Milton meets Einstein
Inquiring Minds want to Know

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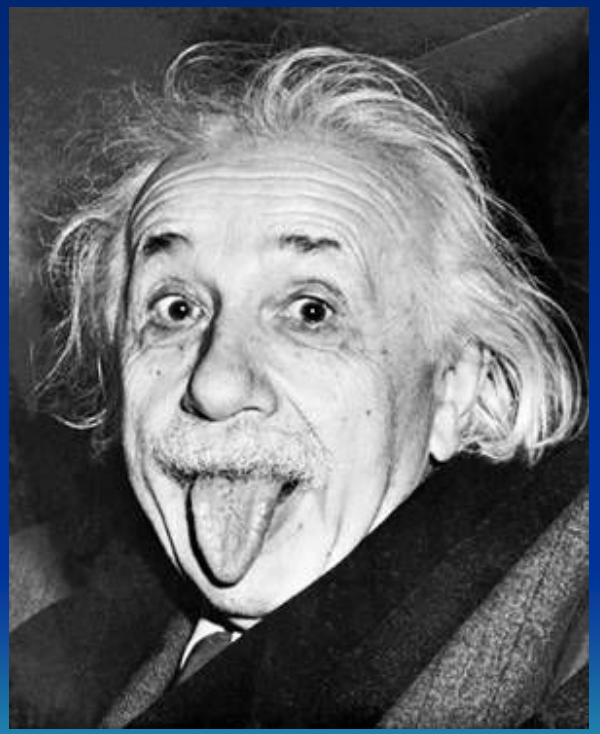
at the University of Nebraska – 9 April 2009

INQUIRY In
Science and
Literature



Failure produces learning

A paradox (a more gentle form of failure) can help learning –

The incompleteness of mathematics:
Godel (1933) strikes down the completeness of axiomatic set theory postulated by Whitehead and Russell in “Principia Mathematica” (1912)

Is a parallel to
The incompleteness of science
Refinement of Newtonian theory (the Principia, 1702) by Einstein’s theory of relativity (1905)

Incompleteness in literature too!

From Sorensen (2005)

G.G. Berry was one of the first individuals to produce new **semantic paradoxes**. Berry's paradox was first presented to Russell (1905) in the following sentence: "'The least integer not namable in fewer than nineteen syllables' is itself a name consisting of eighteen syllables; hence the least integer not namable in fewer than nineteen syllables can be named in eighteen syllables, which is a contradiction"

A more recent paradox (Douglas Hofstadter) is

"What is the smallest uninteresting integer?"

What do you think it might be? – Is it different from mine?

As part of the answer you can note:

1 is interesting – it is the smallest positive integer, 2 is interesting – it is the smallest even number

3 is interesting – it is the smallest prime-number, 7 is interesting – it is a prime-number …..

…….

These Inquiring Minds both want to know

BUT… They ask different questions!

Key Concept 1

Elegant Solutions

are the highest order of what might be termed

Quality Intellectual Work

To produce
good scientists,
good humanists,
good world citizens,

our goal must be to support quality intellectual work in teaching and learning at all levels,
i.e. from earliest childhood til' death do us part.

ELEGANT SOLUTIONS ➢**Concise synthesis** ➢**Deceptively "simple" but comprehensive in what they explain** ➢**Compelling**	
Physics/sciences	Poetry/arts
Open-ended question concerning the **nature of the physical universe**	Open-ended question concerning **Human nature**
Uses causal reasoning Result is **reproducible** Solution can be validated by reproducing the proof and is verified by other/new experiments or demonstrations	Uses inference, analogy, metaphor Result is **unique, irreproducible** Truth or validity resonates with the human experience Imitations lose the elegance of the solution
Einstein : Why the passage of time depends on our relative speeds? (scientists in general)	**Milton** : How does imagery of the sun shining on a man-centered universe justify God's ways to man? (artists in general)

Inquiring minds may want to know different answers to the same question:

In Physics, Literature, Life

The **two body** problem has satisfactory solutions

The **three body** problem remains challenging

Key concept 2

Learning Play

Quality Intellectual Work

Quality intellectual work, learning, and play are different angles in the process of

INQUIRY

Key Concept 3:

Inquiry
calls for deep engagement
with the question;

