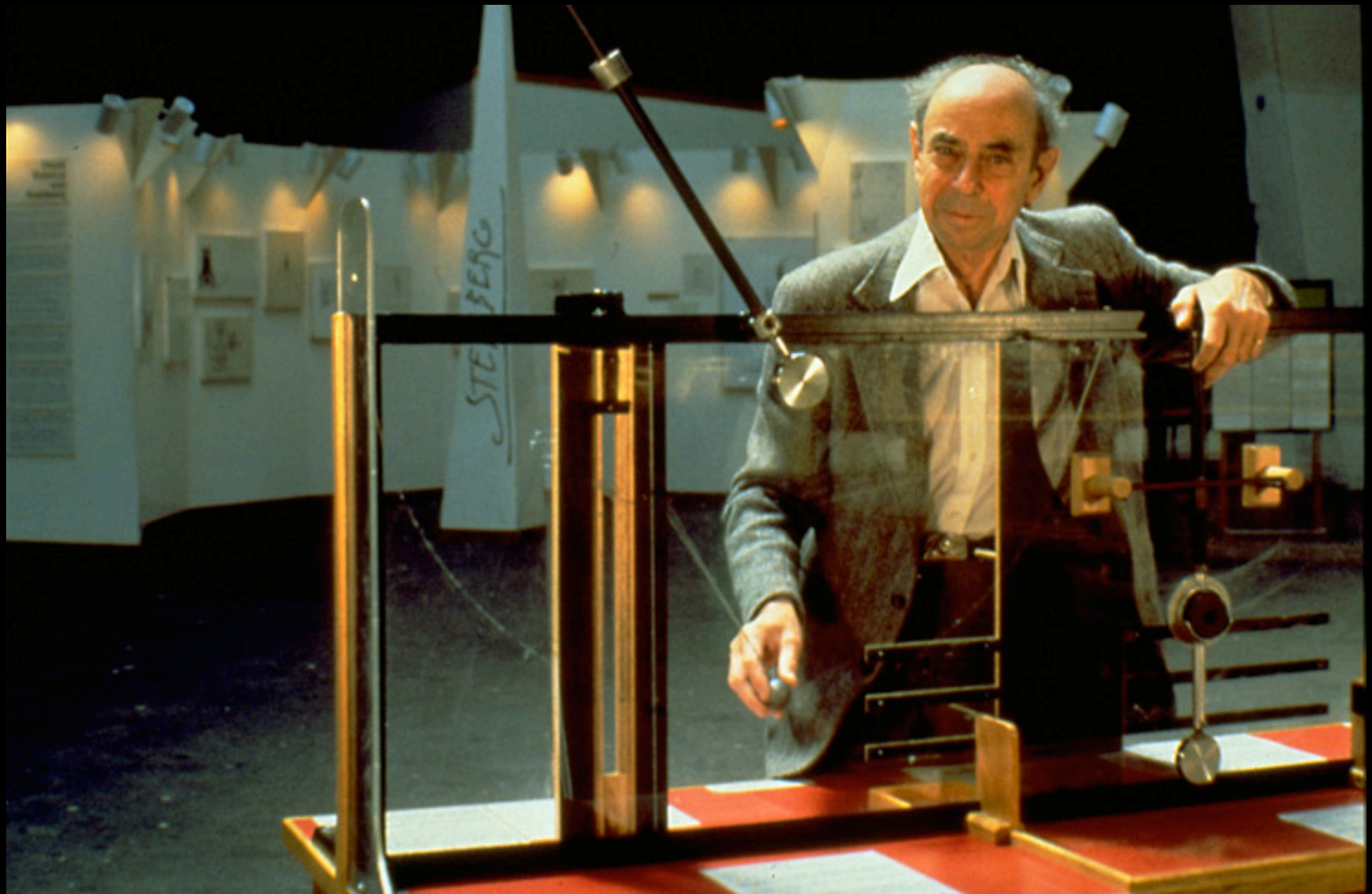
When writing for the public, write so there is at least one way that the writing can be interpreted correctly.

*

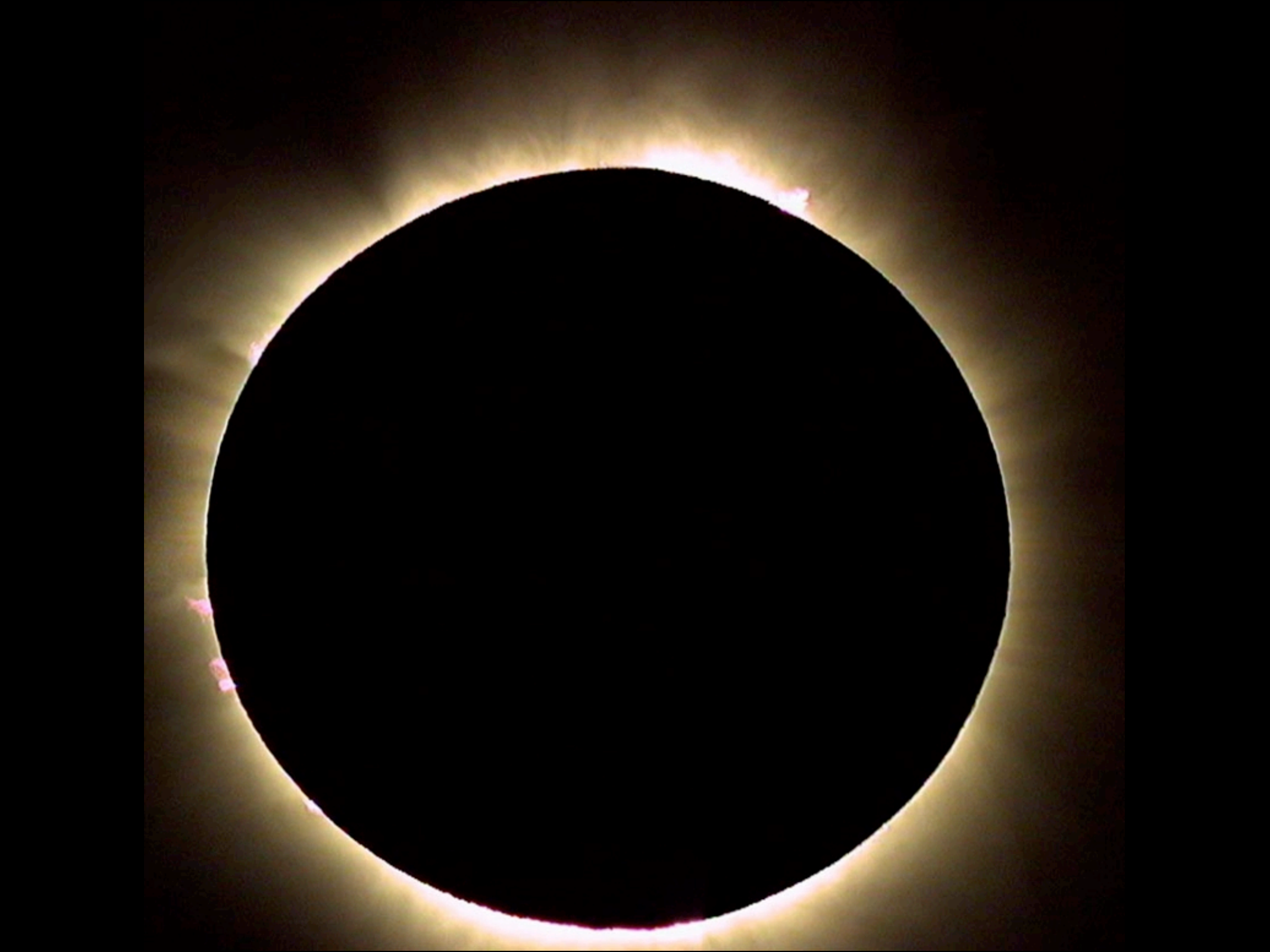
It is more complicated than that.

You have just learned Newton's Laws
They are wrong.

Frank Oppenheimer
Director 1969-1986



Goery Delacote
Director 1990-2005



You white scientists have been lieing to us for 100 years,
But this time you were right.

Eclipse Explainers Amasya Turkey
"Our teacher says the sun doesn't rotate."

