FOR PRESENTATION AT THE
NATIONAL SCIENCE TEACHERS ASSOCIATION
EASTERN REGIONAL CONVENTION

2 - 4 November 2006
Baltimore, Maryland

DOZENS OF ZINGERS GUARANTEED TO KNOCK YOUR SOCKS OFF!

Wyndham Baltimore-Inner Harbor
McKeldin Room

Part I — 2:00 to 3:00 Part II — 3:30 to 4:30

Compiled and Presented by

Dr. Mitch Batoff
Past President, New Jersey Science Teachers Association
Professor Emeritus, New Jersey City University
mbatoff@aol.com

Chairperson
The Famous Daryl L. Taylor
Greenwich High School, Connecticut

PLEASE NOTE

This presentation is chock full of original ideas or ideas used in a different creative way, plus ideas from numerous sources requiring considerable research. Therefore, there is legitimate concern about this material appearing in whole or in part in some commercial publication—such as a book or the Internet—without written permission of the author.

Limited permission is hereby granted to make copies of this document for **non**-commercial distribution to teachers, K through university. The cover page and **this page** must appear on all copies reproduced for **non**-commercial distribution.

This consent does not extend to copying or transmission by other means—electronic, mechanical, or graphic—for any other purpose, such as general distribution, for advertising or promotional purposes, for creating a new collective work, for sale, or for information storage and retrieval system. No copies are permitted—of the entire presentation or any part of it—**for any commercial purpose** without written permission of the author.

Printed in the United States of America

ACKNOWLEDGMENT

We all learn from others as well as from reading, a lot of thinking, and "messing around" with materials, tinkering, and playing. Some of the ideas in this presentation derive from workshops presented by the late Tik. L. Liem, a great performer. Other ideas have been inspired by Dr. Verne N. Rockcastle, Professor Emeritus, Science and Environmental Education, Cornell University—through workshops he has presented all across the country and around the world, papers he has written, the insightful Cornell Science Leaflets (long out of print) and his classic text, ***Teaching Science with Everyday Things,*** 1968, 1982, 1995. Verne is a longtime friend and truly "a national treasure". The latest edition of his book (with Victor E. Schmidt) was published in 2002.

Much of the material in the following pages is original—not found in any book—or an original twist on something that's been around along time. Thus, the previous page on copying and copyright.

PREFACE

Discover the power of **discrepant phenomena**, conundrums, **motivating zingers**, and **other energizing surprises** that capture attention, arouse interest, pique curiosity, excite wonder, and are ideal for launching a lesson or unit of study.

Gain insight into why Jean Piaget said, "The element of **surprise** is an essential motor in education" and how surprises can add zest and enjoyment to teaching.

Note that at least twenty of the following activities/demonstrations have a **quantitative** component and provide an opportunity to infuse some **mathematics** into the teaching of science.

Come to realize that the teaching of science is at its best when it is **quantitative** because numerical evidence is more convincing than qualitative statements.

Discover the synergism of science and mathematics in teaching, and its basis in the **inseparable relationship of mathematics to science** as found in the day-to-day activities of scientists, in the history of science, and in the Standards.[1]

THE DEMONSTRATIONS, HANDS-ON ACTIVITIES AND VERBAL PROBLEMS

1. **THE MAGIC COLORING BOOK** that's really not magic! Remember: one of the four reasons for doing demonstrations is to nurture close, careful **observation**. The legendary Hubert N. Alyea used to tell teachers that when students entered his freshman chemistry course at Princeton, only about 10% observed a demonstration **carefully**. At the end of the year 90% did.

---

[1]The main focus of this presentation is on **discrepant phenomena**, thought-provoking conundrums, and other motivating zingers but some of the activities/demonstrations have been drawn from another workshop, viz., "The Joy of Mathematics and Its Inseparable Relationship to Science and Technology."

2. **NOT ONE BULB WILL LIGHT.** Why? Look at the sheet with twelve diagrams. Observe each of the twelve very carefully. Question: Why will *none* of these light?.... Observe each of the drawings very, very carefully, paying close attention to details. Why will *none* light as drawn? Note the "whisper in my ear" questioning technique which avoids bringing all thinking to an abrupt halt when one person calls out the correct answer.... Clue: This challenging conundrum involves three things: (1) very close observation of details, (2) understanding the concept of a complete circuit, and (3) understanding the construction and operation of _____. **(Physics and More)**

3. **THE AQUA VASE.** A subtle demonstration used in this workshop as well as in the video presentation of the legendary Harry K. Wong. **WHAT IS GOING ON?** What science concept is involved here? Discussion. I will tell you where you can obtain one of these and also **how to make one** at almost no cost. **(Physics)** Besides the vase, what else is perplexing?

   Note: Both of these counterintuitive observations are dealt with in great detail in the second handout to be distributed later.