Misconceptions and error
are essential to the process
of
problem-solving

Quality intellectual work

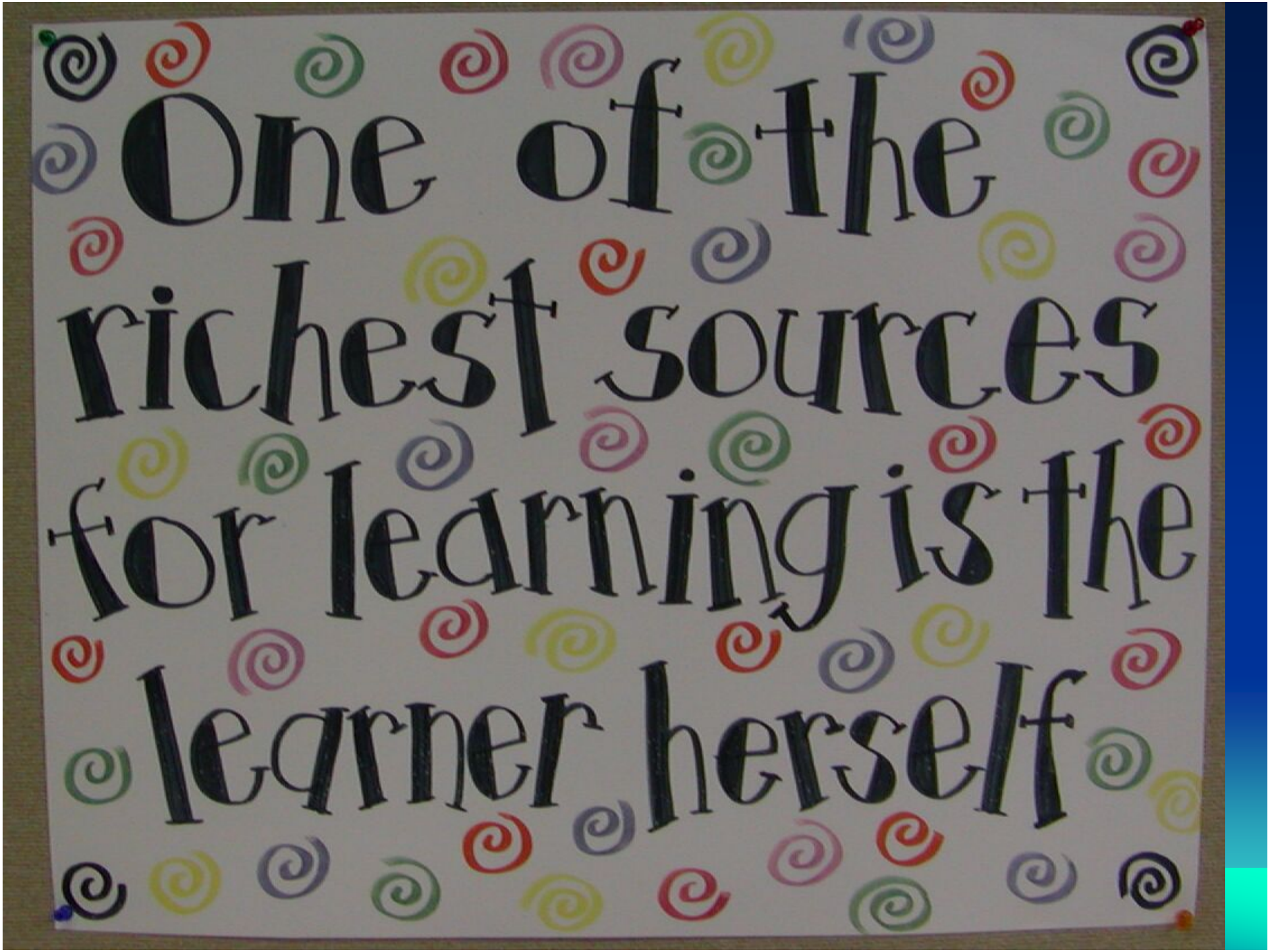
Has three essential features:

Construction of knowledge that actively involves the learner in developing his/her understanding

Through the use of ***Guided/disciplined Inquiry***

To produce discourse, products, or performances that have ***Value beyond*** the classroom.

cf: Newman, F. and associates. (1996) *Authentic achievement: Restructuring schools for intellectual quality.* San Francisco: Jossey-Bass.


