

Learn Science by Doing Science

Paul Doherty

Exploratorium Teacher Institute

The Exploratorium San Francisco, California





The Exploratorium

A museum of Science, Art, and Human Perception



and Humor

RESTROOMS



The Exploratorium is moving to Pier 15
Last day at the Palace of Fine Arts Jan 2, 2013
Opening the new Museum spring 2013



Pier 15 and the Observatory



The Exploratorium

1 room, 475 Exhibits, 10,000 m²
1 new exhibit a week

600,000 visitors a year

The Exploratorium website

40,000 pages

5 new pages every day

500,000 visitors a week.



The Exploratorium isn't just a museum, it's an ongoing exploration of science, art, and human perception—a vast collection of [online interactives](#), [web features](#), [activities](#), [programs](#) and [events](#) that feed your curiosity.

We're Moving to the Piers in 2013! [Follow Our Progress.](#)

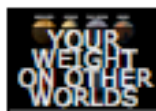
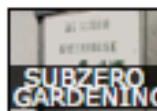
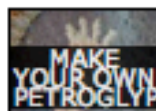
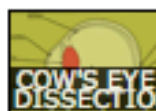
explore | [our websites](#)

Come with us to the bottom of the ocean, the farthest reaches of space, and everywhere in between.



explore | [things to make and do](#)

Enjoy hands-on activities, online interactives, videos, and more.



visit | [the museum](#)

[Hours & Admissions](#)

[Location & Directions \(Doyle Dr. Detour Info\)](#)

[Calendar](#)

Exploratorium @ The Palace of Fine Arts
3601 Lyon Street
San Francisco, CA 94123

(415) 561-0360 - general information

(415) 561-0362 - Tactile Dome reservations

Open Tuesday—Sunday
10 a.m. to 5 p.m.

Closed Mondays (except certain holidays). For details, visit our [calendar](#).

And now we do Apps

App #1 23 Oct 2011

Color Uncovered

App Store > Education > Exploratorium



Free App

Category: Education
Released: Oct 10, 2011
Version: 1.0
Size: 55.1 MB
Language: English
Seller: Exploratorium
© 2011 Exploratorium

Rated 9+ for the following:

- Infrequent/Mild Mature/Suggestive Themes
- Infrequent/Mild Profanity or Crude Humor

Requirements: Compatible with iPad.
Requires iOS 4.3 or later.

Color Uncovered

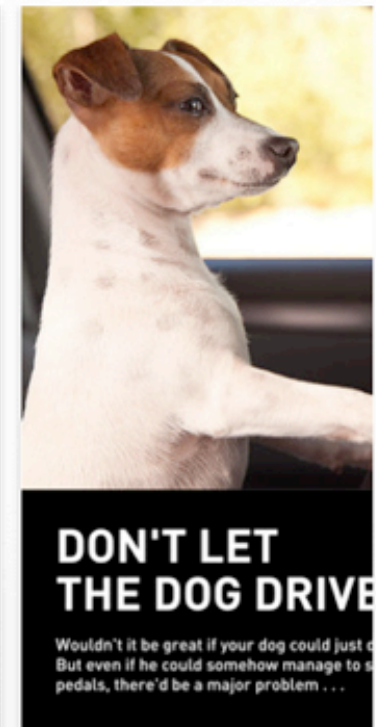
Description

Explore the surprising side of color with Color Uncovered, an interactive book that features fascinating illusions, articles, and videos developed by the Exploratorium. ...

...More

[Exploratorium Web Site >](#) [Color Uncovered Support >](#)

iPad Screenshots



#1 question is

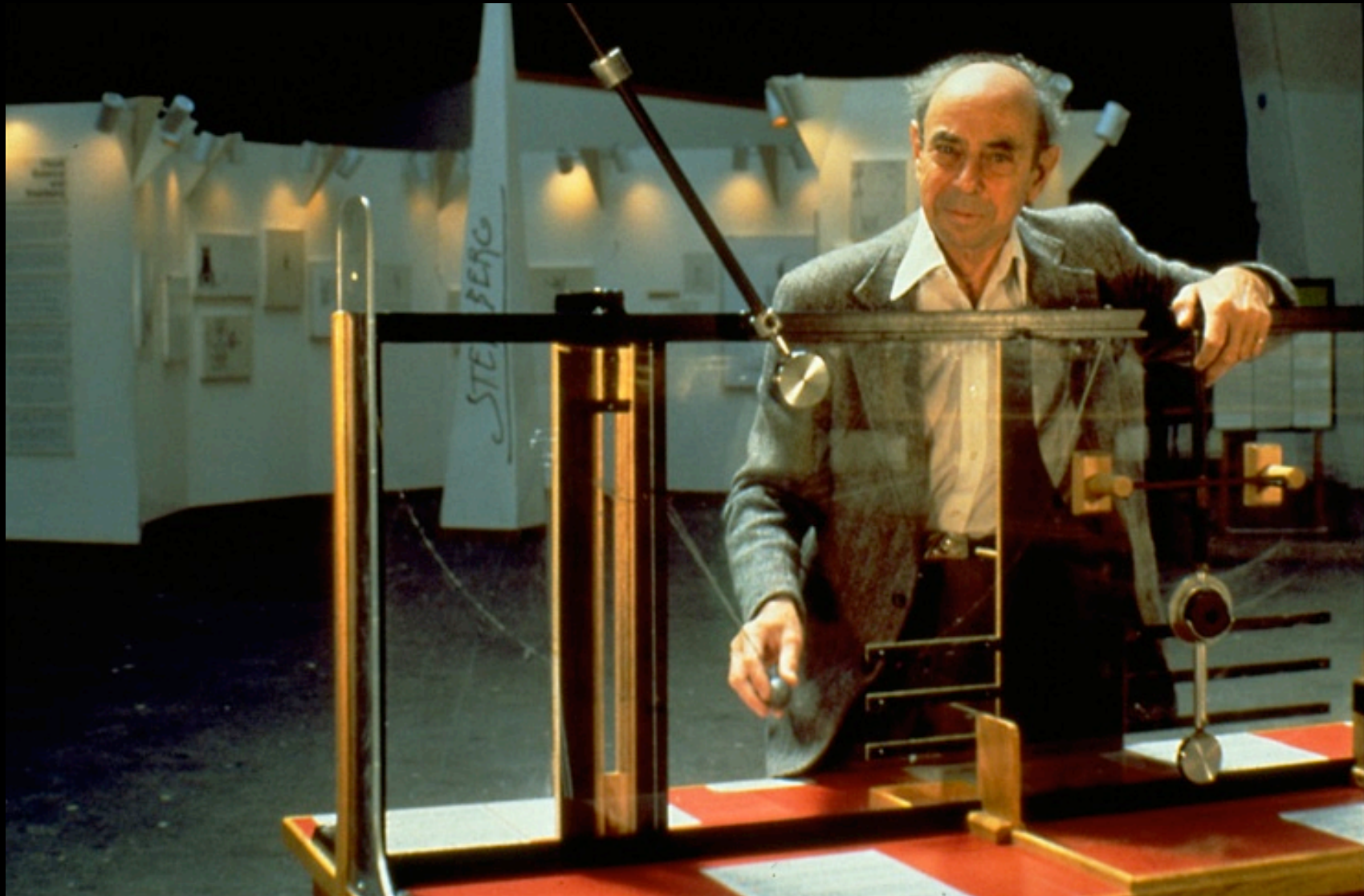
Where do you get your ideas?