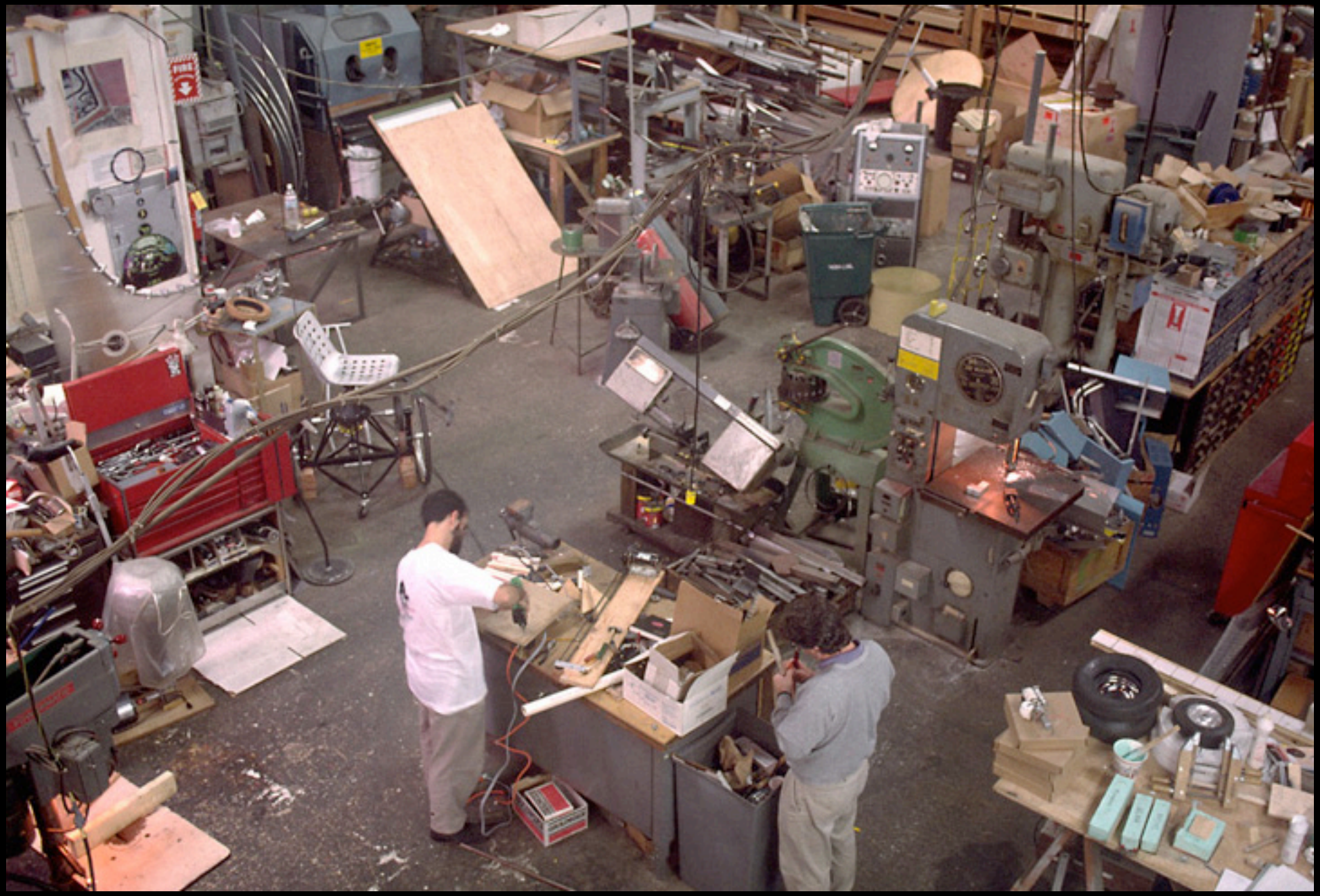
Adults have fun learning too!
Teachers with badges get into the museum free.

50% of our audience is over 18 years old.

What do you see?

Where are the rays?

Humor



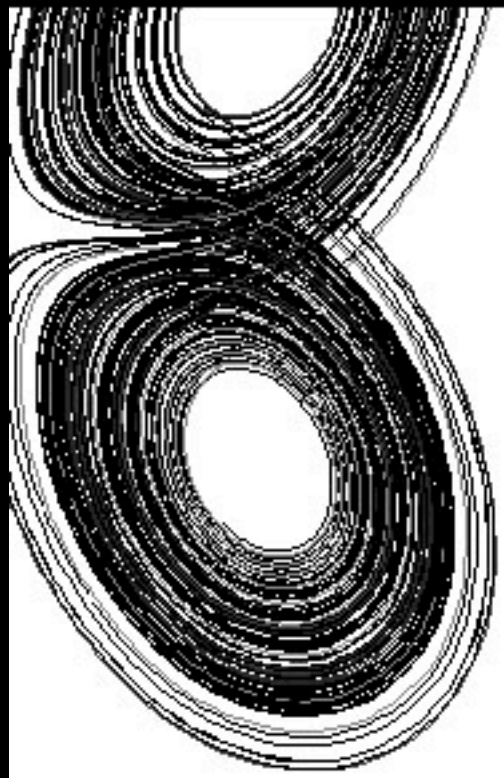
Mercator Your Face

exploratorium
the museum of science, art and human perception

SEARCH GO
SiteMap

EXPLORE | EDUCATE | VISIT | PARTNER | SHOP

Saturday, April 10th, 2004



Play with the Lorenz Butterfly!

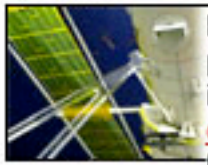
SCIENCE OF MUSIC

Explore the science of music, through online exhibits, movies, and questions.

JOURNEY TO MARS

Learn about Mars and the rovers now on the red planet. Raw data for Opportunity and Spirit available.

ORIGINS



Explore the places, people, tools, and ideas behind the origins of matter, the universe, and life itself.

AT THE MUSIC

What do you really know about what you see? And what traits of life do all organisms share?

SPORT SCIENCE

Find out how surfing the Web can help you surf the waves, make forecasts, and more.

SHOP

New publication! Math and Science Across Cultures

VISIT THE EXPLORATORIUM!

Check out the events calendar for film screenings, live Webcasts, and other public programs. Need Directions?

LIVE WEBCASTS

- Coming Soon: Transit of Venus!

Recent Webcasts:

- Iron Science Teacher
- Try This!
- Journey to Mars
- Archived Webcasts

TAKE A LOOK!

- Current Weather
- Roof Cam
- Exhibit Cam

WHAT'S NEW?

- Science of Music
- New Press Office
- Sign up for eNews

GET INVOLVED

- Become a Member
- Summer Camp
- Make a Donation
- Volunteer!

Scientific Explorations And Adventures

with Paul Doherty

Explore the world. Do experiments. Examine scientific images.

New activities added September 30,2003.

Scientific Explorations:	**Outdoor Adventures**:	**Writing**:
Alphabetical Index	Alphabetical Index	Books, Lectures, Webcasts
Archive and Topic Index	Archive with photos	Media and Topic Index
Most Recent	Most Recent	Most Recent

Biography	Family	Links

Contact me at Pauld@exploratorium.edu

Breaking News

At the National Science Teachers National Convention of 2003 I was given the Faraday Award for excellence in science communication.

At the award ceremony David Heil showed the film clip where I worked with him to show the physics of climbing on the Newton's Apple television series. Steve Jacobs presented the award which is a glass sphere showing the earth, inside the sphere a cloudy atmosphere rises above the continents and oceans.

Somehow Linda and Modesto who knew about the award managed to keep it a secret from me so I was totally surprised.

I was honored to be recognized by fellow science teachers and science communicators for work which I love to do.

Paul receives the NSTA Faraday Award from Steve Jacobs.

Scientific Explorations

My most recent workshops are on top.
If you don't find your workshop here go to the archive.
To find specific activities go to the alphabetical index.

What Physicists Do, Developing Magnetism Exhibits at the Exploratorium

Physics Seminar at Sonoma State University, 27 Oct 2003

RAFT Dinner 2003

Magnetism activities using RAFT Donut Magnets

Outdoor Adventures

My most recent adventures are on top.

Mt. Lyell 2003

Up Lyell and around it via the Sierra High Route.

Right, Paul Morgan climbs the ridge of Mt. Lyell.->

50 miles in 5 days.

Adventure on trail and off.

Writing and Media

My most recent publications are on top.

Try This with Paul's Friends

A monthly program of science experiments demonstrated by the world's greatest science teachers.

Exploratorium Teacher Institute

founded 1985

2100 science teacher alumni

The Teacher Institute is
21 years old next year.

We invited all of our alumni to a party.

We are old enough that,

We can serve alcohol.