4. **THE MYSTIFYING LIGHT BULB.** Observe an "ordinary living room light bulb." What's going on here? Ask me some questions. But remember, I can only answer "yes" or "no". So phrase your questions carefully and thoughtfully. **(Physics, Technology)**

5. **SOME "IMPOSSIBLE" AFTER-DINNER SCIENCE.** Imagine a person's feet touching the rim of the Grand Canyon and the body extended over the Canyon, eyes looking down into the Canyon. Or, picture a diving board over a swimming pool with the end on the dock not bolted down, just resting on a ledge. Observe this amazing demonstration! You need only five items: a fork, a spoon, a glass, a **flat** toothpick, and a match. How do you explain this discrepant phenomenon? What's going on here? **(Physics)**

6. **THE BIRD...** and numerous other similar demonstrations such as those found in Edi Lanners' delightful book, *Secrets of 123 Classic Science Tricks and Experiments*, TAB Books, 1981 (based on parlor tricks and scientific curiosities popular at the end of the 19th century and earlier). Place the bird on top of a pencil or dowel. What's going on here? How do you explain this and similar discrepant phenomena? **(Physics)**

7. **"IMPOSSIBLE" BALANCING BOTTLES.** Demonstration. Observe the two 1-liter bottles balanced on the 25 cm long piece of wood set at a 45° angle on the table. How is this strange set-up possible? What's going on here? How do you explain your observations? Awesome! **(Physics)**

8. **KNITTING NEEDLES AND STYROFOAM SPHERES.** If time permits I will show you an interesting demonstration—via video—by the late Tik L. Liem, a very inspiring teacher.

9. **YOUR FINGERS.** Pupils may have studied about the human body, learned about the bones of the skeletal system and movement of bones by muscles. What about the fingers? Discussion. Now for the rest of the story that may or may not come as a surprise! Why is this significant? **(Biology)**

10. **A PERPLEXING QUESTION LEADING TO AN IMPRESSIVE FACT.** Question: What is the mass of a cubic meter of water? Stumped? How about a cubic meter of Chinese soup? Note: this is no joke! I'm leading up to some serious business! Do the arithmetic/mathematics. Use the factor labeling method and scientific or exponential notation to help solve the problem. What is your answer in English and metric units? Surprised? See the one-page handout. Discussion. Note at least four significant items you can learn from this sheet. **(Physics, Chemistry, Meteorology, The Science-Mathematics Connection)**

11. **OH, MY NEW SHIRT!** This is a demonstration which I don't want to describe here because it will dampen the effect. After the demonstration, a short video segment will be shown featuring Lee Marek and David Letterman. Discussion. Neither demonstration is trivial but involves some significant science. The whole thing is described in Part II where explanations are given. **(Chemistry, The Science-Mathematics Connection)**

12. **LISTEN TO THIS STORY, THEN OBSERVE THE DEMONSTRATION** (which, in a workshop setting, could be done by each student as a hands-on activity). What's going on here? How might you explain your observations? **Clue:** A_____ G_____ G_____ d **22571**. Detailed information on this is given in the second handout to be distributed later. **(Chemistry)**

13. **REFRIGERATORS, SOUND SYSTEMS, FARMERS AND VETERINARIANS.** I use this anticipatory set to arouse curiosity and provoke thought as an introduction to a particular science unit. What is the unit? Why do you say that? Demonstration using a **box of paper clips and something often found in the trash**. Two CMs will also be demonstrated. In an elementary school classroom numerous activities would follow in teaching this fascinating unit. **(Physics, Technology)**

14. **TORRENTIAL RAIN, NO WIPERS, PERFECT VISIBILITY!** I will relate the story of our experience in Indiana when the windshield wipers on our camper failed and the parts required for their repair were not available for several days. We wanted to continue our journey but it was raining cats and dogs (Where does this expression

come from?). We did continue our trip with perfect visibility. How was this possible? Discussion. Ask me questions that I can answer "yes" or "no". **Clue:** A technological application of physical science concepts will help you explain this discrepant phenomenon. A demonstration or group activity will follow. **(Chemistry and Physics, Technology)**

15. **CRACK A NUT.** Hold a walnut in one hand and crack it open without using a nutcracker or pliers or the table top or anything else; just one hand. Now the next step. Discussion. What's going on here? What is the explanation? A lead-in to a significant concept. **(Physics, The Science-Mathematics Connection)**

16. **A COMMON ATTRIBUTE.** Examine the assortment of objects in the cigar box or Zip-loc bag. What **single** attribute or characteristic or property is shared by **all** the objects in the box or Zip-loc bag? Ask me questions to which I can answer "yes" or "no" or "what else"? You can be sure there will be many questions. This will be followed by a very enlightening hands-on activity. **(A Significant Connection)**

17. **WHO WAS OTTO VON GUERICKE?** We'll find out shortly, but first we'll do two demonstrations using bathroom plungers, called **Pull, Pull, Pull**. The first involves taping the plungers. In the second demonstration the two bathroom plungers will be pressed together, using no tape, just pressed so as to obtain the best possible seal. What are we trying to do at this stage in the demonstration? Now for the fun! Just pull them apart. What's going on here? How do you explain this? Let's get **quantitative**. When was a demonstration like this first performed? **(Physics, The Science-Mathematics Connection)**