#2 question should be

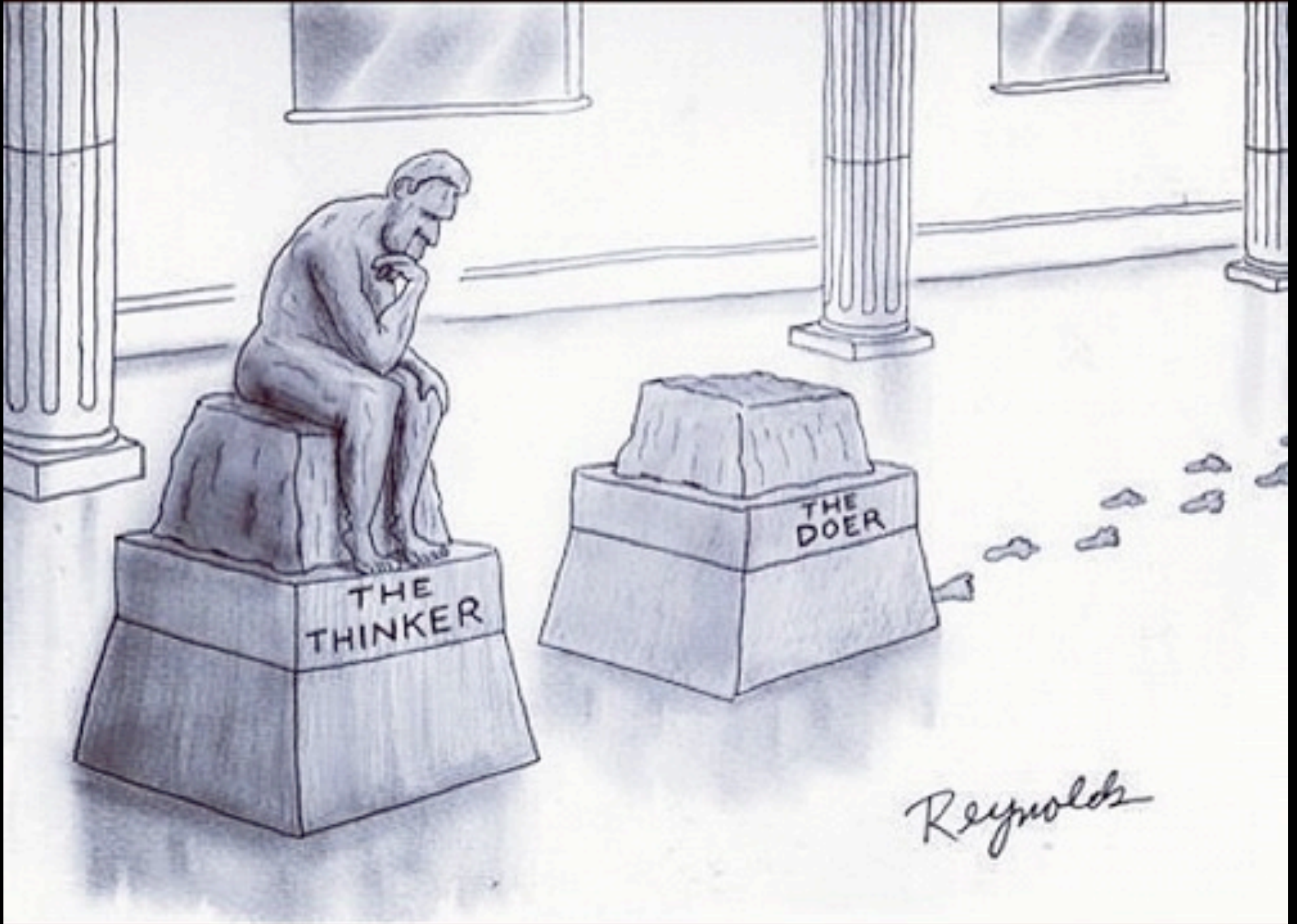
Once you get an idea, how do you make it come to life?

Frank Oppenheimer

Answer to #2 “Make Working Prototypes”



It takes both



Who?

Is your audience?



Who?



Understanding perception and reality is important for Scientists and buddhists



Experience the Real Phenomenon

A small syringe full of
water pushes against a
large one.

Feel the winner!



Where are the rays?



Paul Doherty ask “What do you see?”

My favorite question, with no wrong answers.

And sometimes students see things no one has seen before.

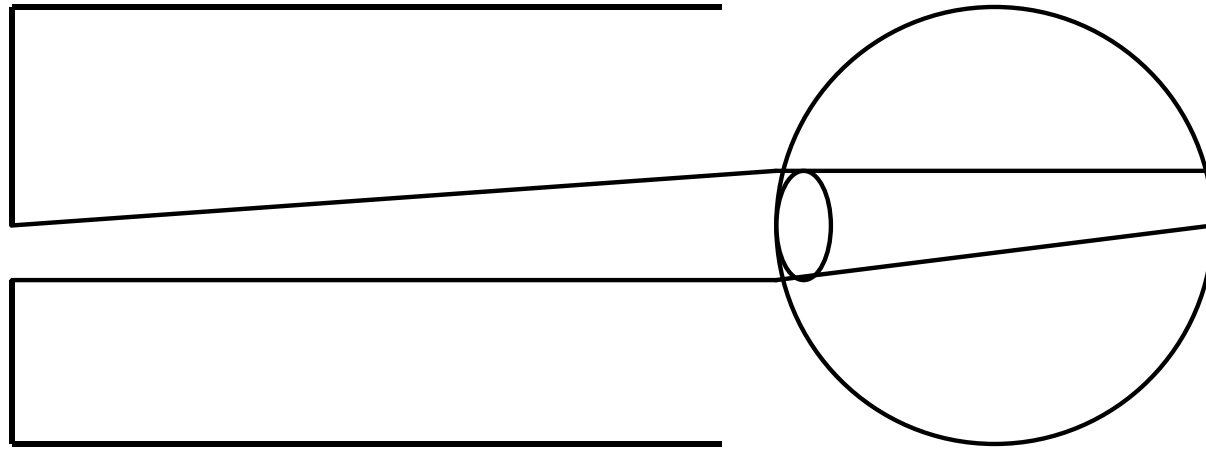


Look through a pushpin hole in a film can.
Open and close the other eye and watch the hole change
size.

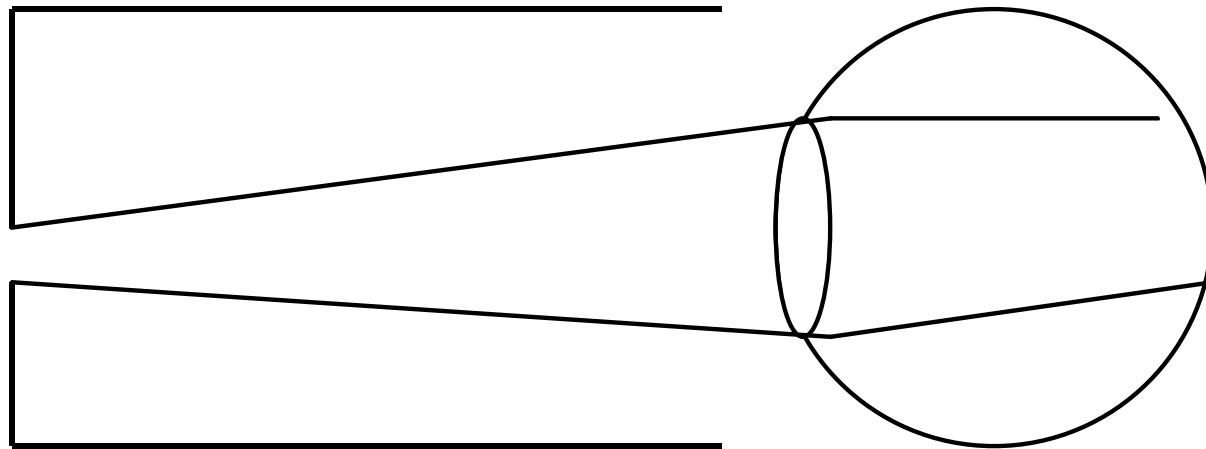


Modesto Tamez “What we do is Jazz”
The path of each class will be different.
Facilitate learning by listening to the students,

What's Going On?



Your eye cannot focus on the close hole
You are seeing your pupil change size



Progress?

Losses

Phone Cords
Film Cans
Magnetic Tape

Going

Compact Disks

Gains

Camera phones: Apps
Neodymium Magnets
LEDs

Don Rathjen: "Keep it simple"



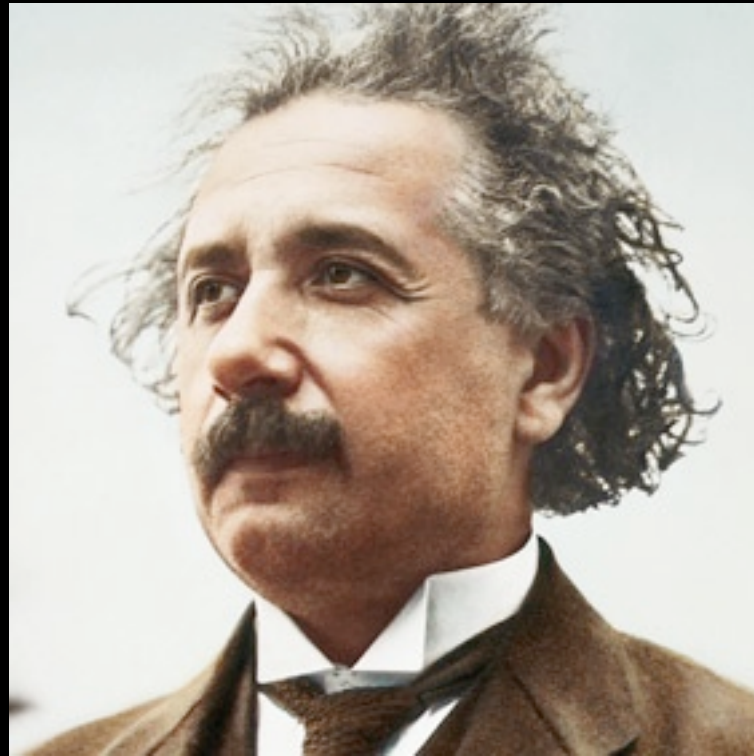
Making a square wheels exhibit with toilet paper tubes!