Teachers attend a 4 week long Summer Institute

Monday - Thursday

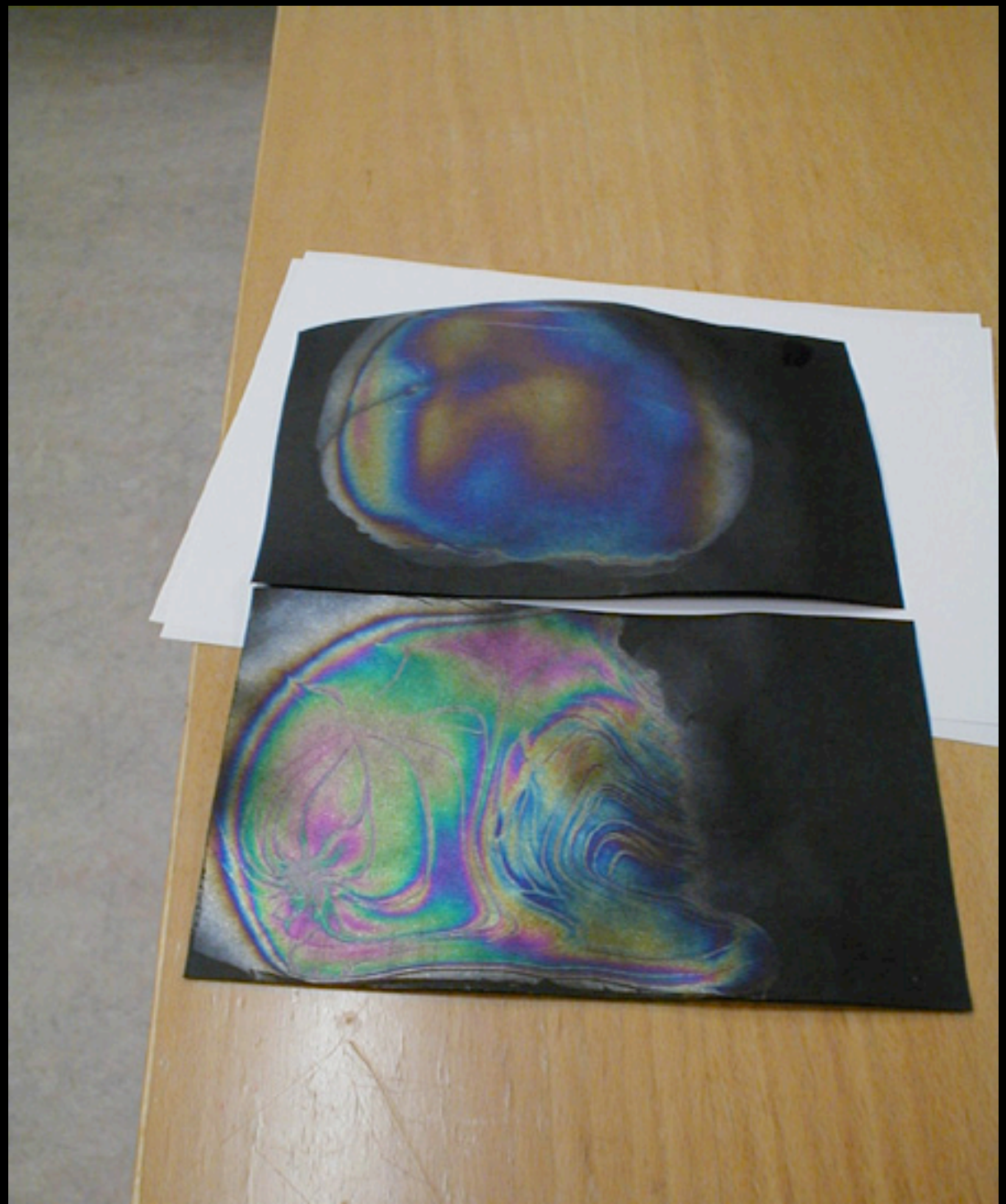
08:00 - 10:30 Exhibits
11:00 - 12:30 “Snacks”
12:30 - 2:00 Teacher Time
Machine shop
Library

Friday

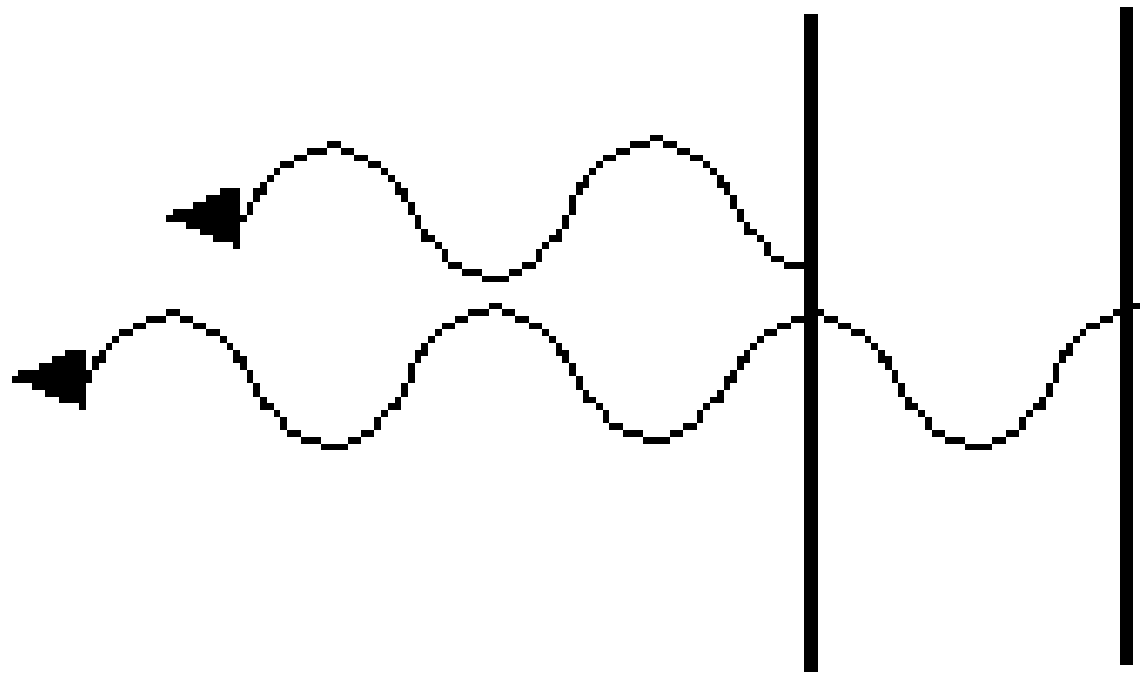
Teachers Present lessons to us.

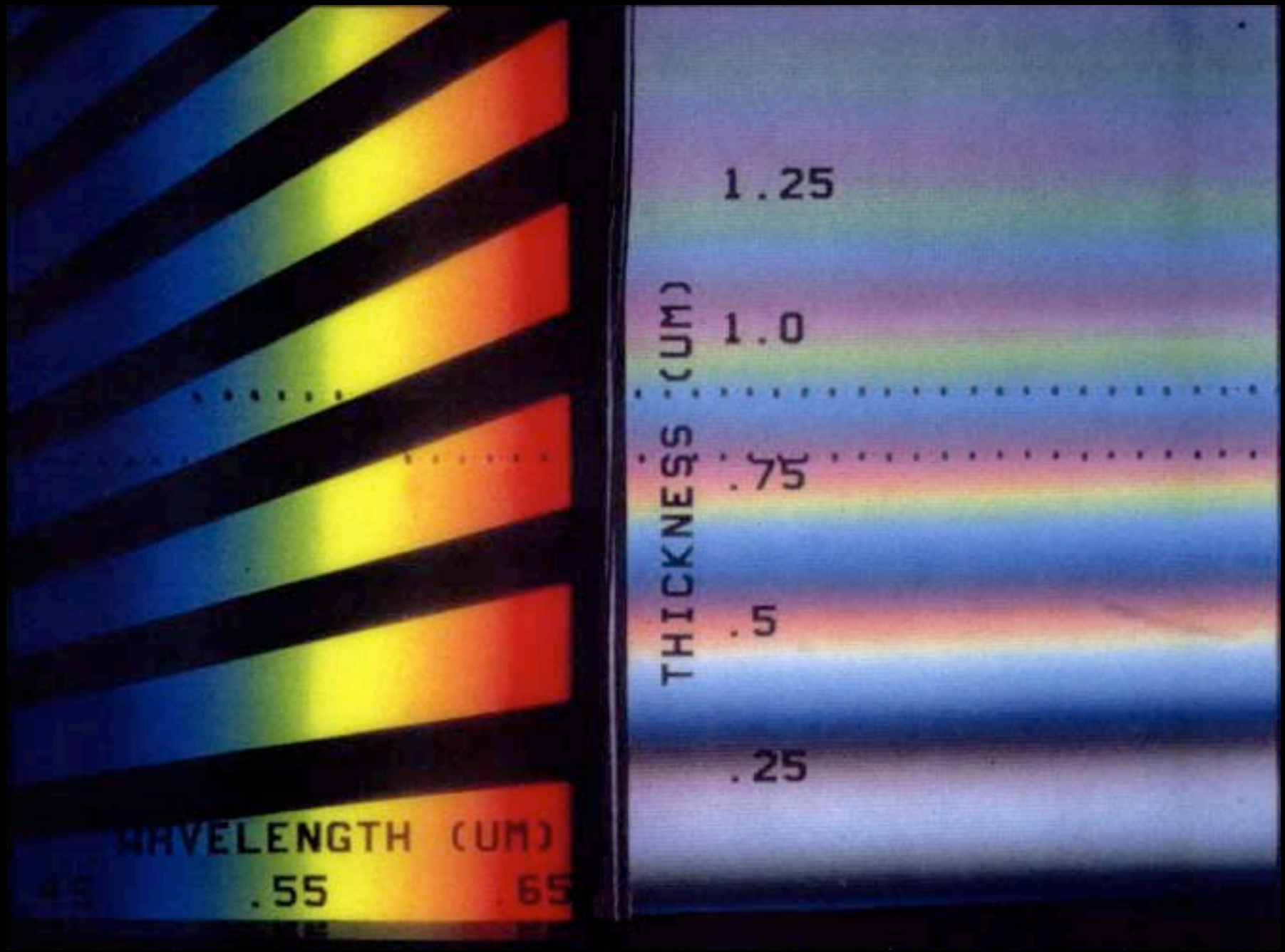
The Sound
Column
a concrete tube
17.5 m long
Fundamental
frequency 10 Hz

The teachers discover the sound is loudest at the floor at the node!