18. **SEEING IN THE DARK...OR ALMOST DARK.** Hands-on activity. When my children were in school they often performed in concerts and plays and, like many parents, I would be there with my camera. I would often use high speed film (ASA 1000) with available light rather than a flash. Since the auditorium was dark it was difficult to check focus and lens opening as well as how many exposures were left on the film. A little penlight would have been useful but I invariably forgot to bring one. What did I do? What might you do? **(Physics)**

19. **THE WINDBAG CHALLENGE.** Demonstration. A Windbag™ is like a balloon but lacks the elastic qualities. They do not stretch like ordinary balloons and are thus easy to inflate. And since these bags are 8 feet long, working with them can be quite dramatic. Here is the challenge: How many breaths would it take to blow up an 8-foot-long bag? How many do you think? 10, 20, 30, 40, 50, or more? Make a

prediction.[2] Watch. What's going on here? How do you explain your observations? **(Physics)**

20. **A LITTLE PHILOSOPHY OF SCIENCE regarding laws and principles.**

21. **EGGS, EQUINOX, AND CARL SAGAN.** I do not know how it got started but it has become somewhat of a tradition to stand raw eggs on end on the first day of spring, the vernal equinox; one of the two times each year when the sun crosses the celestial equator resulting in day and night being of equal length. This appears in the news nearly every year. Some articles will go on to state that balancing can happen only for an hour or two centered on the exact time of equinox. The articles usually show photographs of people balancing eggs. **However, there is an important question I would hope students would ask. What is it?** What is the answer? **(Physics, Astronomy, and Something Very Important)**

22. **A BAROMETER SURPRISE.** Demonstration. What can you learn about the weather by looking at the barometer reading, e.g., 30. Discussion. Now the rest of the story. **(Meteorology, Physics)**

23. **FOLDING PAPER, POPULATIONS, ENERGY CONSUMPTION, AND MONEY IN THE BANK.** Hands-on activity. Take a sheet of paper and fold it in half. Now fold it again. And again. Try to do this 32 times. Where are we going with this activity? Consider the napkin example from the *T.C. MITS* classic. Discussion. How might this be related to the "delicate Pacific Seaweed now a monster of the deep"? *New York Times*, Saturday, 17 August 1997, and the story of the boy who agreed to take out the garbage for his neighbor every day. There's also the story of the court mathematician in India who years ago invented the game of chess for his king.... **(Mathematics, Biology, Technology, the Environment, Finances, and More)**

24. **THE SPECIAL SIGNIFICANCE OF 70 ? Clue: Mathematics, Biology, Population Growth, Energy Use and Consumption, Finances, and More.**

25. **WHAT COLOR IS IT?** Demonstration. Guest presenter: Bassam Z. Shakhashiri, Professor of Chemistry at the University of Wisconsin at Madison. Professor Shakhashiri is renowned nationwide for his chemical demonstration shows, and in particular for his annual Christmas presentation at Madison, "Once Upon a Christmas Cheery in the Lab of Shakhashiri." This delightful mix of science and entertainment has played to packed houses for more than 30 years and continues the tradition of Michael Faraday (1791-1867) who initiated the memorable

---

[2]Acknowledgment: I learned about this from Steve Spangler, a great demonstrator from Englewood, Colorado.

Christmas Lectures in London in the 19th century. The demonstration you are about to see is from one of these Christmas lectures. **Observe as Professor Shakhashiri combines three clear, colorless liquids in a large beaker. What's happening?** Now for some information on this fascinating chemical reaction. **(Chemistry)**

26. **RATTLEBACKS.** Hands-on activity. Explore the behavior of these intriguing Celts or Space Pets as they are sometimes called. What does it do? How does it behave? What questions does it raise in your mind? Discussion on your observations, ideas, and the various physics journal articles that have been written about these mind-boggling Rattlebacks or Celts. **(Physics)**

27. **BLOW, BLOW, BLOW.** Just place a sheet of paper across two books about 10 cm apart. Now blow under the paper and attempt to blow the paper off the two books high in the air. Discussion. **(Physics)**

28. **A LITTLE PHILOSOPHY OF SCIENCE** regarding laws and principles.