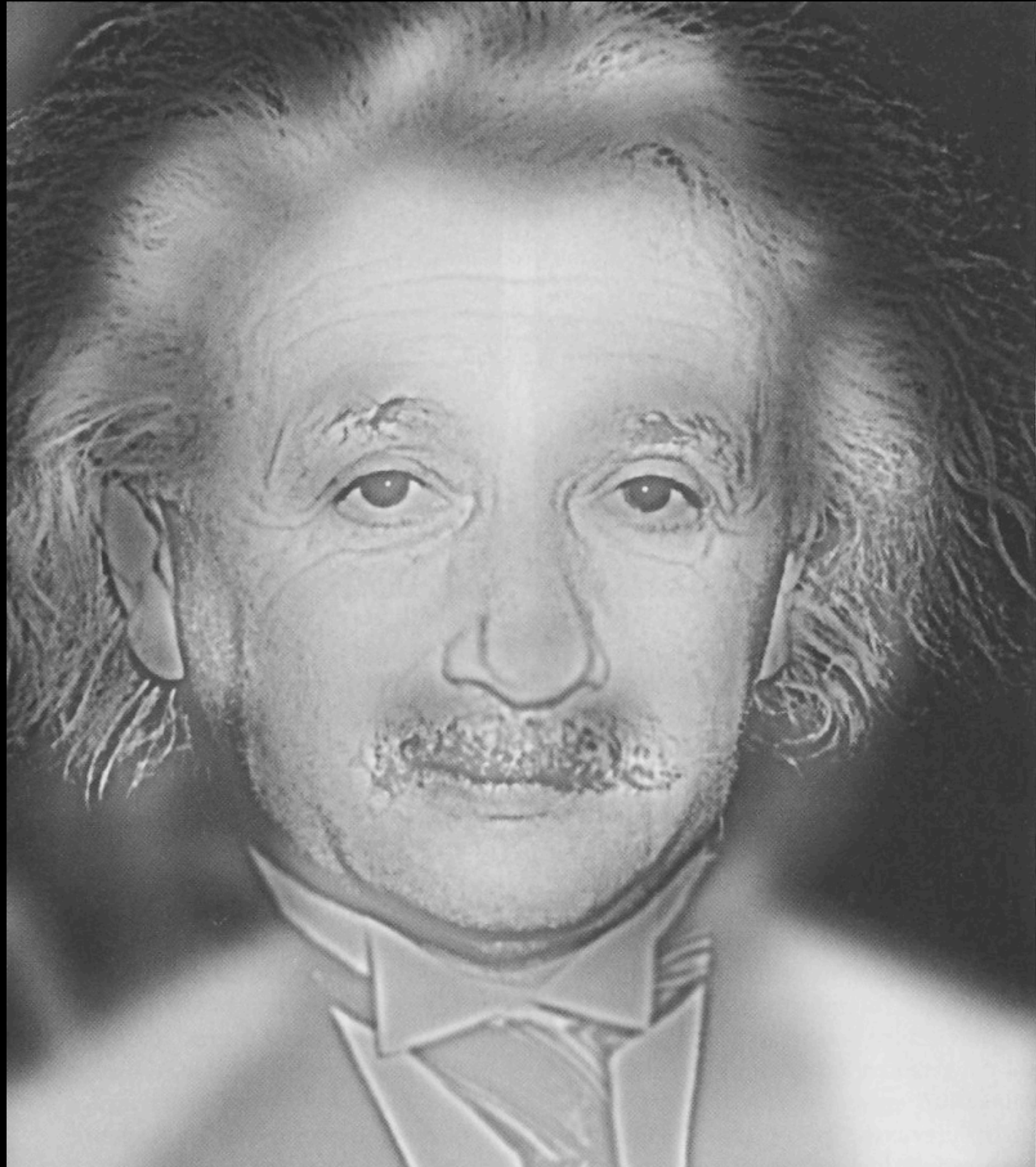
Exploratorium Exhibit \$10,000, Snack \$1



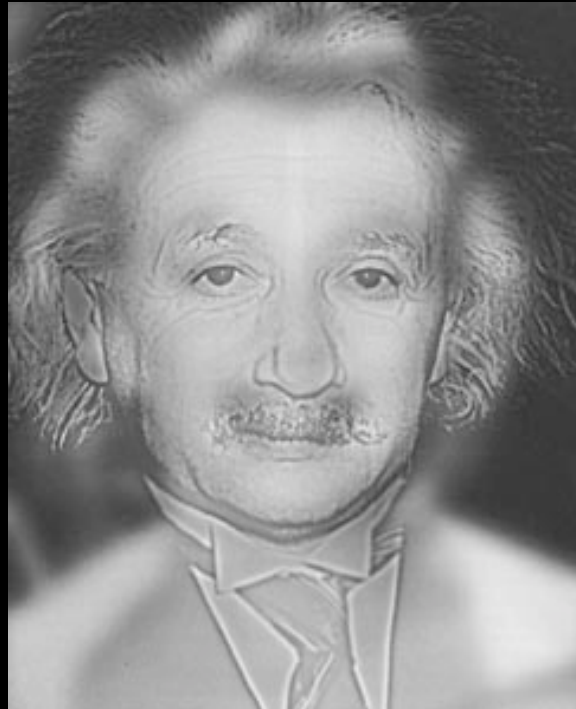
Einstein

“Everything should be made as simple as possible,
but not simpler.”





See what happens when you make it too simple?



Hybrid Image
by
Aude Olivia
MIT

Facilitate going further

Watch carefully, your students may surprise you
Put a cell phone in a string telephone



The Monks: “Find Joy in what you do”

Make it social



Combine two things: Social and Fun



Eric Muller: hums the theme from Gilligan's Island

Make it Social



Learning is fun!



Trace a face on a manila folder, then cut it out!



In class discovery: Put your head against the head of a monk biting a music box and you can hear it!



Make Science: Interesting



Learning about yourself is interesting!
Make it a whole body experience:
What is the surface area of a human?



Make it Relevant
Keep it simple

Lori Lambertson makes models of CO₂, and H₂O

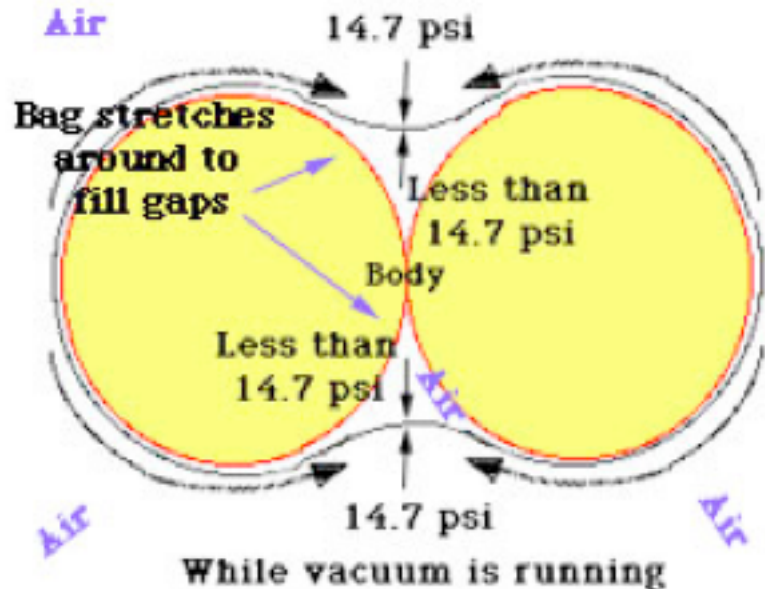


Fun

Understanding vacuum packing.

Measure it!

pressure reduction inside the bag is only 2 PSI



and Correct

Speak and write so that what you say in “Not Wrong”
There must be at least one way to understand
how what you say is correct.

Scientists often write so that it is
difficult to misunderstand
with the result that what they write is
difficult to understand.