Soap Film in a can




WAVELENGTH (UM)
.55
.65
THICKNESS (UM)
1.25
1.0
.75
.5
.25


GMH

These pages are full of Snacks...but they're not the kind you eat. They're the kind you can learn from and have fun with. Exploratorium Science Snacks are miniature versions of some of the most popular exhibits at the Exploratorium.

Try activities from our latest Snackbook!

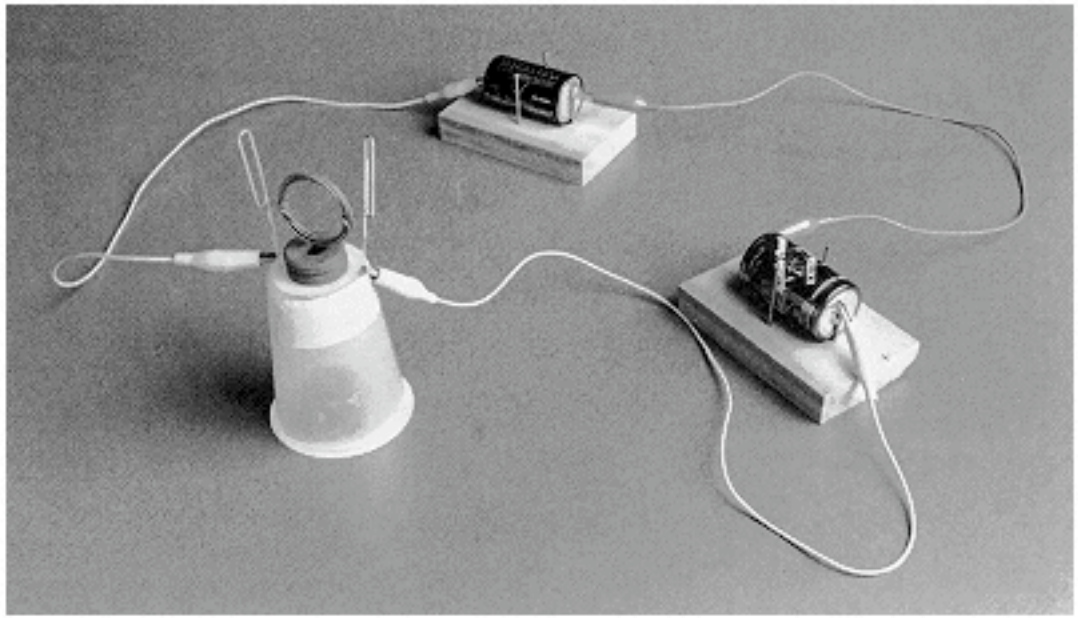
Questions about Snacks? Click here!

Snack name	Description
Afterimage	A flash of light prints a lingering image in your eye.
Anti-Gravity Mirror	It's all done with mirrors!
Balancing Ball	Suspend a ball in a stream of air.
Balancing Stick	Does it matter which end is up?
Benham's Disk	A rotating black-and-white disk produces the illusion of color.
Bernoulli Levitator	Suspend an object in air by blowing down on it.
Bicycle Wheel Gyro	A bicycle wheel acts like a giant gyroscope.
Bird in the Cage	Stare at a color and see it change.
Blind Spot	To see or not to see.

Snack name	Description
Glue Stick Sunset	Why is the sky blue? That's a sticky question.
Gray Step	Without a boundary, it's hard to distinguish different shades of gray.
Hand Battery	Your skin and two different metals create a battery.
Hand-Held Heat Engine	You can make the liquid in this toy rise and fall in a cycle.
Hot Spot	You can focus the invisible light from an electric heater.
Inverse Square Law	Why the world gets dark so fast outside the circle of the campfire.
Jacques Cousteau in Seashells	There's more to seeing than meets the eye.
Laser Jello	Use gelatin as a smoked lens, to view total internal reflection, and as a color

Stripped Down Motor

As motors go, this is about as simple as it gets.



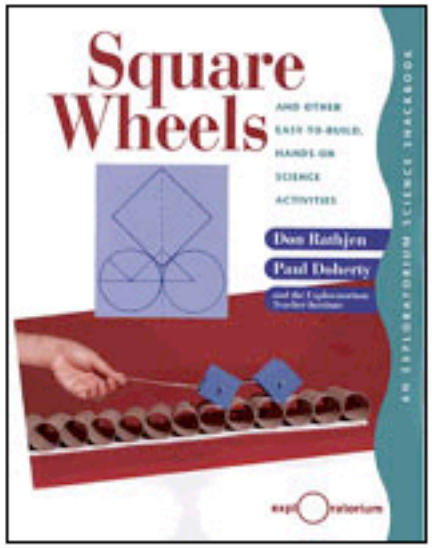
A coil of wire becomes an electromagnet when current passes through it. The electromagnet interacts with a permanent magnet, causing the coil to spin. Voila! You have created an electric motor.

materials

- ✔ **5 small disk or rectangular ceramic magnets** (available at Radio Shack).
- ✔ **2 large paper clips.**

exploratorium

Square Wheels



...and Other Easy-To-Build, Hands-On Science Activities by Don Rathjen, Paul Doherty, and the Exploratorium Teacher Institute

The latest in our popular Snackbook series, this volume features 31 all-new Science Snacks-- small-scale versions of exhibits you will find in the Exploratorium made with easy-to-find materials-- which are perfect for the classroom. Topics covered in this book include: Chemistry, Light & Color, Electricity & Magnetism, Sound & Waves, and Heat & Mechanics.

Read what teachers are saying about "Square Wheels."

Sue Pritchard, Ph.D.
Middle School Science Teacher

Kenneth King
Assistant Professor

Purchase Square Wheels from our online store

Sample Pages: Click on a link below to view the PDF file. In order to download and view the PDF documents, you will need the free Adobe Acrobat Reader. Get Acrobat Reader.

Table of Contents
Modulated Coil
Modulated LED
Square Wheels
String Machine

3601 Lyon Street San Francisco, CA 94123 | 415-EXP-LORE | Contact Info

Curt Gabrielson

Wrote the new science curriculum for
East Timor

A Snackbook
Using local materials

It is the first technical book ever written in Tetum

IRON SCIENCE TEACHER

鐵教師

Teacher Institute leader Diane Whitmore introduces a group of teachers to our panoply of power tools.

Click here
to view webcast.

Prior to the webcast this will link to a test message.

You will need the free **RealPlayer** in order to receive the audio and video live feed and/or archive of the webcast. Please visit RealNetworks' Service & Support page for more information.

Live@The Exploratorium: IRON SCIENCE TEACHER
Each webcast, the Exploratorium staff and teachers demonstrate their

Webcast Archives!

Date Broadcast	Secret Ingredient
August 8, 2003	Iron Nails
August 1, 2003	Disposable Plates
July 18, 2003	Kitchen Utensils
July 11, 2003	Water
June 27, 2003	Sticky Tape
October 31, 2002	Apples
August 9th, 2002	Zip-Lock Plastic Bags
August 2nd, 2002	Pencils
July 19th, 2002	Eggs
July 12th, 2002	Shoe Boxes

My pyramid scheme to take over science education.

2100 alumni

100 return as co-teachers

20 come for a 1 year sabbatical.