One of the
richest sources
for learning is the
learner herself

The SIP Principle

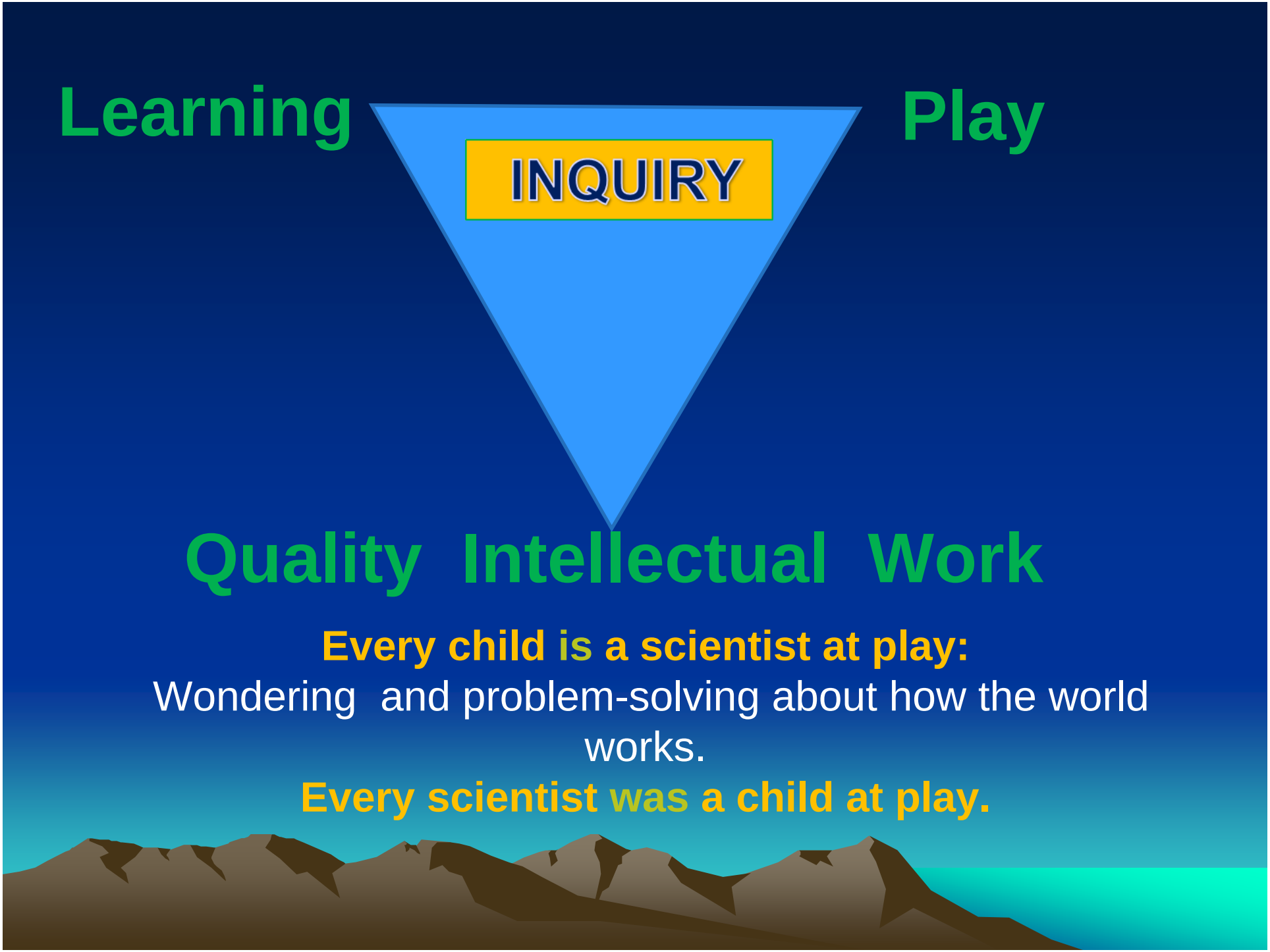
Play is

✓Satisfying

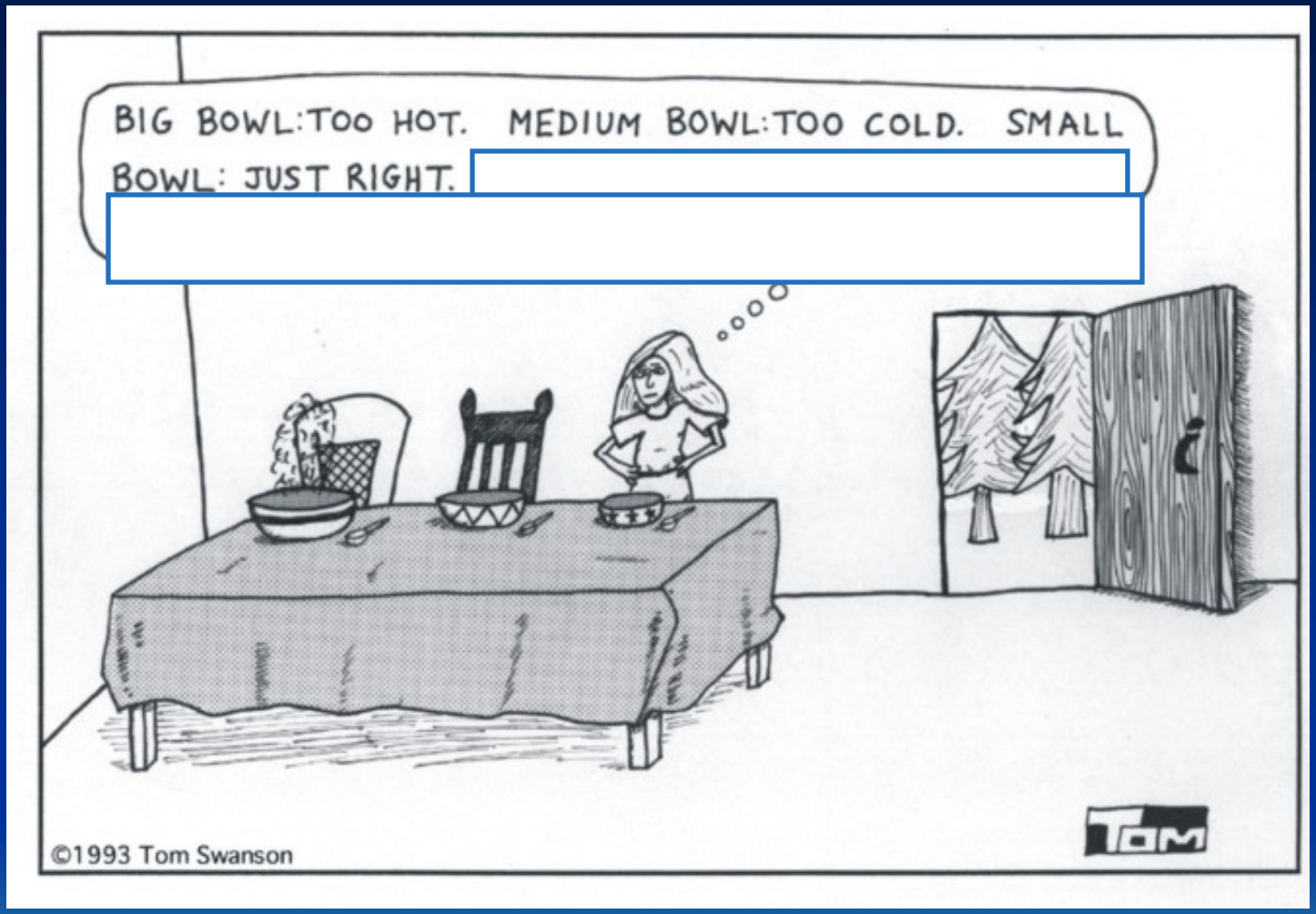
✓Intentional

✓Problem solving

Do you feel the same way about your work?


Learning
Play
INQUIRY
Quality Intellectual Work
Every child is a scientist at play:
Wondering and problem-solving about how the world works.
Every scientist was a child at play.

Goldilocks and the Three Bears



Has the science in this story ever worried you?

How could the porridge in the Bears' bowls be too hot, too cold and just right?

Working with 1 or 2 others:
write an explanatory scenario **in your "blue book"**
that is consistent
with your scientific understanding.

Do we have any volunteers with solutions….!

What Makes Guided Inquiry?

Engagement

Exploration

Evaluation

What makes Guided Inquiry

Engagement

ENGAGEMENT is triggered by posing an interesting, open-ended question about a specific problem that does not have a unique solution

Whatever the solution, it must be well-supported

What Makes Guided Inquiry?

Exploration

EXPLORATION is **carried out by the learners,**

Drawing on prior knowledge and experience,

using methodology appropriate to the discipline (in this case, physics - the laws of thermodynamics).

The Teacher facilitates by raising clarifying, probing questions.

NOT full frontal lecture, cookbook science lab; fill-in-the blank worksheets

What Makes Guided Inquiry?

Evaluation

EVALUATION is intrinsic.