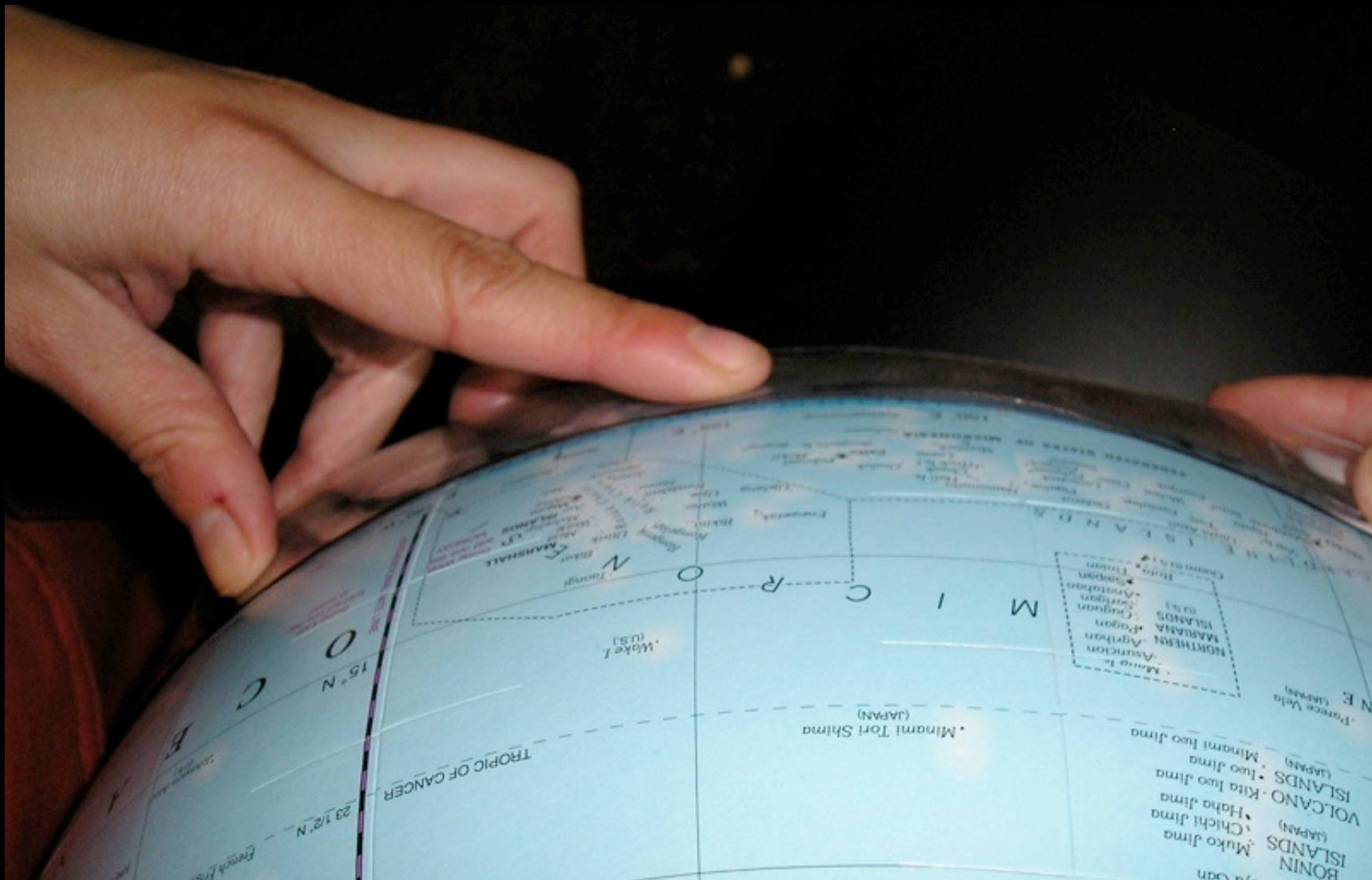
Make it timely





Atmosphere Model
3 transparencies model the atmosphere

90% of the atmosphere is within 15 km of the surface
within 0.5 mm for a “14 inch” earth globe.



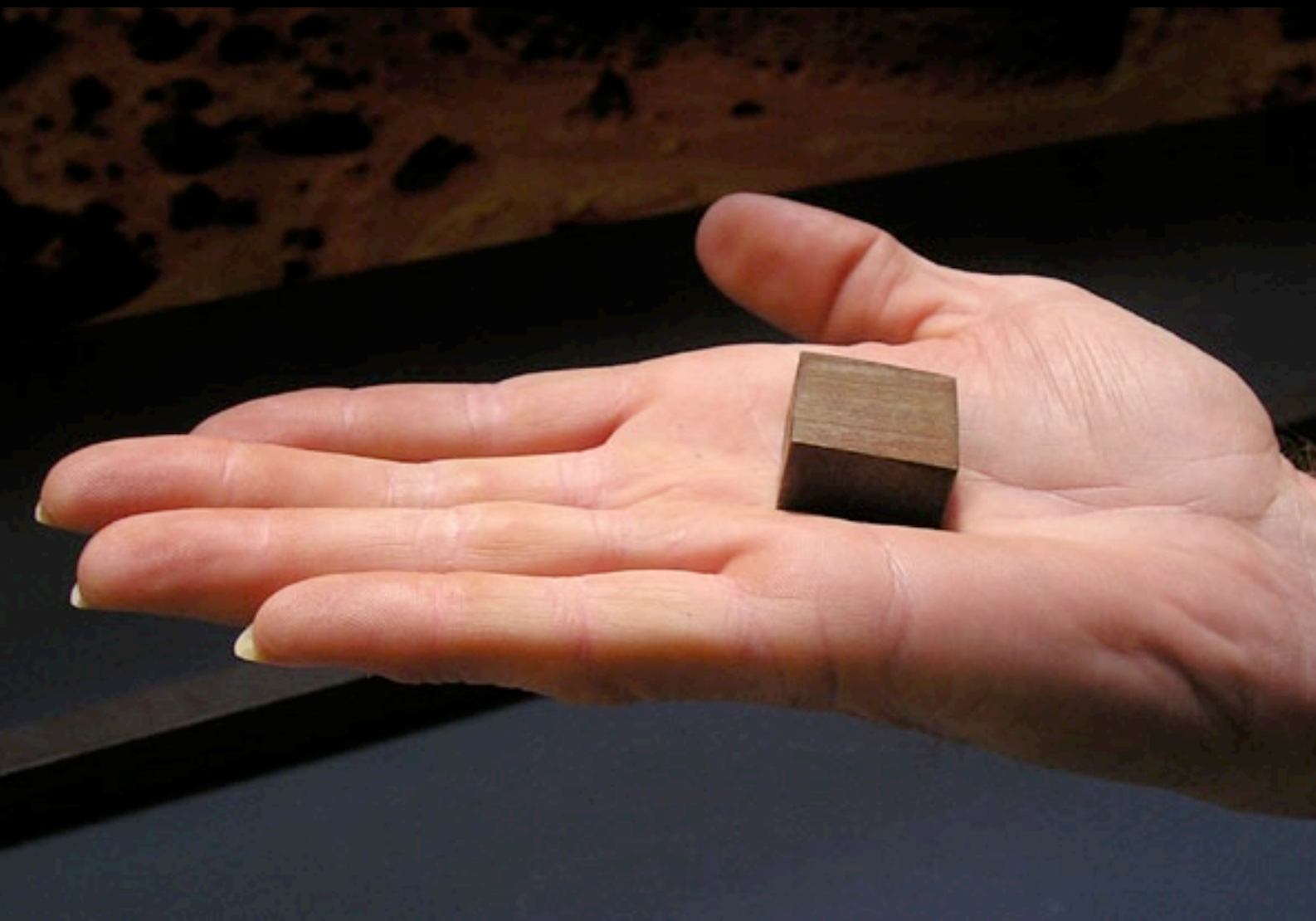
Atmosphere Model





Feel it!

1 Atmosphere = 1 bar
14.7 lb 1 square inch



Mars Bar



When you pull on a syringe full of water you reduce the pressure inside.

And it boils at room temperature.

Just as Felix Baumgartner's blood would have!

Total Recall exposure to low pressure Mars Atmosphere.



Classic Storytelling

Do it in 3s

And on the third occurrence

add a twist.

A scientist looks at something that
everyone has looked at

and sees something that no one has
seen

A teacher helps students to see
things

they have never noticed before.

Students ask questions that will help
teachers

see things they have never noticed
before.

Modesto Tamez

Begin with a
“provocacione”

Imperfect Instructions
lead to creativity

What we do is Jazz



Provocazione

People “Know” what is going to happen, surprise them!





Make it Big: Giant Slinky

Make it Big: Giant Bell on a straw oboe
Of course this was the 3rd bell added.





Make it Big: Get inside a musical instrument.

If you can't go to the moon model it



Make it Big: Giant moonwalk



Listen to students: They discovered orbits could be explored with a giant conical moonwalk.