8 become permanent employees

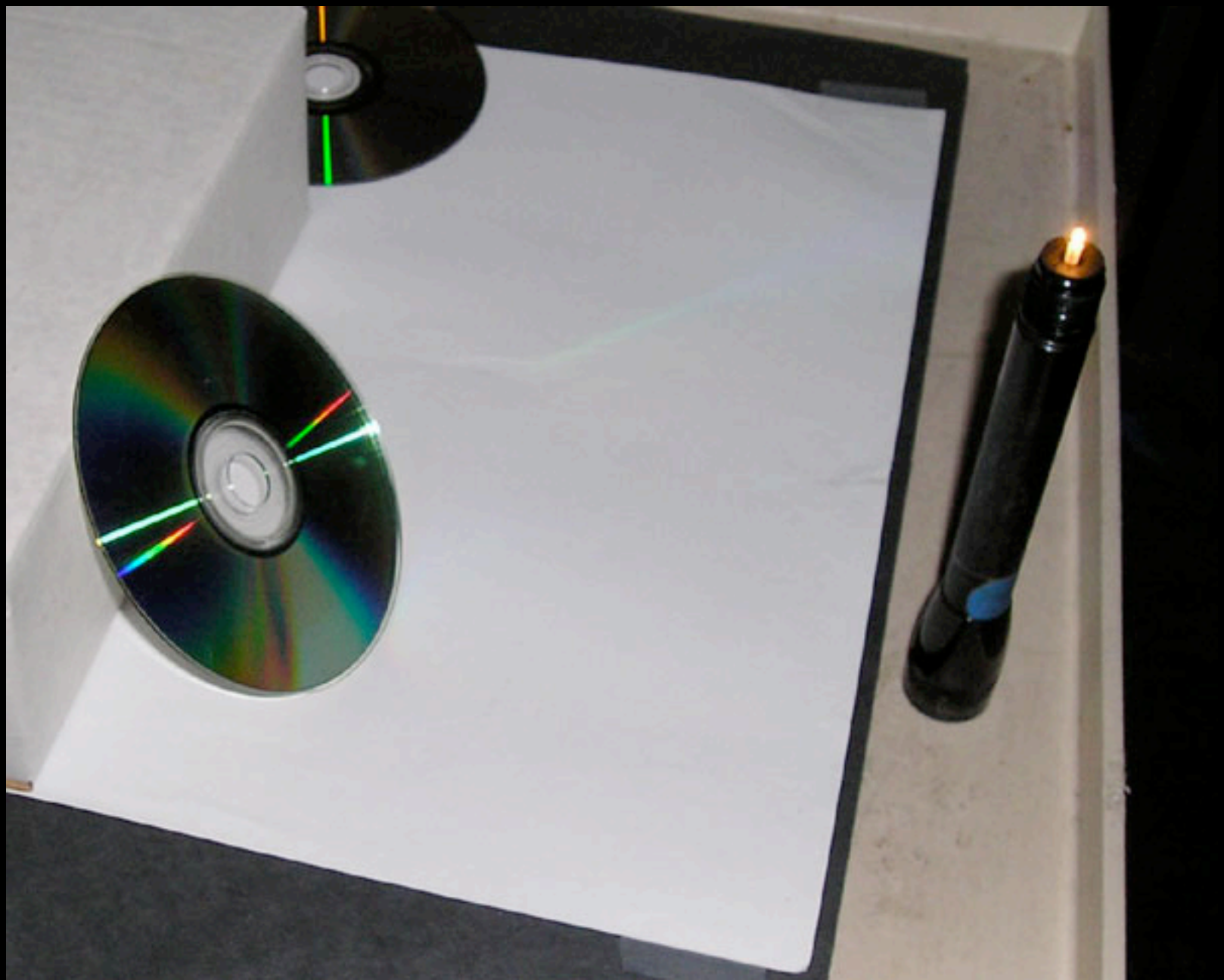
8

20

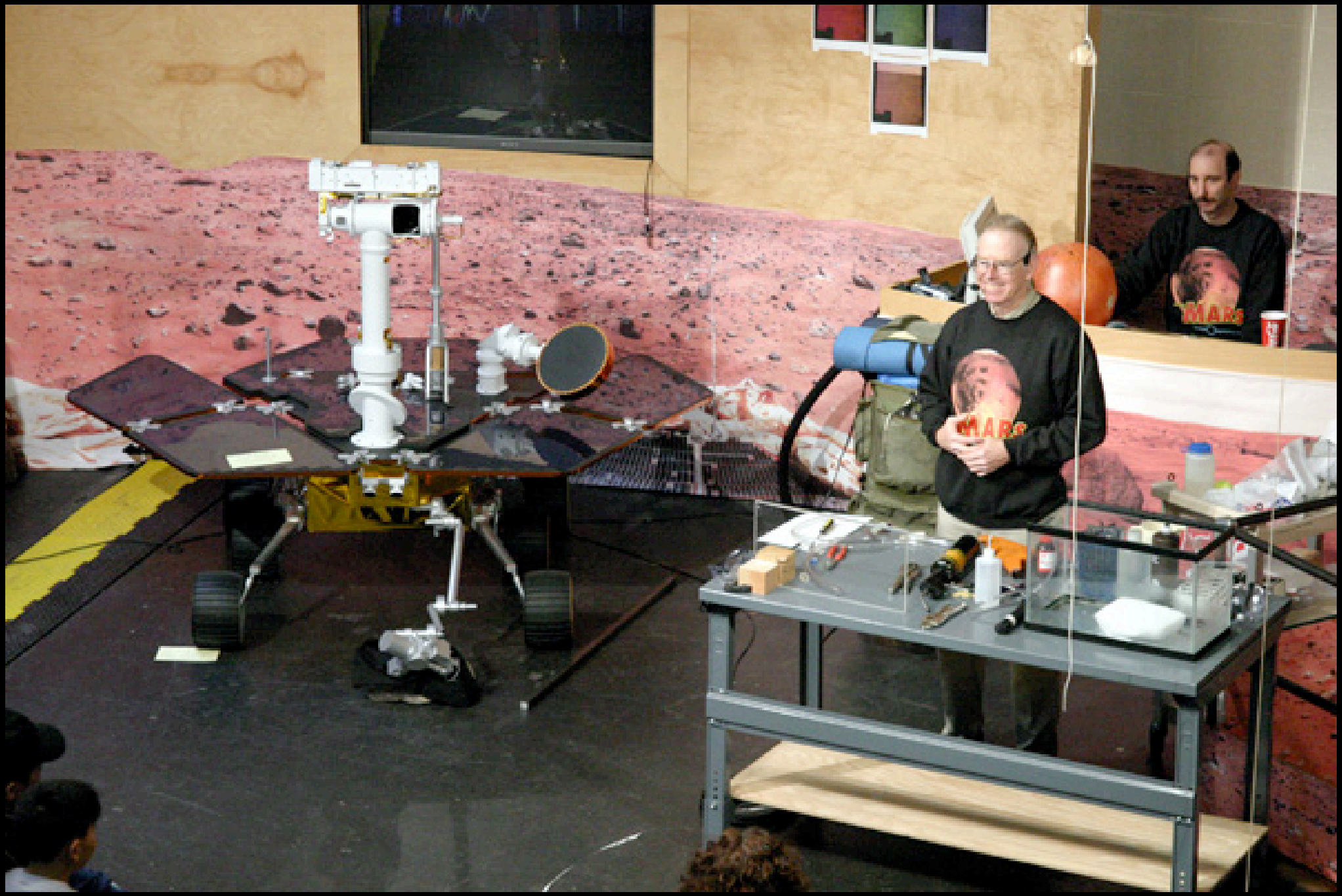
100

2100

Spectra in a compact disk



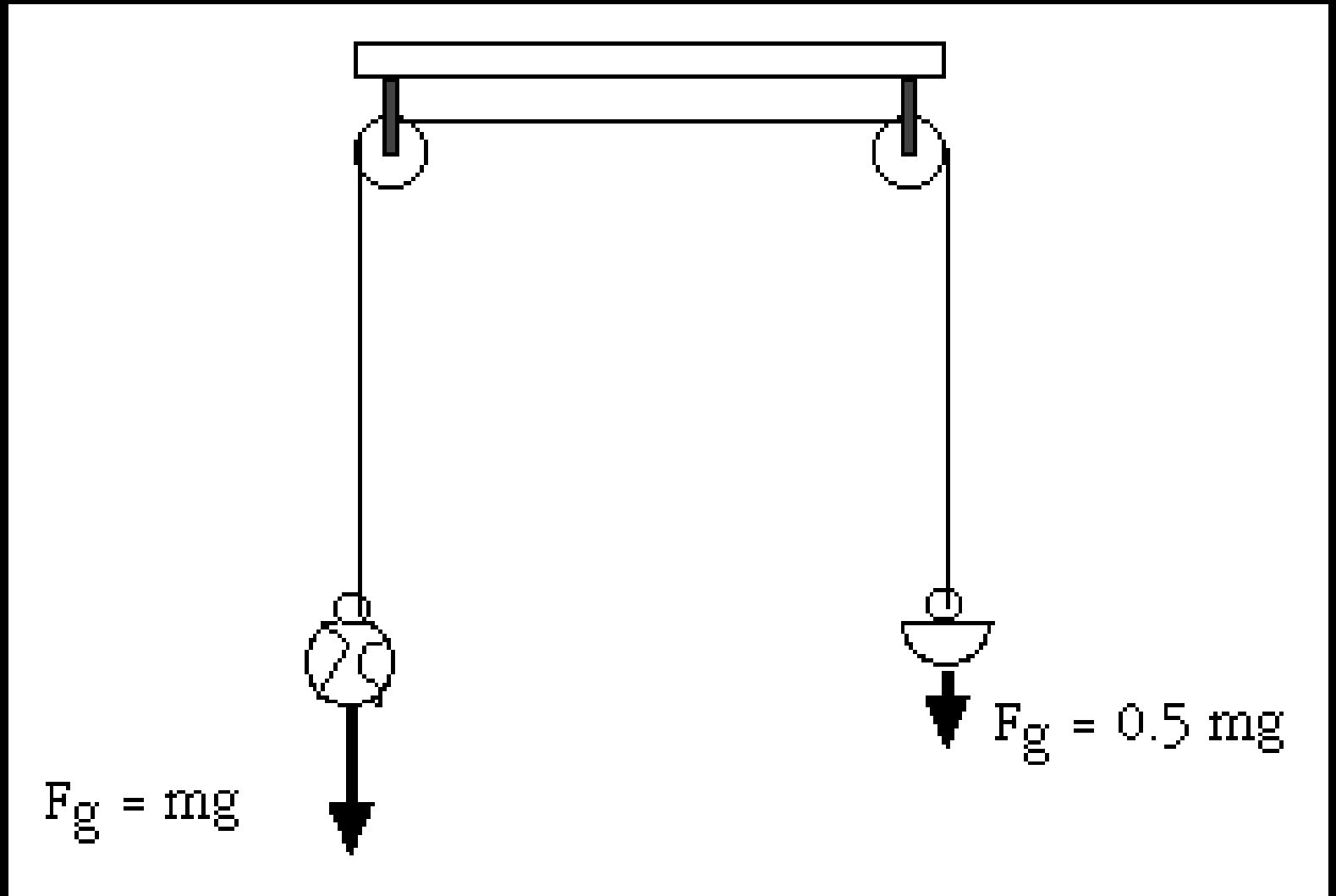
CD spectrometer


MARS
MARS


LIVE @
expl
ratorium