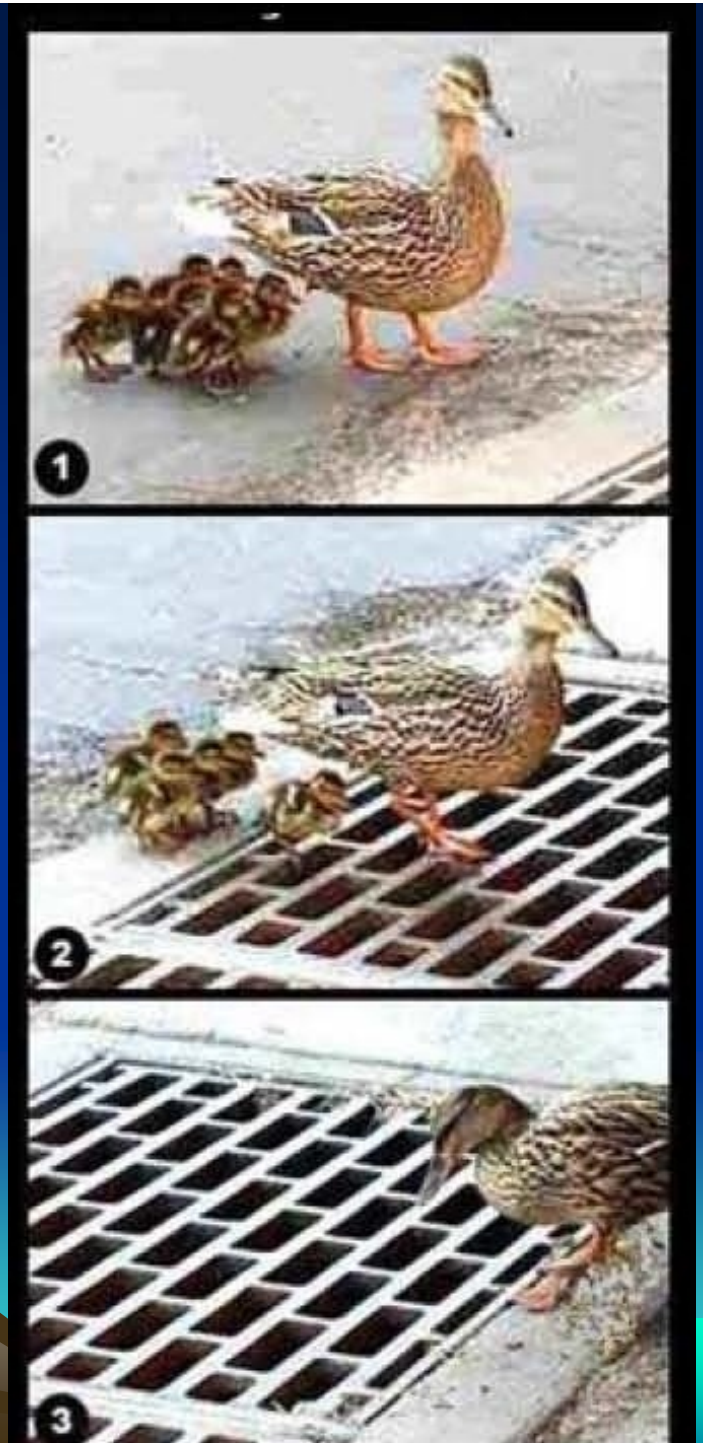
Is this a sufficient answer to the problem, as far as I'm concerned? Possibilities include

- **Yes,** it's Good—or at least it's good enough
- **Yes,** but it raises a new question/problem I now want to pursue.
- **No,** I need to decide if
  - the question needs revising or
  - there was a problem with the investigation (identify new variables, refine data collection, use tools better or use better tools)

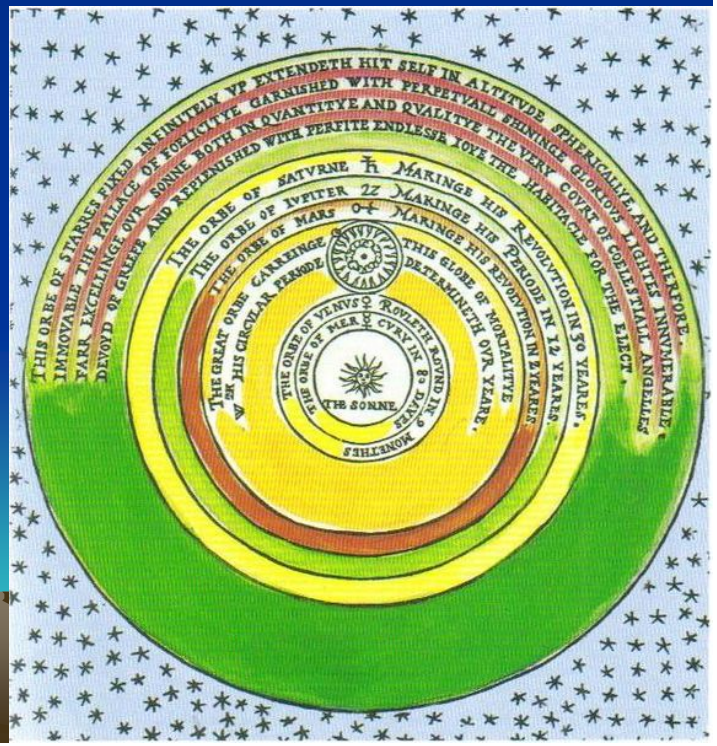
NOT: *Is this the teacher's right answer?*