Make it Big: Giant Mirror

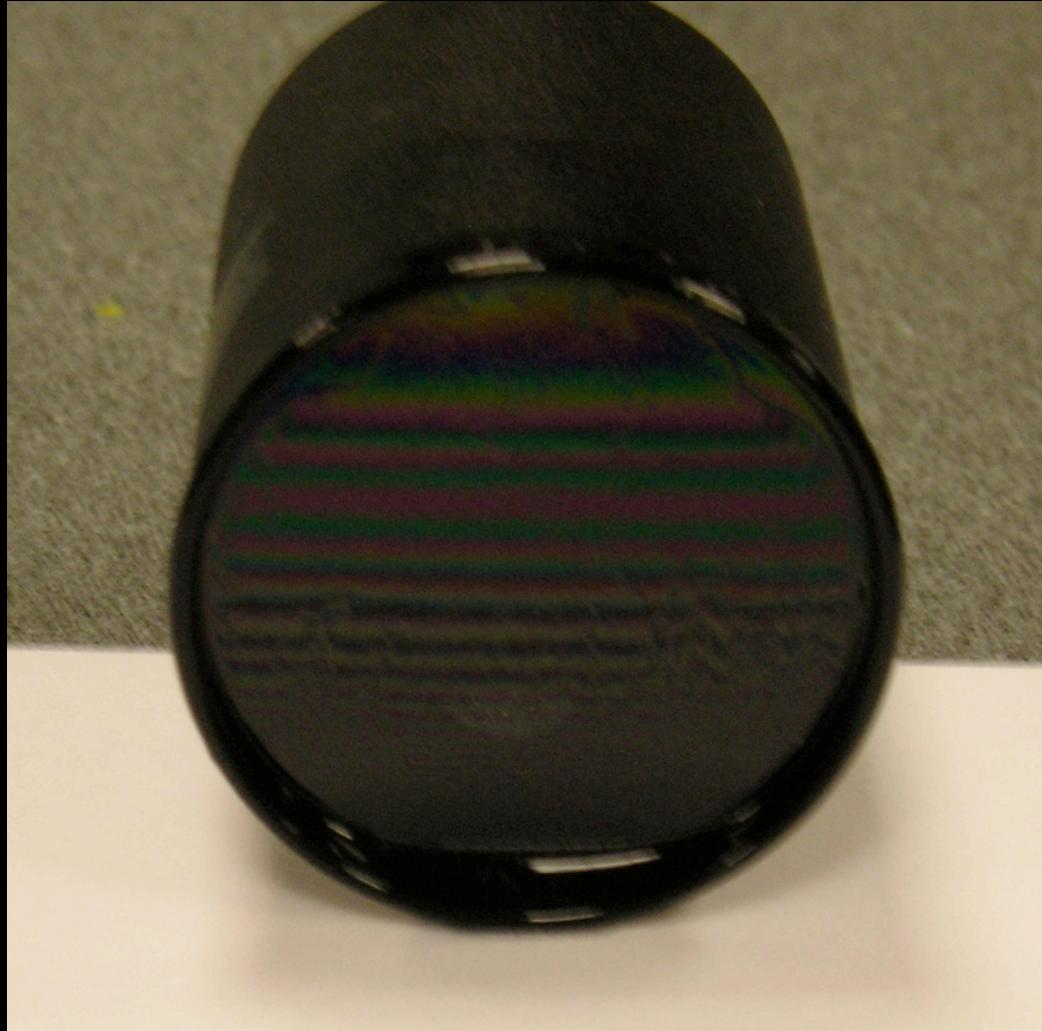


Adults have fun learning too!
Teachers interacting with a soap film.



Make it small

Soap Film in a can

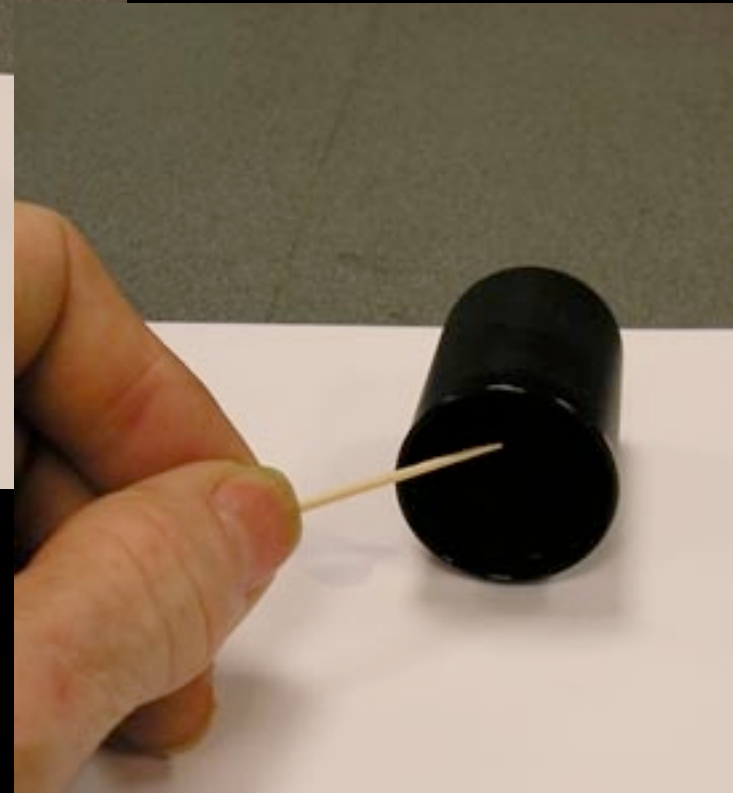
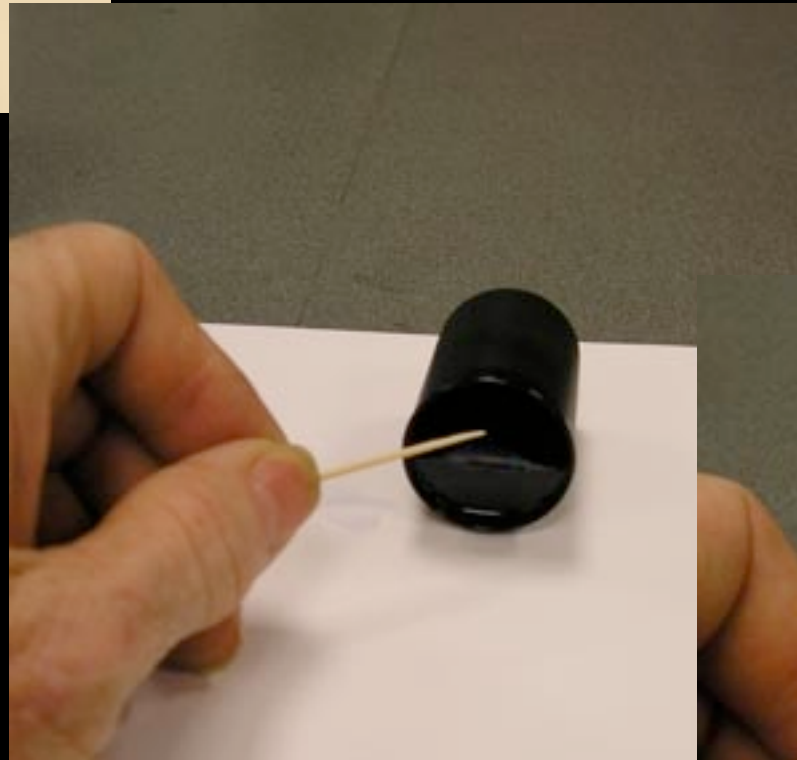


http://www.exo.net/~pauld/summer_institute/summer_day8interference/soap_film_in_a_can.html