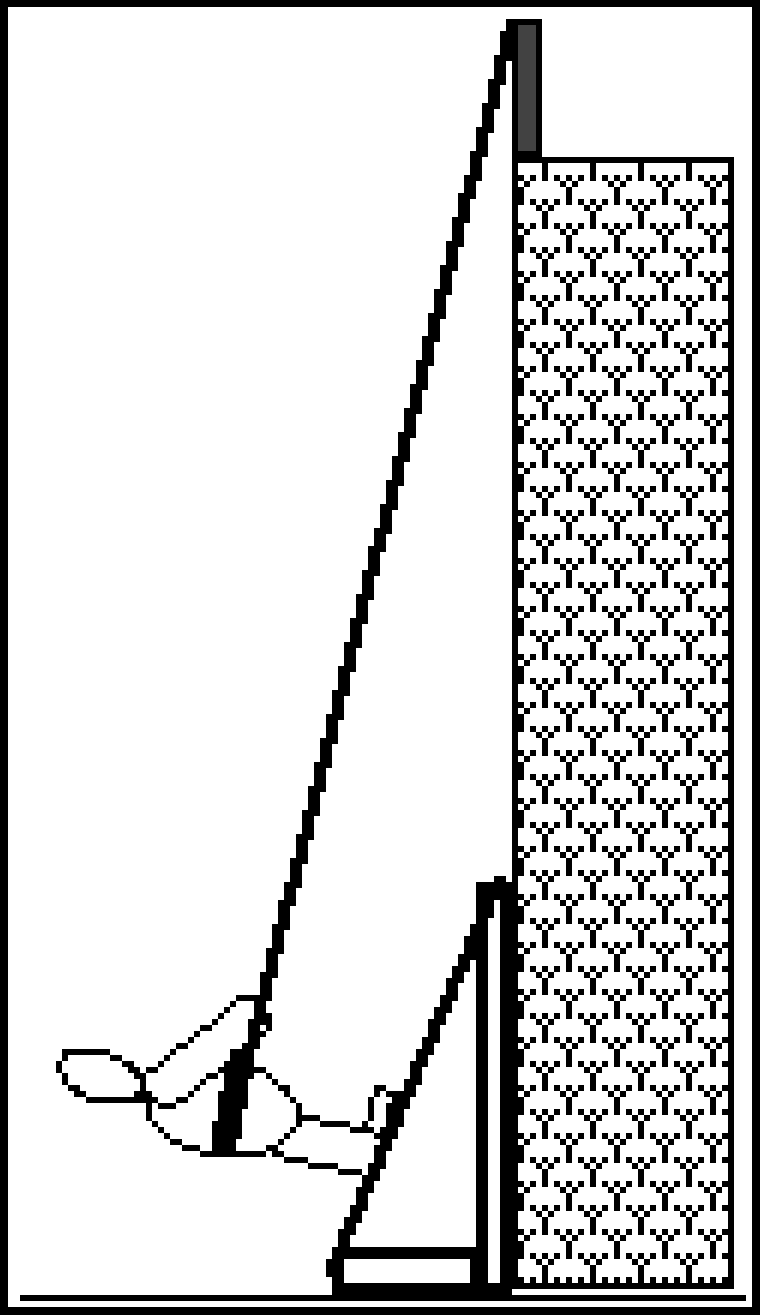
Public = Martian Baseball

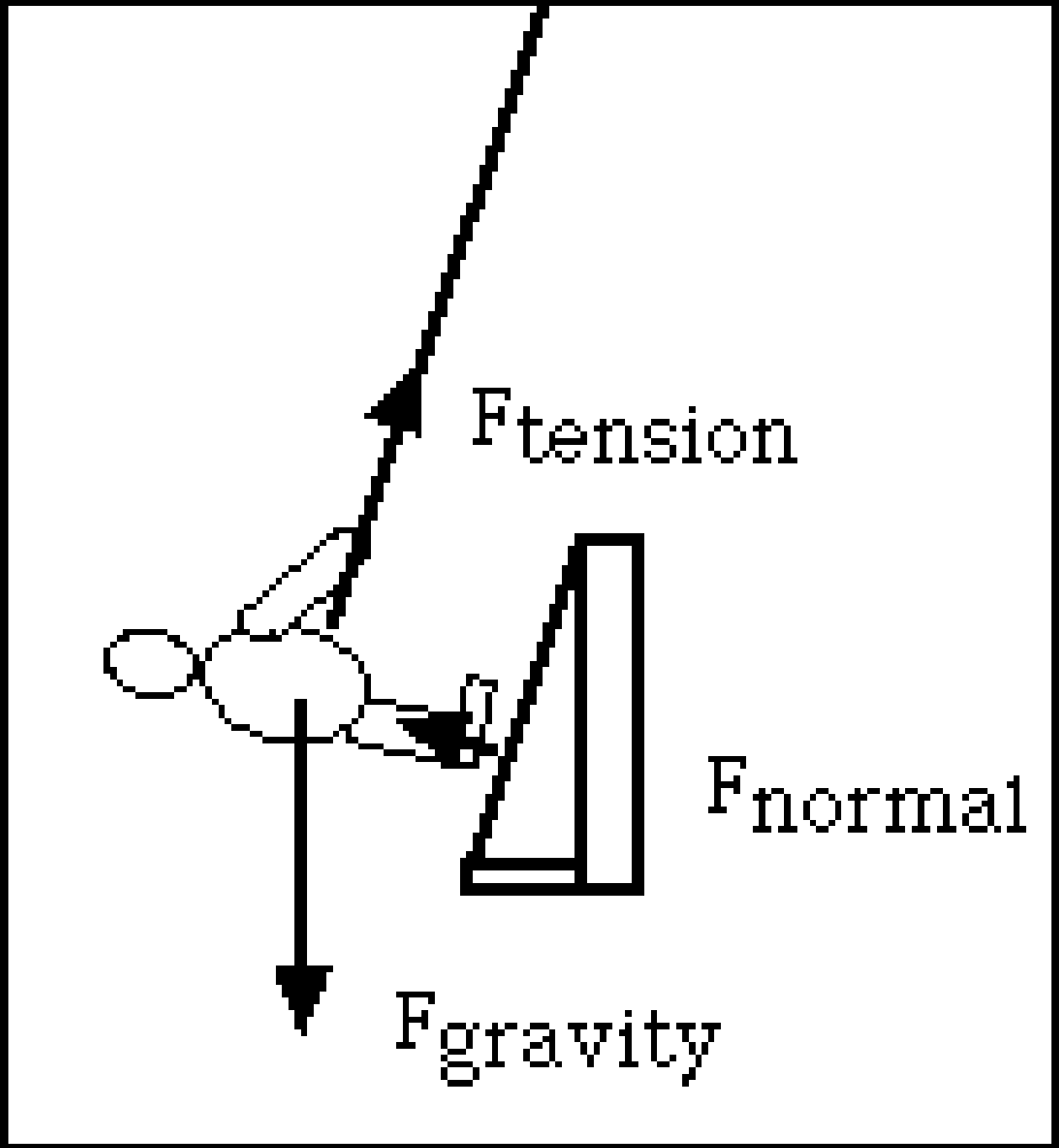
Physicist = Atwoods Machine



Moonwalk Exhibit Experience 1/6 g

Marswalk snack: experience 1/3 g,
experience an inclined plane.