Mis-Guided

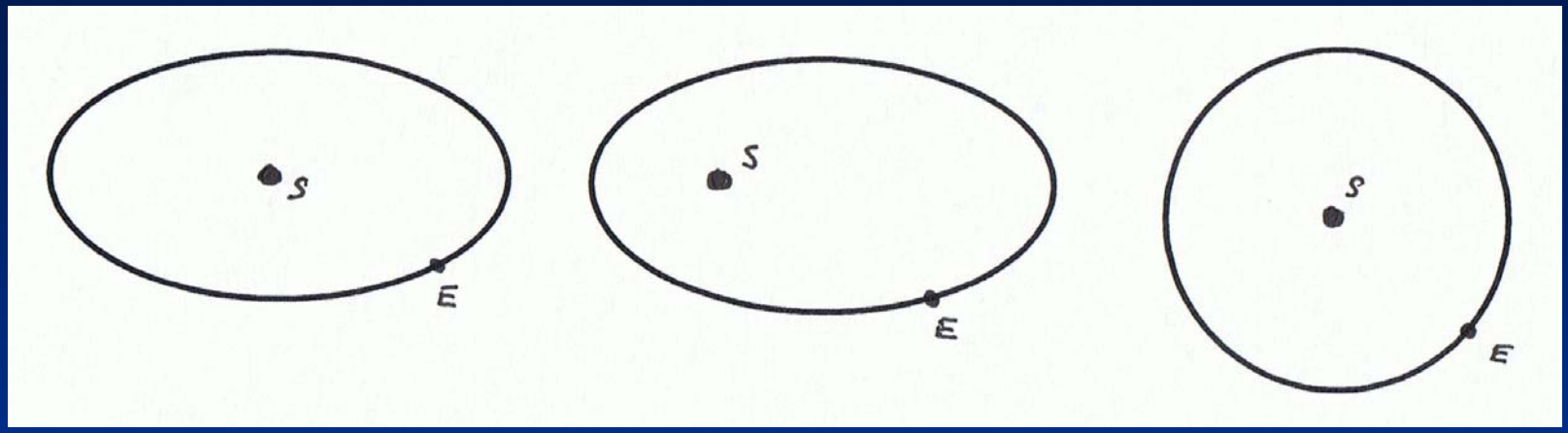
Inquiry



Ptolemaic
vs
Copernican Universe
Better Poetry
Vs
Better Science



Representations of the Solar System



A **B** **C**

Which of these three figures best represents the earth moving in orbit around the sun?

Let's VOTE….

How do preconceptions/misconceptions affect the ability to learn?

How do Harvard Professors and students compare with Nebraska professors and students?

Graduation at Harvard….. The Reasons for the Seasons

Notes:

1. Why are these misconceptions so strong? (even after taking several physics courses)

2. How do you verify prior learning or mislearning of your students?

A more personal view of one's UNIVERSE

Consider

The science you do

The science you **teach**

IS IT WORK?
or
IS IT PLAY?

Do you consider
Quality Intellectual Work
Important?

Which is a more serious concern?

✓The students don’t work hard enough.

✓The students are only interested in the right answers, not in reasoning or playing with the ideas?

Science Daily (Feb. 1, 2009)