Make it human

Hooke: There is a force but no film

Newton: pin

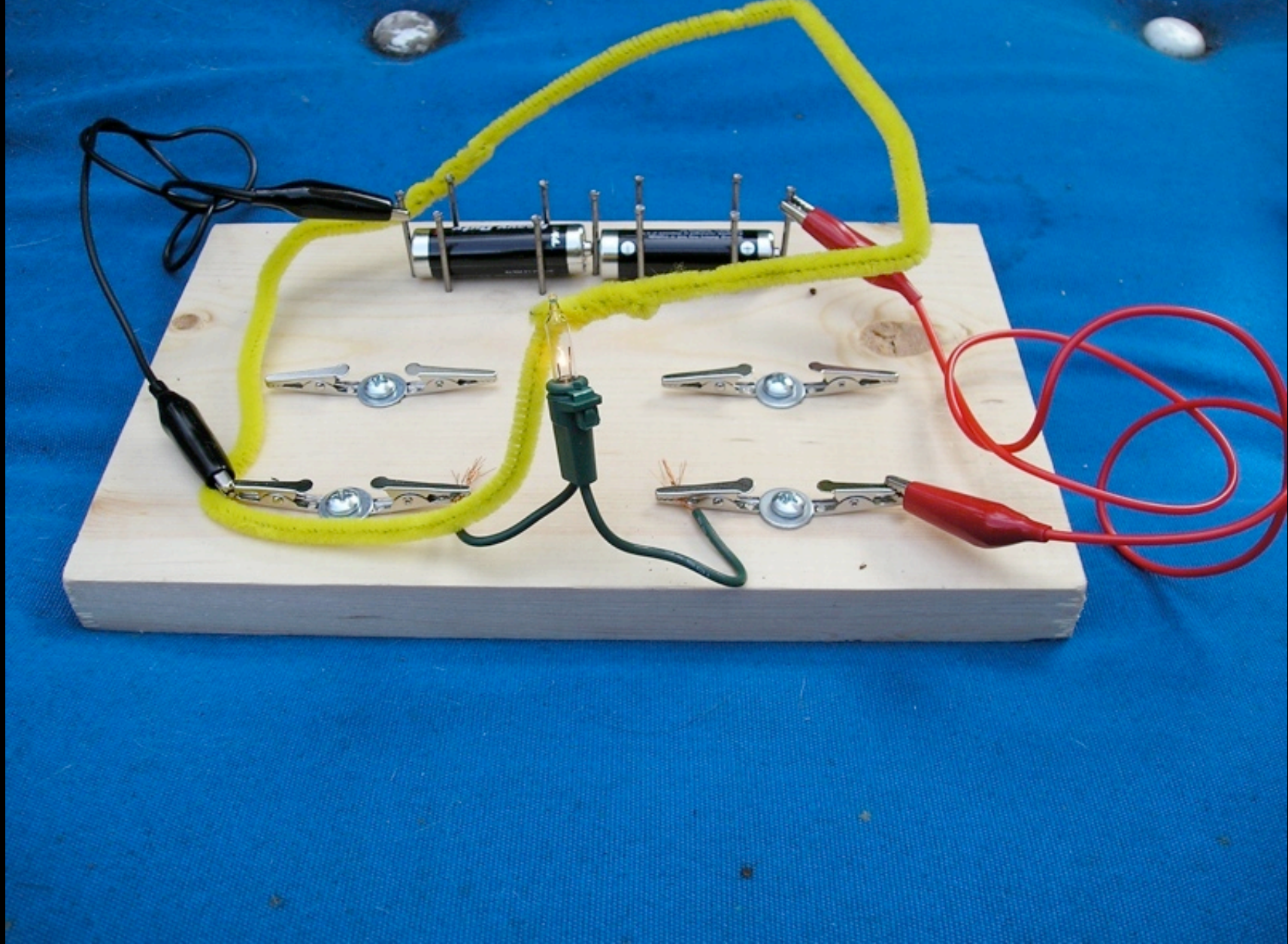




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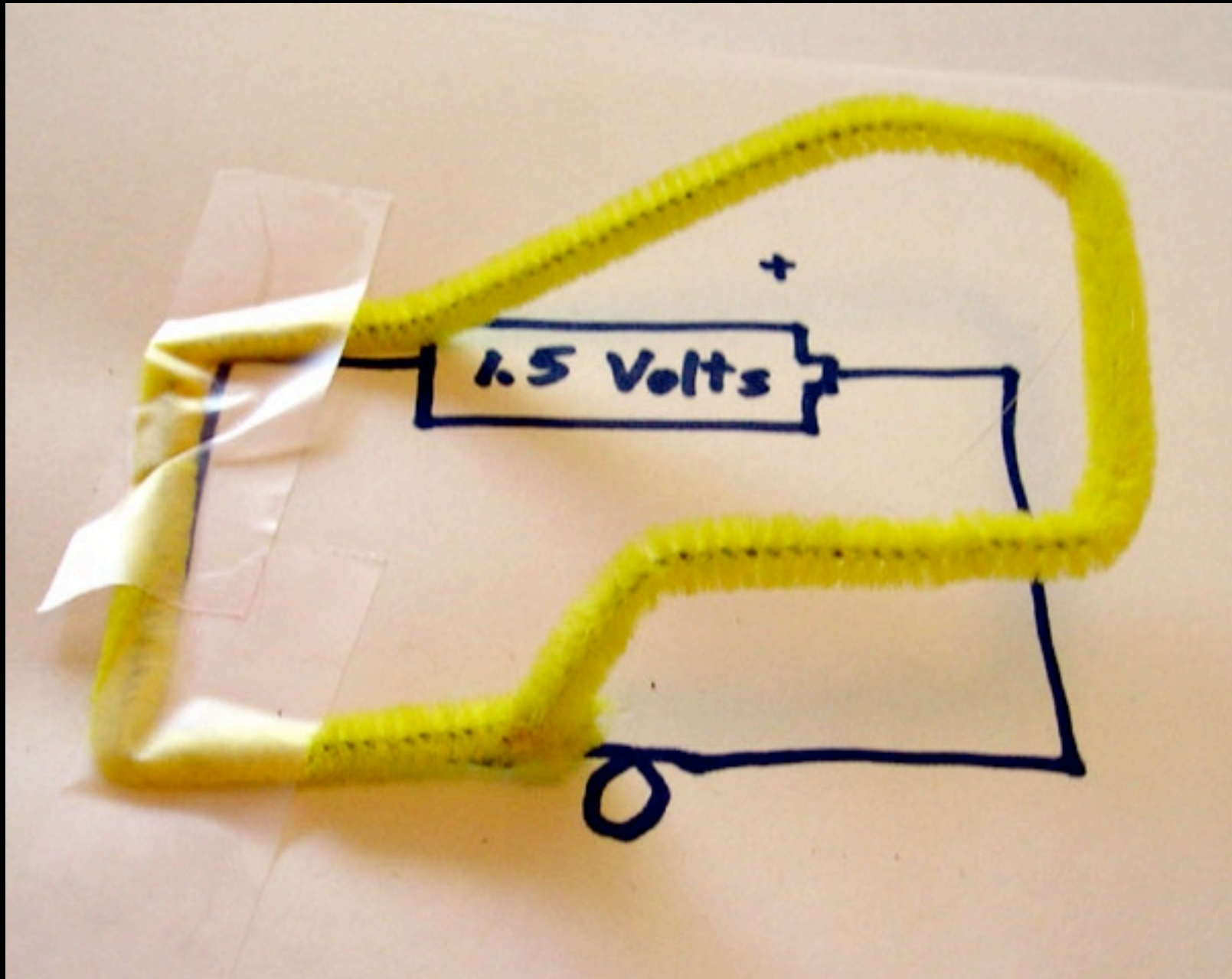
Where does the science appear in the world?





Voltage Model
Portray voltage as height
 $1 \text{ volt} = 1 \text{ inch}$

Go from the real to the abstract



Make it multiple?

5 Slinkies show earthquake motion better than 1



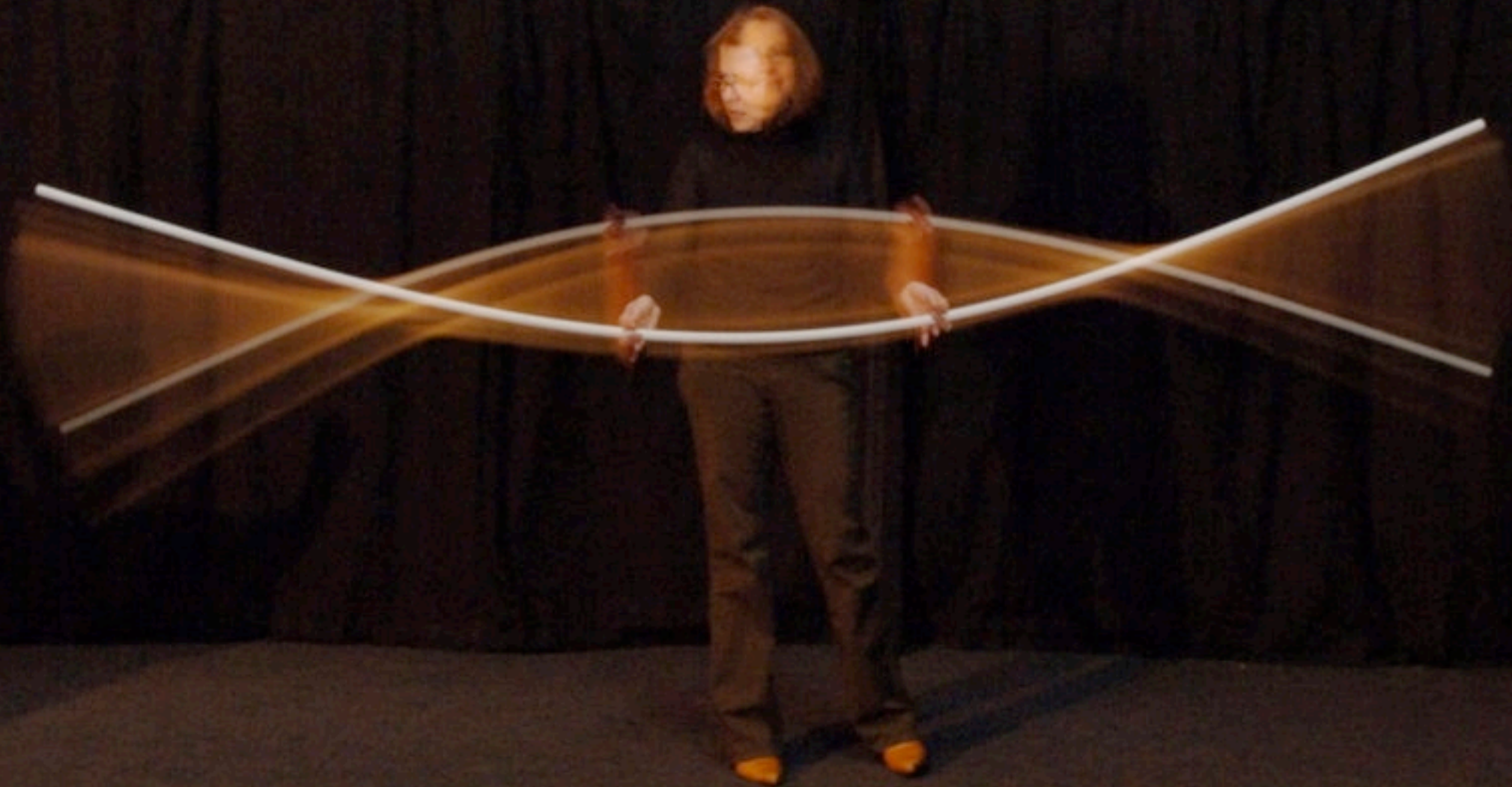
John Lahr

Reduce the number ridiculously small Bed of Nails



Seat of Nail
Do it safely!