Ftension
Fnormal
Fgravity

Orbital mechanics

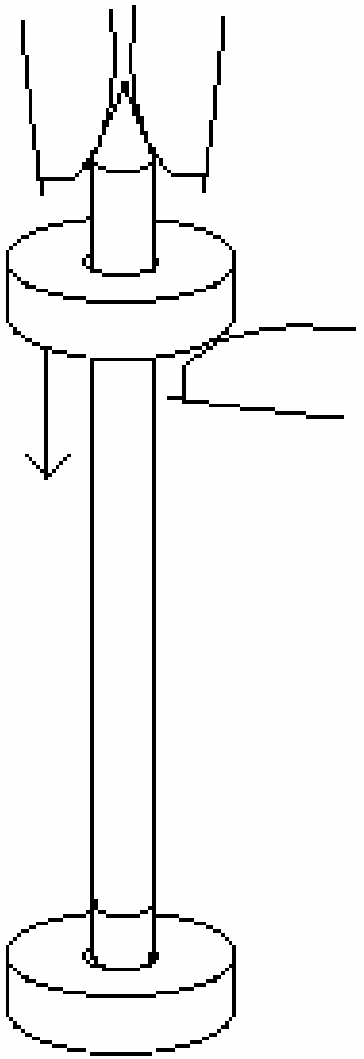
Scientists are like composers

Teachers are arrangers

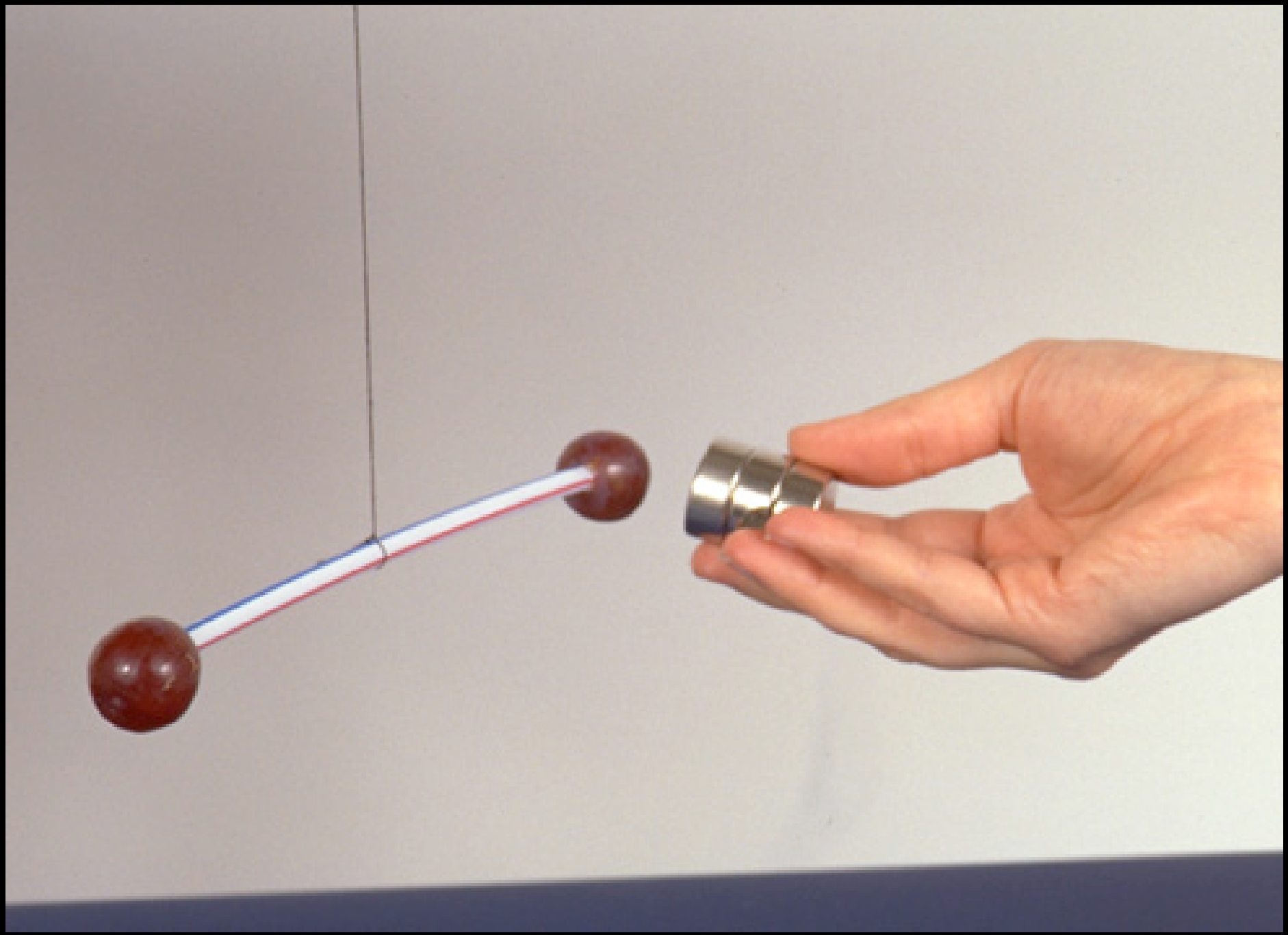
Students play the music

Scientist/teachers
play jazz in a jam with the students

Silent Collisions

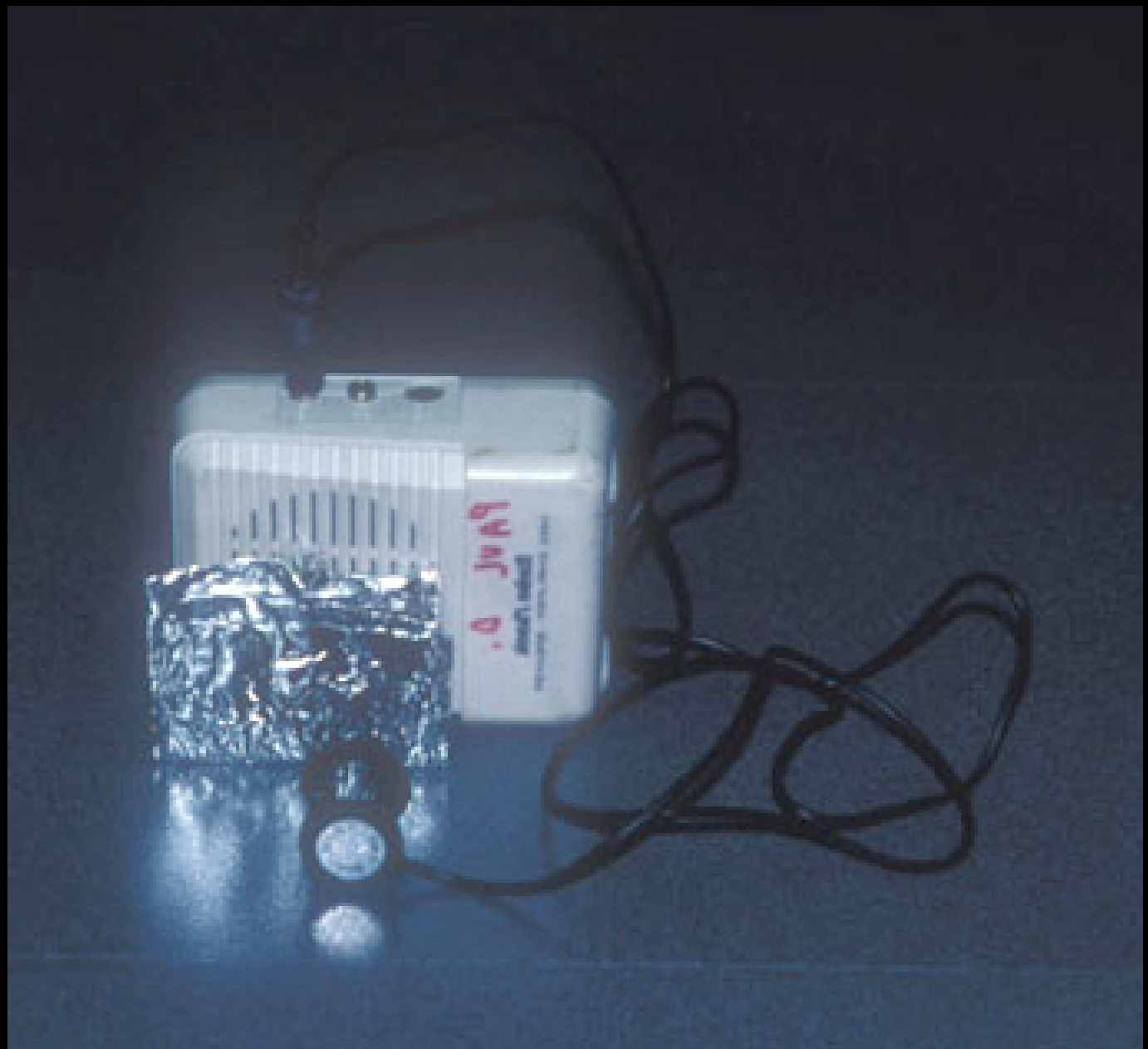


Push a grape with diamagnetism



Digital Magnetic Tape

Metal Detector Barkhausen effect

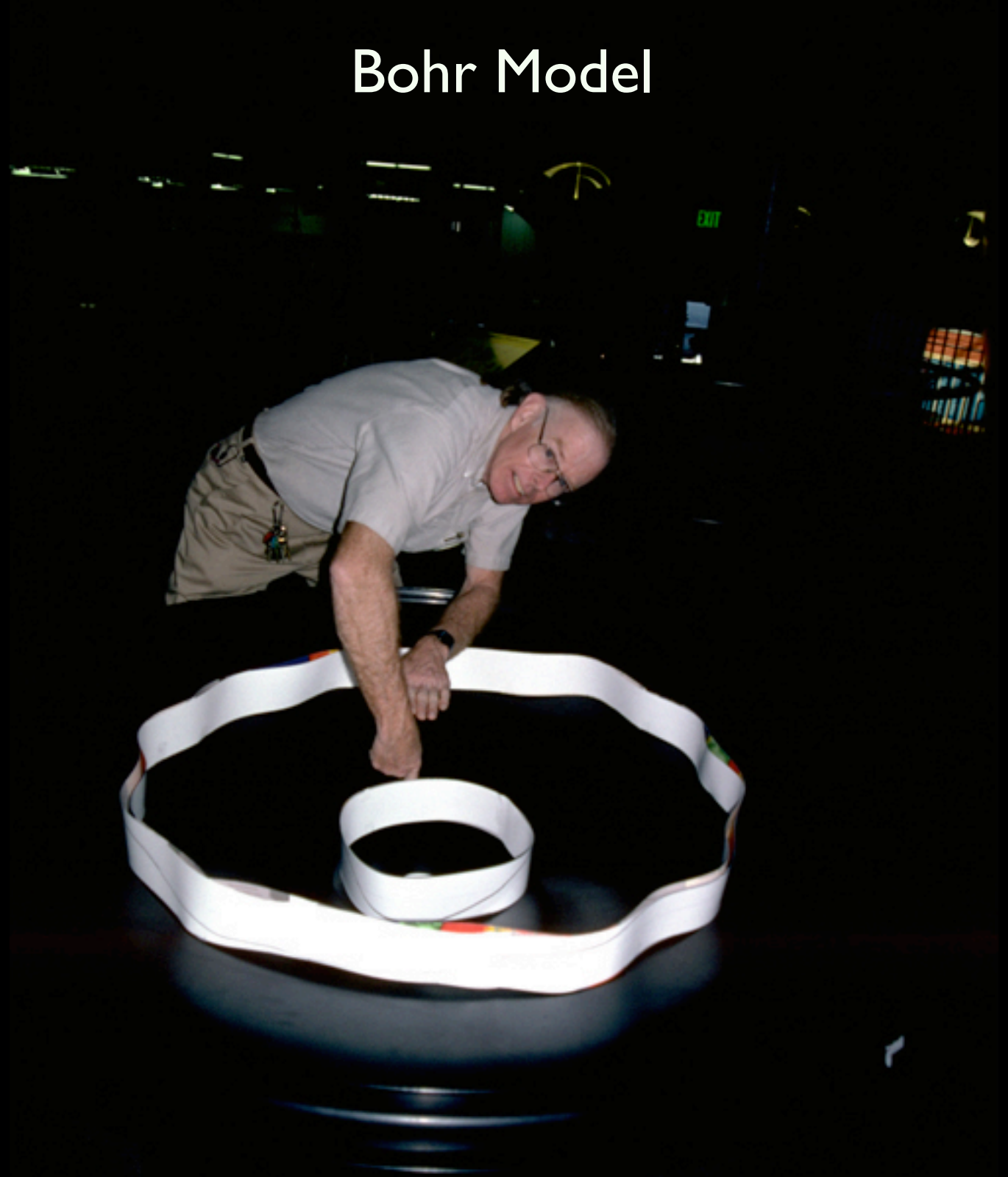


2006 Benjamin Franklin 300’th Birthday

Waves on a phonecord

Bowling in a Gravity Well

Bohr Model



Light comparator

This presentation is available on my website

Paul Doherty

use google

or

http://www.exo.net/~pauld

Progress?

Losses

Phone Cords - Cordless Phones
Film Cans - Digital Cameras