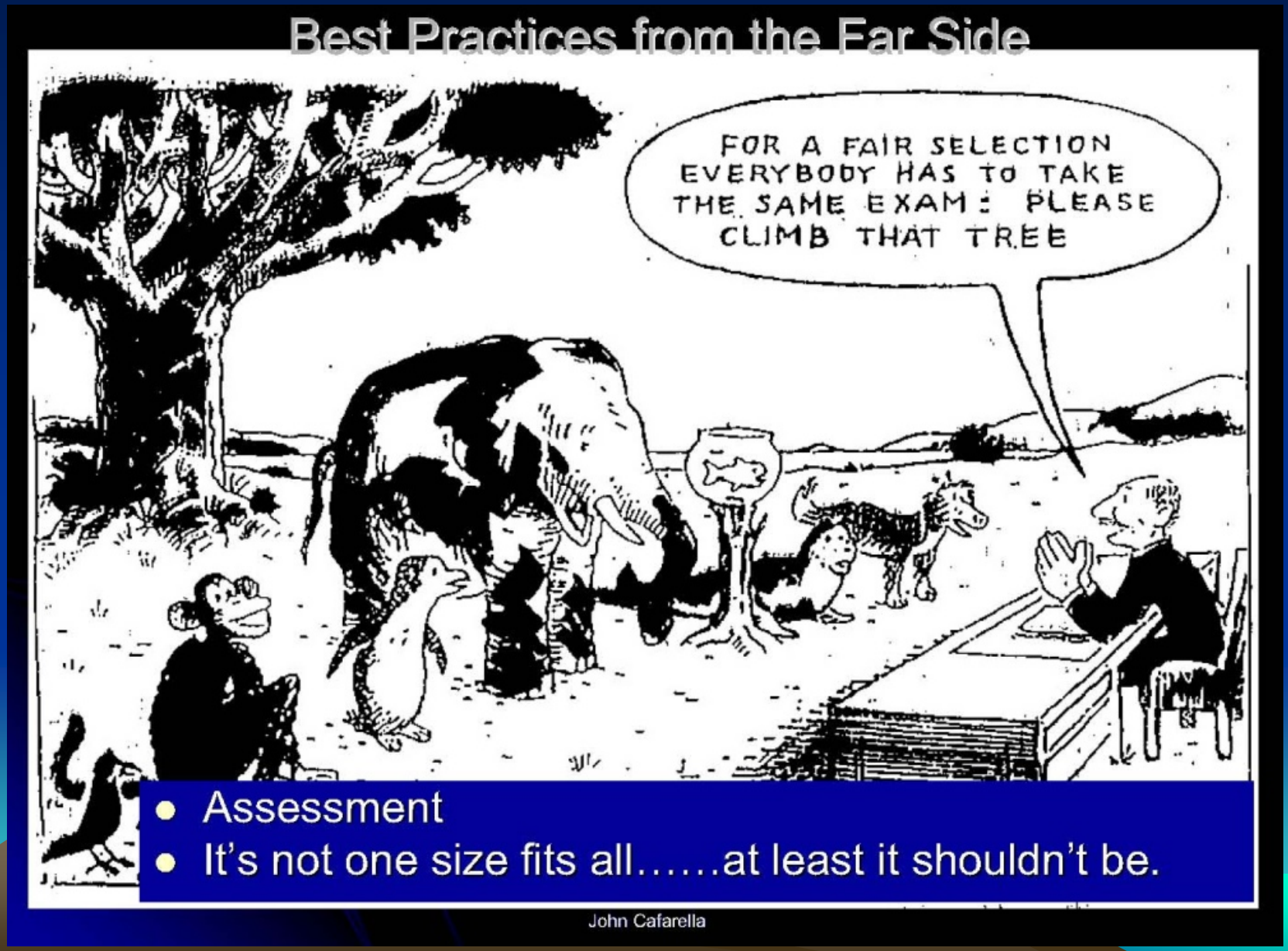
Researchers Tested Nearly 6,000 Students Majoring In Science And Engineering At 7 Universities -- 4 In The United States And 3 In China.

Chinese Students Greatly Outperformed American Students **On Factual Knowledge Of Physics** –
Averaging 90 Percent On One Test,
versus The American Students' 50 Percent

But **In A Test Of Science Reasoning,**
Both Groups Averaged Around 75 Percent –

Not A Very High Score, Especially For Students Hoping To Major In Science Or Engineering.

Does your testing of students follow this model?



Experience is a better teacher than the voice of experience.

We tend to remember Inquiry – Based Learning

Two questions for you about this presentation

1.What surprised /interested/ delighted you?

2.What applications do you see this having to you own teaching

Please write your answers in your blue book

They will help us in our research on
Learning how to learn

- Thank you

The END

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A pdf file of this presentation can be found at the website: http://www.nd.edu/~hgberry/berry1.html

Love Song from a Hollow Cathode

LINES WRITTEN AFTER SEEING WARREN KREYE'S SPECTROSCOPY EXPERIMENT TO MEASURE THE DOPPLER PROFILE OF THE SPECTRUM OF GOLD FROM AN ARGON-FILLED GOLD HOLLOW CATHODE.

Ares' fleece is too solid sullied stuff for
Love the golden light has an airy
Function we cannot do without.
If this present argonaut would seek
To know the warmth of golden thrust
In hollowness and thus to find the peak,
Some alchemy must breathe through his air,
A colorless odorless element
That penetrates but will not bind—
Argon makes such golden atmosphere.
So breathe you argon on these my golden walls
And gold to airy thiness beat.