29. **THE MYSTIFYING PING PONG BALL.** Demonstration and hands-on activity. Do you find it mystifying? Why? Why not? Consider the following: Assume that you used the Mystifying Light Bulb (See number 4 on the foregoing pages) to launch a **unit on Batteries, Bulbs, and Circuits.** Assume that, over a period of weeks, your students used batteries (D-cells), bulbs, switches of various types, and other related items to form a variety of closed and open circuits; and that they had a number of experiences with conductors and non-conductors (or insulators). Then, toward the end of the unit you introduced the Mystifying Ping Pong Ball, and did the activities engaged in at this workshop. **WHAT QUESTION WOULD YOU HOPE ONE OR MORE OF YOUR STUDENTS WOULD ASK? (Physics, Electronics, Technology, The Science-Mathematics Connection)**

30. **THE FISH ON PALM MYSTERY.** Hands-on activity. In this ideal inquiry experience, each student is given a novelty item consisting of a piece of red cellophane about 9.5 cm long shaped like a fish.[3] Have students place the fish on the palm of their hands and carefully observe its behavior. After they completed several trials, challenge them to formulate hypotheses (based upon their observations, prior experiences, and knowledge of science) as to what causes the fish's behavior. What's going on here? Require them to formulate plans for testing their hypotheses, carry out these tests and submit a written report of their findings. Require multiple tests to obtain more convincing evidence. Since the fish are very

---

[3]Acknowledgment to Al Guenther, master teacher and outstanding presenter, for this activity.

inexpensive, these investigations are ideal for homework assignments and "family science". **(Physics, Inquiry Development, Analytical Thinking)**

31. **THE WRIST WATCH CONUNDRUM.** Demonstration/hands-on exploration. Why would a watch be uncomfortable during part of the year and an annoyance during another part of the year? Okay, that's a satisfactory explanation but what further questions does it raise? **Did you ever notice how many answers lead to more questions? (Physics)**

32. **SPOON ON THE NOSE.** Observe Jearl Walker perform this demonstration on Johnny Carson's The Tonight Show a number of years a go. Then I will give out spoons for you to try it. This is **not** a trick but rather involves an interesting explanation in physical science. What's going on here? How do you explain this? You may be surprised by what appears to be happening. **(Physical Science)**

33. **JOHNSTON'S "SINGAPORE SLING."** How can you have a liquid in a half-filled, open-topped tumbler on its side and upside down and never spill a drop? Observe the tumbler with liquid in it. Discussion. Then the demonstration. How do you explain this discrepant phenomenon? There is more information on this in the second handout.[4] **(Physics)**

34. **A BOX OF NUTS.** One approach: Distribute the cigar boxes or Zip-loc bags to each table of four pupils. Each contains about seven kinds of nuts in shells and there are approximately 25-35 nuts in each box. The task is to separate the nuts in each box into just **two groups**. Use only **one attribute** or characteristic or property as your criterion for putting them into two groups. An alternate approach, if you are caught up in "a certain hysteria", is to separate the nuts into the two groups you observed in the workshop. Do this as a demonstration with one box at the front of the room. Then ask the class, "What single attribute, property, or characteristic did I use to separate the nuts into these two groups?" Eventually, give them a clue: It is **not** an observable attribute. **(Botany)**

35. **A TUNING FORK AND YOUR HUMOROUS HUMERUS.** Hands-on activities using an inexpensive tuning fork, the table top, your humerus, and other parts of your anatomy. Are you surprised at what you observe? What's going on here? What light can you shed on the title of this group of activities? **(Physics, Biology, Etymology)**

---

[4]Acknowledgment to John B. Johnston of The Faraday Center in Livingston Manor, New York.

36. **A FASCINATING DRINKING CUP.** Hands-on activities using some very simple materials and possibly leading to some interesting surprises and perplexing questions. What's going on here? What questions does this activity provoke? **(Physics, Technology)**

37. **40 to 140 or 6 to 60.** Have you ever run into these two numbers together? What do they represent? **Knowledge and action** associated with these two numbers could save your life or at least help prevent a lot of grief. **(Biology)**

38. **IS PAPER ATTRACTED TO A MAGNET?** Hands-on activity. As part of a unit on magnets and magnetism students learn that there are four common materials that are attracted to a magnet: **iron, steel, nickel, and cobalt.** Three are chemical elements; one is an alloy or mixture. Is a penny attracted to a magnet? How about a nickel? How about aluminum? How about a tin can? How about paper? Now test a particular piece of paper with the magnet. Several types of magnets will be available at each table. What is going on here? How do you explain your observations? **(Physical Science)**

39. **AN ORANGE, A BLOB OF CLAY, AND SOME SURPRISES.** Use the orange to represent the sun in our solar system. Take a piece of Permoplast modeling clay and fashion it into a sphere after you decide how large it should be to represent the earth. Then use a second piece of clay to make another sphere after you decide how large it should be to represent our moon. Discussion will follow, including some surprises, ...and a lot more as we construct a model of our solar system. **(Astronomy, The Science-Mathematics Connection, Critical Thinking)**

40. **SEEDS, NUMBERS, YOUNG CARL F.G. ...AND A SURPRISE.** Three classes are collaborating on an interesting investigation involving seed growth and amount of space between seeds. The only variable is the number of seeds which of course will influence the amount of space. Student A will plant one seed; student B, two seeds; Student C, three seeds, Student D, four seeds...the last student in the third class, 99 seeds. **Question:** What is the **total number of seeds** we will have to purchase for this investigation? Can you give me an **answer in less than 10 seconds?** Little Carl did! Now a famous story. **(The Science-Mathematics Connection and More)**