Magnetic Tape - i-pods

Gains

Neodymium Magnets
Compact Disks

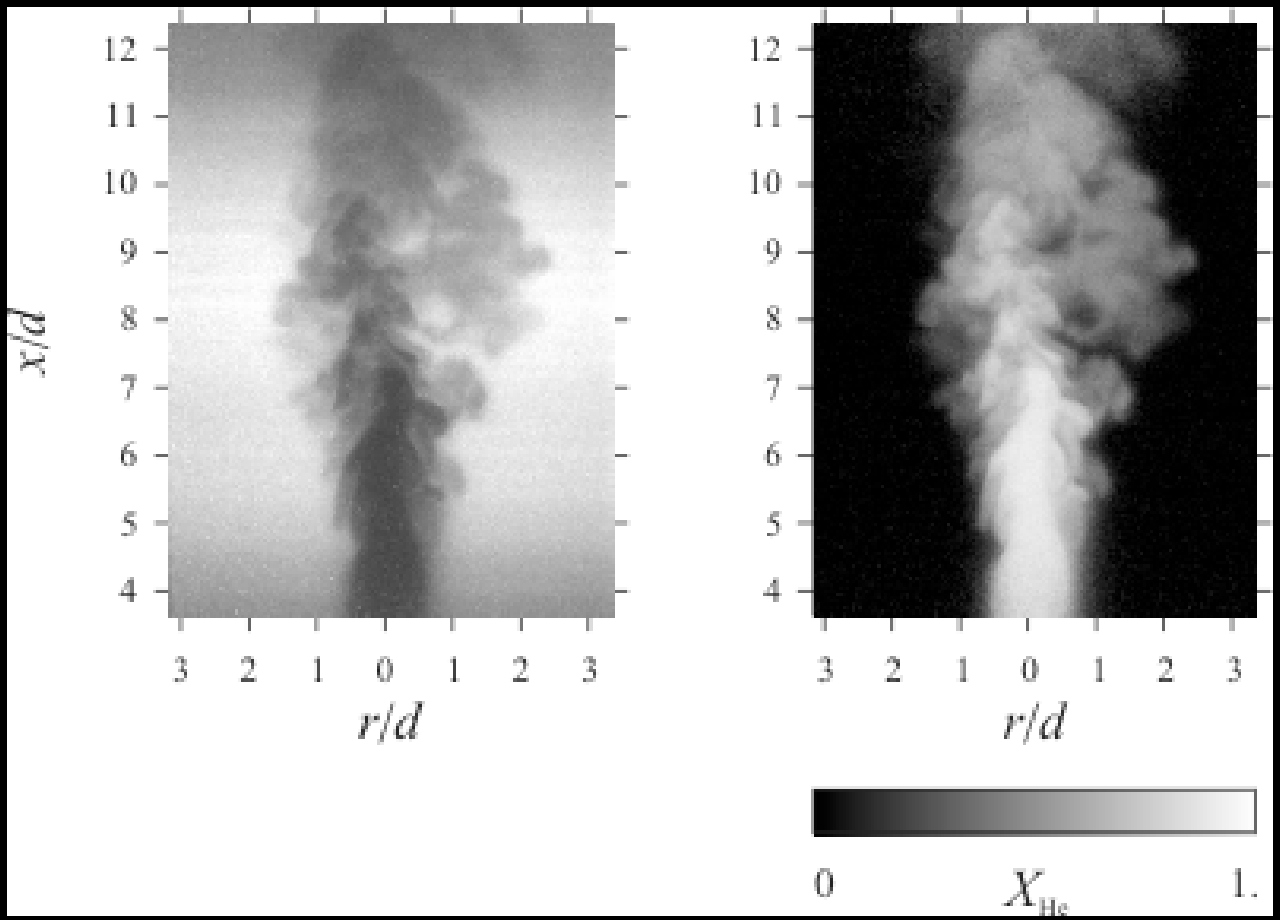
Museums Need Scientist/Teachers

Scientists need Museums

Moshe's question

On-hand science

Why when you blow on your hand through pursed lips do you feel cold, while when you blow with open mouth you feel hot?
Is it Joule-Thomson throttling or entrainment.
Here is a photo of entrainment:



Moshe's question

When Moshe did the experiment in a sauna even the blow with pursed lips was hot.

When you blow through a straw the air is hot.

So it seems that entrainment is most important.

A high speed low volume flow jet of air mixes into stationary air to produce a low velocity high volume flow which is a turbulent mixture of the jet and the air.