The poem has literary as well as spectroscopic allusions: the Golden Fleece sought by Jason and the Argonauts hung in the temple of Ares, the Greek god of war and strife. The first line is an experimental application of a theoretical debate on Shakespeare's spelling. Critics cannot decide whether Hamlet said: "O that this too too solid flesh would melt/Thaw and resolve itself into a dew" or "too too sullied. . ." Either is possible and both are meaningful. The last line echoes John Donne, from *A Valediction Forbidding Mourning:*

Our two souls therefore, which are one,
Though I must go, endure not yet
A breach but an expansion
Like gold to airy thinness beat.

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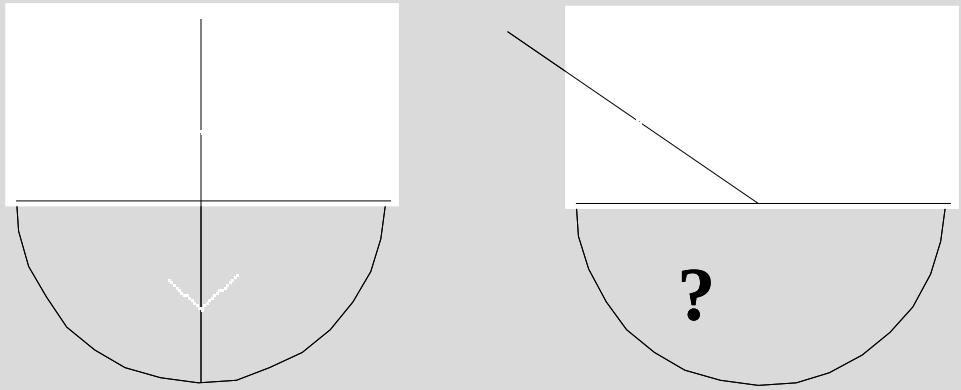
W. C. Kreye and F. L. Roesler, J. Opt. Soc. Am. 60, 1100 (1970). For preliminary observations, see also M. Hynes, Appl. Opt. 7, 1809 (1968)

1. **Reflection (a lesson you have had before - although you may not remember the details...)**
   - from a "rough" surface" - from a flat mirror - from a curved mirror

2. **Refraction - the lesson for today**

How does light change direction when passing through a transparent material?

The sketch below on the left shows a light beam passing through the flat face of a semicircular block. How do you think the beam will behave if it enters the flat face at an angle as shown in the sketch at the right?



(A) Draw a sketch - you might want to make the sketch "scientific" by adding labels/short explanatory descriptions.

(B)WHAT ARE YOUR GROUP'S IDEAS? **Draw sketches and ideas that are different from yours. Can you come a consensus on what happens?**

(C) Now your group can do the experiment with the laser provided....

Important instruction: note that the laser light should hit the surface at the CENTER of the flat side.

Discuss with your group:

What did you observe? Was it what you predicted? If not, how did it differ?

Make a sketch of what happens to the beam of light

(D) Discuss our results as a whole group

(E) What general conclusions can we draw about REFRACTION?

Where do you see refraction in your life - ...??

(F) How did learning take place?

Did you ever wonder why?

When you take pictures of people, the photographs often show the subject's eyes as shiny or red. This happens due to the flash from the camera being reflected from the back of the eye. In humans, the red color comes from light that reflects off of blood vessels in the retinas. In many animals, including dogs, cats, and deer, the red or other color is not changed by the blood vessels. In animals, the retina has a special reflective layer called the tapetum lucidum which acts almost like a mirror at the backs of their eyes. Among many nocturnal vertebrates the white compound guanine is found in the retina of the eye. This provides a mirror-like surface, the tapetum lucidum, which reflects light outward and thereby allowing a second chance for its absorption by the rods. This action allows more light to be absorbed by rods, helping animals to see in dark conditions, and the camera also sees it when light reflects outward from the eye. Thus, if a flashlight or light is shown into eyes of animals at night, the eyes shine back bright light.

Science word use

- Pierre and Marie Curie were radiating enthusiasm.
- Einstein thought it would be relatively easy.
- Volta was electrified
- Archimedes was buoyant about it.
- Ampere was happy that it was up on current research.
- Ohm resisted the idea at first.
- Descartes said he'd think about it.
- Newton was moved to react.
- Salk said it gave him a shot in the arm
- Pavlov was drooling at the thought.
- Boyle said it would not be too much pressure.
- Edison thought it would be an illuminating experience.