Make it visual
Use imagery
Make it dynamic!



Make it Visual

Polarized light and polarizers model

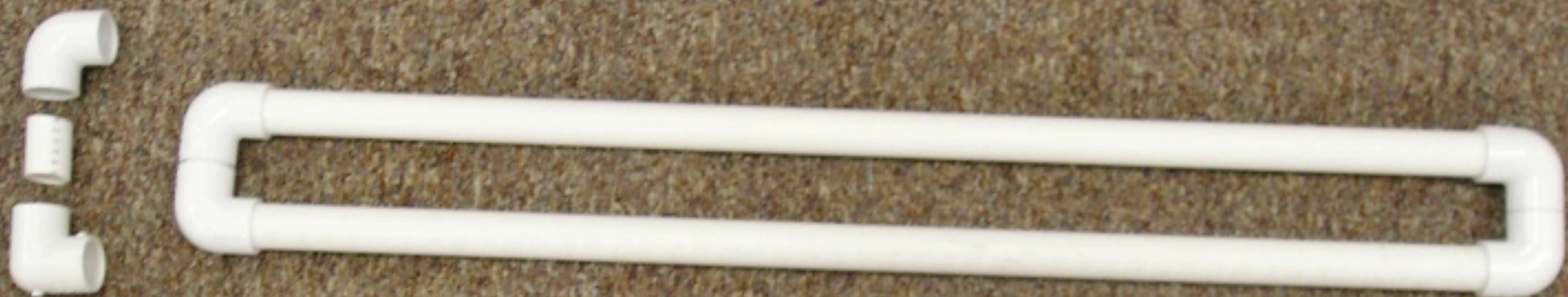


Be willing
to dump the old
and start again

A new polarized light
and polarizer model







Spectra in a compact disk



Some students do things you never expect!



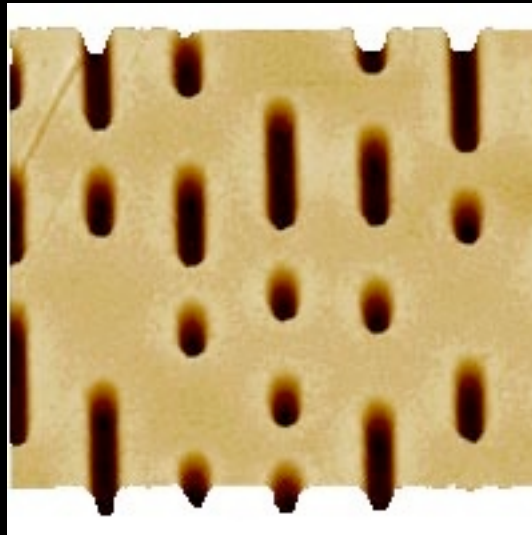
Ask how can I go one step further?
Look for reversals, if you can see a spectrum
can you project one.



CD spectrometer



Pits on a CD



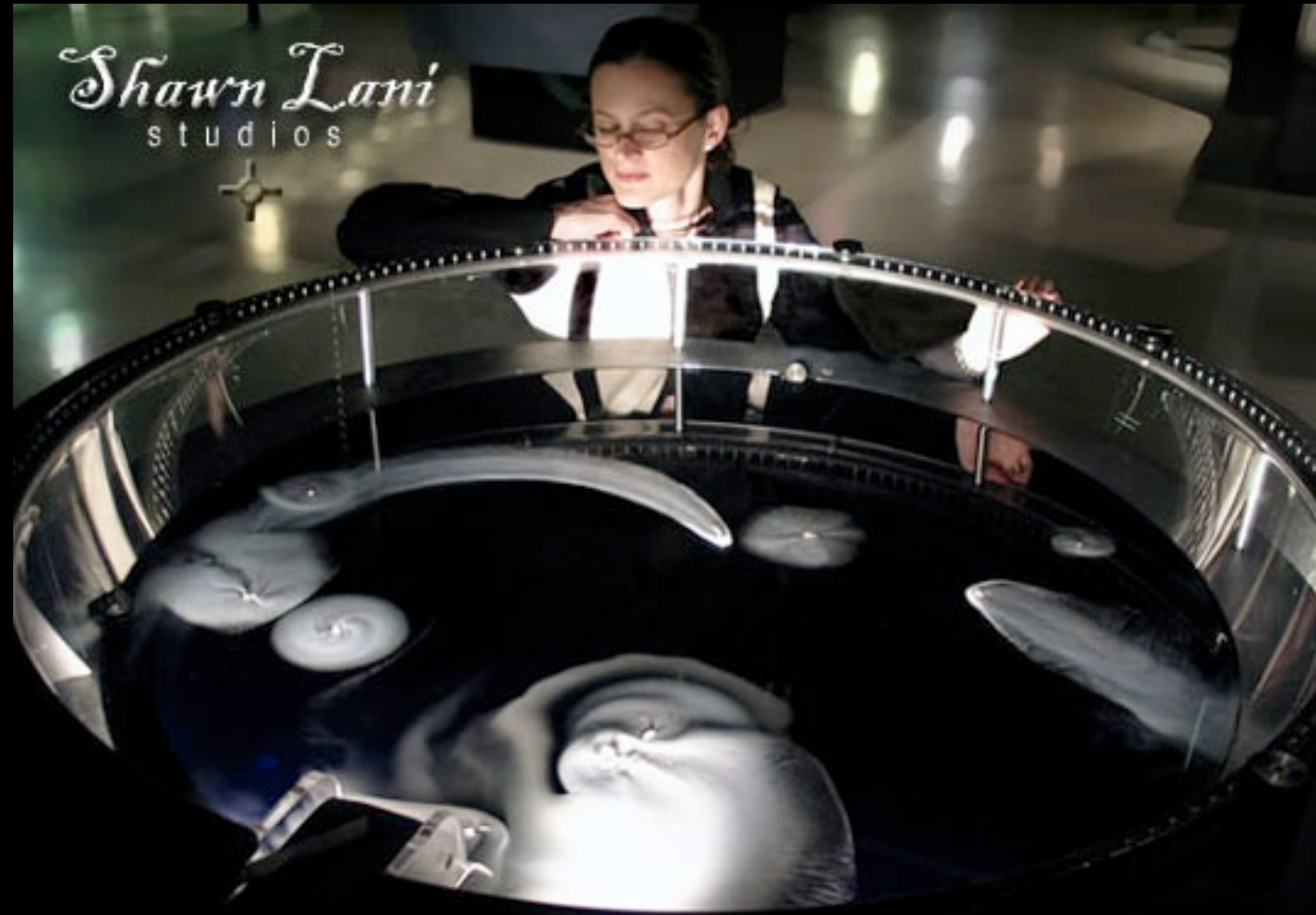
Sometimes a simple image uses a complex tool

Large dry ice bits sink in water, density 1.5 g/cm^3
Small ones float?



Make exhibits safe

Shawn Lani
studios



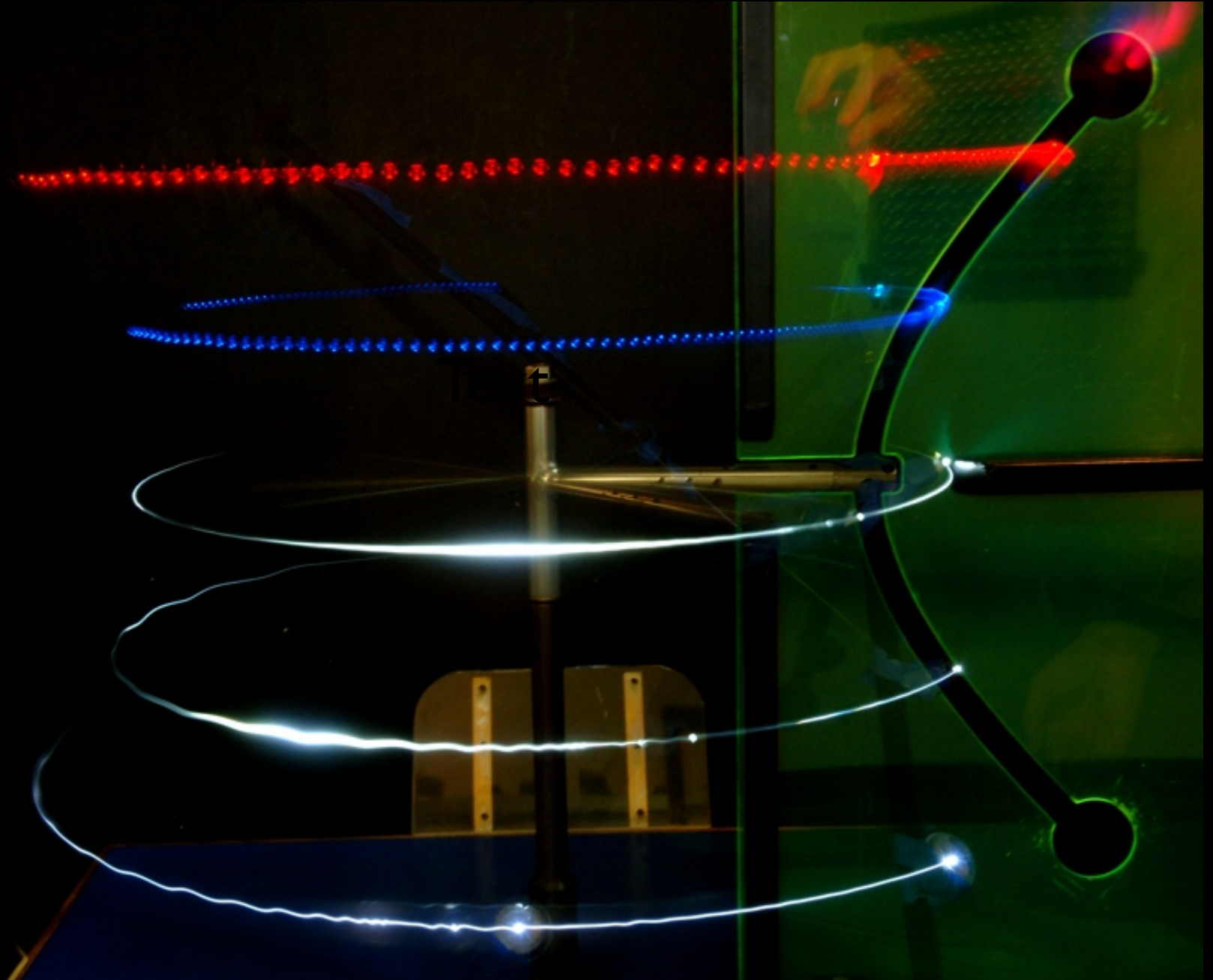
Share your ideas
They will return with
interest.