41. **T O P S.** Hands-on activity. Investigate the behavior of the tops in front of you; universal toy; enduring pastime and the topic of many physics articles and books (at least 367!). What's going on? Do you observe anything unusual? Discussion. Perhaps I will show you the delightful film (now on video) made many years ago by the renowned Charles and Ray Eames. **(Physics)**

42. **ANOTHER WAY TO LIGHT A BULB...** and a lucky accident, great discovery, and a prepared mind. How can we light a flashlight bulb without a battery (i.e., a D-cell)? How about another way? Demonstration using an interesting and useful item...and then a surprise! **(Physics, Technology)**

43. **MIRROR CONUNDRUMS, FASCINATIONS, AND SURPRISES.** Let's start with a simple but intriguing activity using two mirrors and a drawing. Now let us consider some interesting and perplexing questions: How do people see you? As you see yourself in a mirror? Activity: Is it the left eye or right eye? ...What did Lewis Carroll's Alice say when she peered into the mirror above the parlor mantel? ...Recall A.E.W. Mason's famous murder mystery *The House of the Arrow*, in which a central clue is the girl's memory of _____ ...The case of **AMBULANCE** and "rear window college stickers" ...How can you look into a mirror and see yourself as others see you? Try to do this with your mirror/s... Barber shops and beauty salons: i _ _ _ _ _ _ _ r_ _ _ _ _ _. Young chimpanzees seeing themselves in a mirror. Very amusing! ...The "kitchen-television story" and a significant law.

Let me try to confuse you with a simple question asked by Martin Gardner and Richard Feynman. **"Why does a mirror reverse only the left and right side of things, not up and down?** Think this over carefully. The mirror's surface is perfectly smooth and flat. Its left and right sides do not differ in any way from its top and bottom portions. If it is capable of transposing the left side of your body to the right, and the right to the left, why doesn't it also switch your head and feet? Each line in the reverse stanza of "Jabberwocky" reads from right to left. Viewed in a mirror, the lines read from left to right, but why does the top line remain on top, the bottom line on the bottom? Since the mirror exchanges left and right, what happens if we give a mirror a quarter turn clockwise? Will it turn the image of our face upside down? We know, of course, that no such thing will happen. **Then why this spooky preference for left and right? Why does a mirror reverse the room horizontally but fail to turn it topsy-turvy?** Gardner hopes these questions begin to make you feel a bit more like an intelligent monkey contemplating his reflection in a pocket mirror. They are indeed puzzling questions. Try them on your friends and students. Chances are they will be just as puzzled. You will get plenty of embarrassed laughs and stammering attempts at explanation, but it will be surprising if anyone gives a clear, straightforward answer. With respect to mirrors, adults are more like cats and dogs than monkeys. They take mirror reflections for granted without

attempting to get clear in their minds exactly what a mirror does.[5] **(Physics, and More)** ...and there's still more to the story!

44. **IF YOU HAD TO LOSE A FINGER.** Hands-on activity. If you lived in a strange, distant land and committed a heinous crime, you might be brought before the King of Hands. Make believe! The sultan decreed that you were to lose a hand. But you've lived a virtuous life and persuaded him to save your hand. However, your persuasion was not entirely successful. He would bend only so far. You had to lose a finger. Which would you not want to lose? Why? Let's investigate this matter. **(Biology, Possibly Anthropology)**

45. **MOTION BUT NOTHING MOVING!** Hands-on activity. Examine the rulers passed out to everyone in the room. Note the several variations. What's going on here? How do you explain this phenomenon? **(Physics, Technology)**

46. **GHOSTLY WHITE** and the size of a pumpkin. What do you suppose this might be? **Clue:** It is planted. **(Biology)**

47. **FASCINATING LITTLE SPHERES.** Hands-on activity. Explore the behavior of these little spheres. Incidentally, have children learn the term "sphere" as they are using them. What do you *observe*? What can you *infer* from your observations? Use "infer" with your pupils and develop an understanding of the difference between an **observation** and an **inference**. What inferences can you make about the inside of each sphere? Discussion. **(Physics, Clear Thinking)**

48. **SINKING AND FLOATING.** Do things float or sink because of the material of which they are made (e.g., wood or steel)? Do small items float and large objects sink? Do lightweight (mass) materials such as styrofoam float and heavy materials such as iron and steel sink? Observe the demonstration at the front of the room in which a plastic storage container is 3/4 full of water. Now I place the following objects in the water, one at a time: a brick, a grape, a melon, a fork, and a few other selected items. Then some significant discussion relevant to the **deceptively** simple topic of sinking and floating. Now consider the following: Give an example of a situation where the **HEAVIER** of two objects **FLOATS** and the lighter object **SINKS. Both are related and made of the same material.** What's going on here? **(Physical Science and The Mathematics-Science Connection)**

---

[5]Acknowledgment to Richard Feynman and Martin Gardner. See Gardner, Martin. *The New Ambidextrous Universe; Symmetry and Asymmetry from Mirror Reflections to Superstrings*. Third Revised Edition. New York: W.H. Freeman, 1990.

49. **THE STEMMED GOBLET: AFTER-DINNER SCIENCE WITH SINGING GLASSES...** and the glass harmonica. Demonstration; Peter Bennett's audiotape obtained on Bourbon Street in New Orleans; and Robert Greenler's amazing lecture/demonstration on video. **(Physics, Music)**

50. **WATER FLOATING IN WATER.** Demonstration. What! How could this be? Ask me question but remember, I can only answer "yes" or "no." So phrase your questions carefully. ...Now how do you explain this? Discussion. The very interesting an_____ e_____ of _____ which results in _____. **(Physics and Chemistry)**

51. **WHO WAS EMILY WARREN?** Hands-on activity. Use the seven drinking straws and seven paper clips to form a square and a triangle. Discussion. Then you will learn the rest of the story. **(Geometry, Civil Engineering)**

52. **OLD NASSAU.** Demonstration. Observe the legendary Hubert N. Alyea perform one of his signature demonstrations, a classic that illustrates a clock reaction. The late Professor Alyea taught Chemistry at Princeton for 42 years and inspired and influenced thousands of teachers worldwide. **(Chemistry)**

53. **ROMAN ROAD BUILDERS, CAT LITTER, TOOTHPASTE, AND EYE SURGERY.** What an interesting foursome...or perhaps baffling would be a better word. What in the world could these four topics have in common? Add others to the list: the dikes in the Netherlands that keep the North Sea at bay, cobblestone streets, gold deposits, gemstones and incredibly rich soils that are the secret behind many great wines and coffees. Now does that help? Discussion. **(Geology)**

54. **LOST IN THE COUNTRY.** You are in unfamiliar territory driving on a country road in a state where you have never been before, e.g., Wyoming. You are on a rural road with *no* signs and many miles from the nearest hamlet. There are farms and plenty of wide open spaces but no one to ask for help. You are lost, really lost! You have *no* compass in the car and *no* piece of modern technology (GPS navigational device found in some cars) to guide you. Furthermore, since it is an overcast day, *no* sun is visible to help you. And of course, being only 10 A.M., there is *no* Big Dipper or North Star to assist you. You would like to end up in Canada but do *not* want to drive for hundreds of miles in the wrong direction before realizing you are in Colorado! What can you do? How can you solve this difficult problem? You want to head toward the border but have no idea which way to go; and several unmarked crossroads only add to the puzzlement. (Also note: there are *no* sundials on any of the properties; *no* windvanes on any of the houses; *no* birds flying overhead or anywhere nearby; *no* moss on any of the trees; *no* rivers or streams in the area; and you have *no* way of making a magnetic compass of any sort.) **(Observation of Your Environment, Physics, Technology)**

55. **BLOW UP THE TEACHER.** Have no fear! ...just a little levity and levitation! Hands-on activity followed by a dramatic and instructive demonstration. A Rockcastle classic. I will give each person a gallon-size bag (**not** a Zip-loc bag), a drinking straw, and some tape. The fun and learning will begin.[6] **(Physics, The Science-Mathematics Connection)**

56. **KAFKA'S COCKROACH.** Who was Kafka and where do you find the cockroach? Examine the cockroach in front of you as it relates to the next question. From the standpoint of science teaching and Kafka, what is the relevant and interesting question to ask? Discussion. Where might Jonathan Swift's classic *Gulliver's Travels* fit into this lesson? How about John Bunyan's classic allegory *Pilgrim's Progress*?... and J.B.S. Haldane's sparkling little essay—also a classic—published more than 70 years ago. **(Biophysics, Mathematics, Engineering, Aeronautics, and Literary Classics)**

57. **A FLAT PLASTIC SURPRISE AND A FRENCHMAN.** Hands-on activity and demonstration. What are these rectangular pieces of plastic? What do they have to do with a Frenchman? Who was he and when did he live? Where else do you find this interesting item, often in larger form and sometimes made of glass? How does it work? **(Physics and Technology)**

58. **THE WEIGHTED ROD PARADOX.** Demonstration and/or group activity. What is a paradox? Where is the center of gravity of the rod? Now where is it? How about now? Predict in which position of the weight it will be easiest to balance the rod. Observe as a member of the audience balances the rod on a finger, three different ways. Where is the paradox? What's going on here? How do you explain what you just observed? Discussion. **(Physics)**

59. **AN ALYEA CLASSIC.** Demonstration. Observe the late renowned Princeton professor, Hubert N. Alyea, as he presents another of his signature demonstrations, viz., changing a glass of "water" into "wine," then "milk," and finally "beer." It's **not** magic, it's chemistry! What's going on here? How did Professor Alyea use this demonstration in his introductory chemistry course at Princeton?[7] **(Chemistry and More)**

---

[6]Acknowledgment to Verne Rockcastle of Cornell. **N.B. In the age in which we live DON'T EVEN THINK OF USING THIS TITLE!** Instead, let's call it **GIVE THE TEACHER A LIFT** or **GIVE OUR PRINCIPAL A LIFT.** This is really a memorable activity. And do the mathematics after the lift.