Sebastian Martin.



Bree Barnett Dreyfuss

Have students do the work!





Inova Microlight

Maurice Bazin: Facilitate Exploration



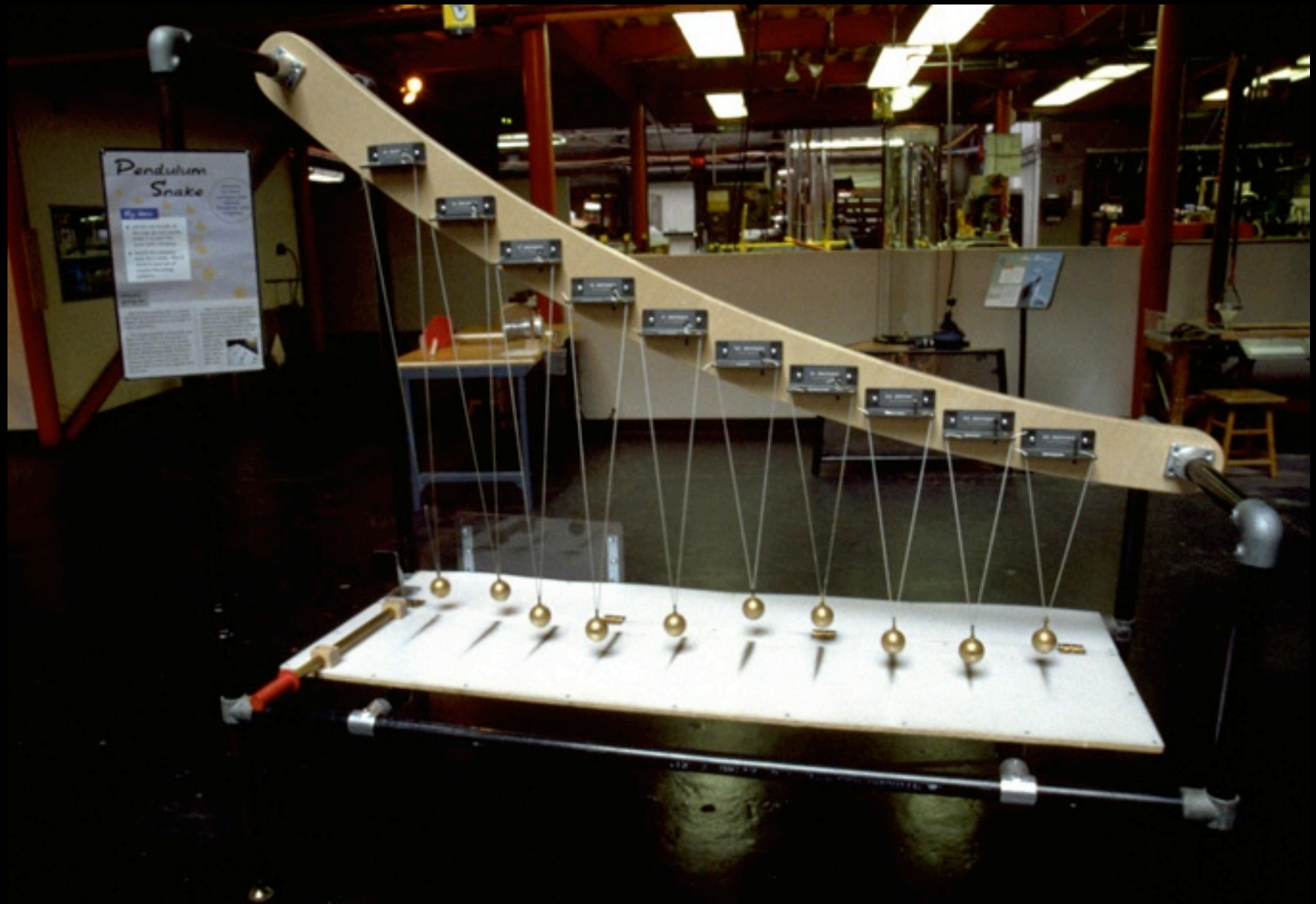


Use the “Mulch” of
stuff you have
learned to create
new things.

It’s not an Atwoods
machine

It’s a Martian baseball
demostrator.

Do the Math!



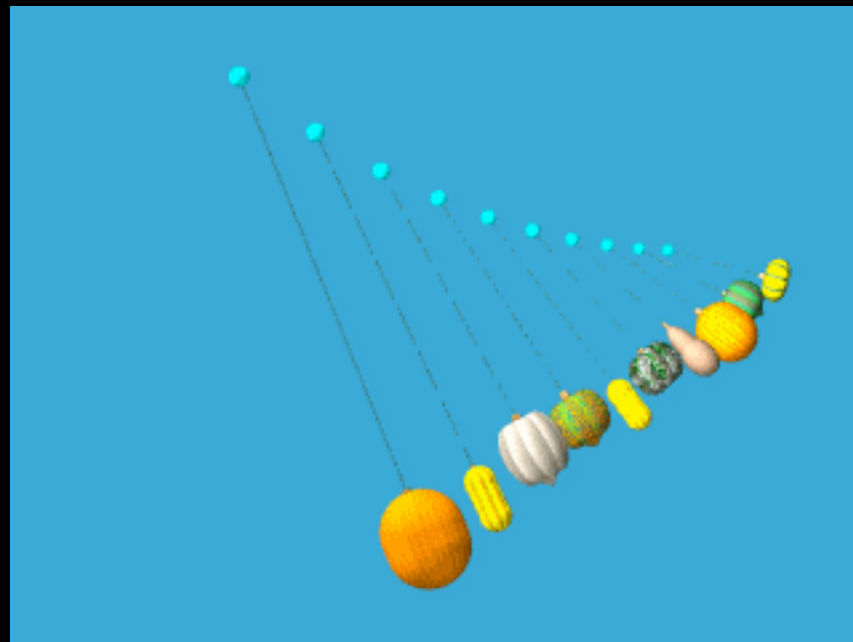
Snack design by Lori Lambertson



A museum visitor
went home
and built a pendulum snake
out of squash.



Pendulum Snake animation









Exhibit

This is where we build

Exhibit Work

Once you have created
and made your new activity
work

Share it with the world

in print
or online





Mind and Science Across Cultures
Exploratorium

The Exploratorium Science Snackbook
Exploratorium

THE BRAIN EXPLORER
PUZZLES, RIDDLES, ILLUSIONS, AND OTHER MENTAL ADVENTURES
Exploratorium

the science explorer
AN EXPLORATORIUM AT HOME BOOK
Exploratorium
Pat Murphy, Ellen Klages, Linda Shore, and the Staff of the Exploratorium

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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.

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.



Scientific Explorations And Adventures

with Paul Doherty

Explore the world. Do experiments. Examine scientific images.

New activities added September 30, 2003.

Scientific Explorations:

[Alphabetical Index](#)
[Archive and Topic Index](#)
[Most Recent](#)

Outdoor Adventures:

[Alphabetical Index](#)
[Archive with photos](#)
[Most Recent](#)

Writing:

Books, Lectures, Webcasts
[Media and Topic Index](#)
[Most Recent](#)

[Biography](#)

[Family](#)

[Links](#)

Contact me at Pauld@exploratorium.edu
[Copyright information.](#)

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.



These activities are available on my website

Paul Doherty

use google

or

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



**You Gotta have heart!
Let your passion show.**

Food is important





Accept humor at your own expense
“I’m Paul, I’m Modesto”