[7]You probably will want to use something other than "wine" and "beer" if you do this demonstration.

60. **THE CIRCULAR MIRROR CONUNDRUM.** Demonstration. What do you observe? What's happening? How can you explain your observations? **(Applied Physics and Mathematics)**

61. **AN ECOLOGICAL PLOT OF LAND.** A philanthropic friend of the school donated a piece of land to be used solely for ecological studies. It measured 5.5 meters x 8.7 meters x 3.2 meters. What is the area of the land? (Note: the area of a triangle is ½ the product of its base times its altitude. Why?) What if you make believe the measurements were scaled down to centimeters, i.e., 1 meter = 1 centimeter. Would that make it easier to solve? She also donated a small parcel of land to be used for a school gardening project. It measured 4.4 m x 6.9 m x 2.5 m. What is its area? **(Ecology and Geometry)**

62. **A DIFFERENT STYLE PITCHER.** Demonstration. What is different about this pitcher? Why is it designed this way? What science concepts led to this design? Does it work? What might cause a problem in its working effectively? **(Physical Science, Technology, Analytical Thinking)**

63. **AN INTERESTING TOOL FROM MAINE.** Hands-on experience. Before I pass these out, see if you can guess the item. Then tell me to what branch of science these relate. Now go a little further. How might this lesson connect to a Wall Street concept? Several activities will follow. **(Physics, Technology)**

64. **STEVEN IS TWENTY-FOUR CENTS.** But Don is only 12¢. Lola is 22¢. William is 34¢. How much is Soo Mi? After you have come up with the correct answer, can you describe the science-mathematics connection?

65. **THE FINGERS AND MARBLE CONUNDRUM.** Hands-on experience. Roll a marble or ping-pong ball between the tips of your first and second fingers while crossed. I will demonstrate what I mean. Then you do it. Keep your eyes closed while you try this activity. Roll the sphere so that it touches first one finger and then the other. What do you experience? What's going on here? How do you explain this? **(Biological Science)**

66. **THE CONTORTIONIST.** If your joints were such that you could put your limbs "into a knot" as contortionists do, how large a box would you need to fit into? Or, in other words, what is your body volume? What do you estimate your body volume to be, in cubic feet (head, arms, legs, torso)? Write it down. How did you arrive at your answer?[8] **(Physics)**

---

[8]I learned this clever approach for estimating body volume from Verne Rockcastle of Cornell.

67. **CARTESIAN DIVERSIONS...AND MISCONCEPTIONS.** Demonstration and/or group activity. Observe Bob Becker's Cartesian divers, perhaps different than you have ever seen before. What's going on? How do you explain their descent and rise? What is the misconception in most explanations? What three concepts are interconnected? How can you set up a bottle so that a floating diver will sink and a sunken diver will rise, i.e., both in the same bottle?[9] **(Physics, Analytical Thinking)**

68. **POP, POP, POP, POP.** Observe what happens the first time the little knob is turned on the side of the battery filler bulb. What happens the second time? ...and the third? What's going on here? Discussion. Now for the **BIG IDEA**, a generalization which pervades all of science and technology; an important concept which I want to leave with you today.[10] **(Chemistry, and Much More; Quantitative Thinking)**

69. **TWO NURSERS AND BLIND NIPPLES.** Demonstration. What is a blind nipple? Observe the baby bottles and nipples over a period of time. What is going on here? Why the difference? What questions do you want to ask? **(Chemistry and Much More: Quantitative Thinking)**

70. **HERON'S INTRIGUING FOUNTAIN.** Demonstration. Observe what happens when the bottles are inverted and inverted again...and again. What makes this a mind-boggling discrepant phenomenon? What is going on here? How do you explain your observations? What questions arise in your mind? Who was Hero or Heron? When and where did he live? What else did he invent and discover? **(Physics, Inquiry Development)**

---

[9]This great demonstration on video was done by the very creative Bob Becker at a Flinn Evening of Chemistry at an NSTA National Convention in St. Louis. Acknowledgment also to Al Guenther ("somewhere in California").

[10]Directions for constructing this device are given in Part II. Acknowledgment to my friend George Gross, now retired, for many years a renowned chemistry teacher at Union High School in New Jersey, who learned about it from Ron Crampton, Westside High School, Omaha, Nebraska, who, in turn, learned about it from another teacher who demonstrated it at a meeting in Washington, D.C. **Note** that the way I am using this demonstration is **original**; the linkage to the important generalization is my own.

71. **WILLIAM TELL BUT NO APPLE!** Demonstration. May I have a volunteer? What do you suppose we are going to use in place of an apple? What will we use in place of a bow and arrow? Watch this demonstration. What's going on here? How do you explain your observations? **(Physics)**

72. **AN INTERESTING CONUNDRUM** which is related to the above demonstration. Listen to the following query, something you may never have thought about. How do you explain this? **(Physical Science, Inquiry Development)**

73. **THE TWO KETE SPHERES.** Demonstration. May I have a volunteer? Watch this. What's going on here? How do you explain your observations? **(Physics)**

74. **GEORGE WASHINGTON'S NOSE.** In teaching the measurement of mass in metric units it is useful to have students learn the mass of some common objects as reference points. A nickel is 5 grams; two blocks of butter and one stick is about a kilogram. A dollar bill and all other U.S. currency has a mass of one gram. Question: What is the mass of George Washington's nose? **(Measurement)**

75. **TWO CIRCULAR DISCS.** Hands-on exploration. "Play around" with the two discs at your table. What do you observe? Anything particularly interesting, perplexing, or unexpected? What's going on? How do you explain your observations? Demonstration. **(Physics)**

76. **JUST PULL THE BAG OUT OF THE JAR, GARBAGE CAN, OR BOX.** Group activity or demonstration. Have pupils insert a gallon-size food storage bag into a large, wide-mouth jar or pretzel jug.[11] Open the bag as far as it will go and seal the edges of the bag to the rim of the jar with rubber bands. Then have one student at a time try to pull the bag out of the jar. What do you observe and experience? What's going on here? **How complete an explanation can you give?** Can you make your explanation quantitative? **(Physics, The Science-Mathematics Connection)**

77. **H.G. WELLS 1897 CLASSIC. Don't miss this perplexing and memorable demonstration.** Observe the liquid in the container as it is passed around the room. May I have a volunteer? Now observe what is done with a P_____ _____ _____. Note the safety precautions taken as it is placed under the rag and another safety precaution as the b_____ _____ is carefully added to the liquid. The top is placed on the container ... Listen and observe the rest of the demonstration. What's going on here? What is the significance of my title for this demonstration?

---

[11]Acknowledgment to Verne Rockcastle for one version of the demonstration.

NOTE

These 77 demonstrations, queries, conundrums, and hands-on explorations have been selected from a collection of over 350, gathered and developed over many years. The list keeps growing. The 77 presented here are some of my favorites.

I tend to over-prepare but realize full well that unless this is an all-day workshop or weekend event, we will be able to do/explore only a fraction of the 77. I will try to deal with as many as possible, some more thoroughly than others, **without minimizing understanding.**

In a separate handout, distributed at the end of the presentation, you will find explanations for **SOME** of the demonstrations, queries, and conundrums. This handout continues to expand so as to include more clues, answers, and explanations.

Remember, one of my goals is to nurture an inquiring mind.

DISCREPANT EVENTS/PHENOMENA

- What are they?
- What is their significance?
- How can they add zest to your teaching?
- What are some examples?
- What are six ways they can be presented to a class?

Discrepant events or counterintuitive events are usually presented to students as a demonstration. But this is not an ordinary demonstration. It is a demonstration of a phenomenon which goes counter to what a person intuitively thinks should happen;

counter to his/her past experience; counter to intuition. They can also be presented as hands-on activities, video clips, or verbal problems.

It is usually quite baffling, perplexing, and thought-provoking; sometimes dramatic.

Demonstrations of discrepant phenomena are a type of anticipatory set. In the teaching of science they are one of the most effective types of an anticipatory set.

The term discrepant event derives from a common English word found in any dictionary:

discrepant: lacking agreement; differing; at variance; Inconsistent.

discrepancy: lacking agreement or an instance of this; difference; inconsistency.

(Webster's New World Dictionary)

Discrepant events/phenomena are significant because they are great motivators. They catch the attention of children, adolescents, and even adults through sheer wonderment. Children's eyes grow larger and they make a variety of sounds to express their amazement. Questioning and discussion follow at a rapid pace.

How can they add zest to your teaching?

Like other anticipatory sets, they are ideal to "kick off" a lesson or unit to arouse interest, to capture attention, to motivate wonder and thought.

By virtue of these qualities, discrepant events add flavor, relish, piquancy, keen enjoyment, a stimulating or exciting quality to a lesson. And they are fun to do! They can make teaching more interesting and exciting.

"Discrepant events are interest-arousing, challenging, surprising, counterintuitive, unexpected, paradoxical, and intuition-offending." (Tik L. Liem).

See the Introduction in *Invitations to Science Inquiry*, Second Edition, by the late Tik L. Liem, pp. xxxv-xxxvii, and the rest of the book and Supplement.

Verne Rockcastle considers a discrepant event as "an event or a happening that is contrary to all preconceived notions of how things should be, how they should interact, and what should be the outcome, given the natural world as we know it."

Jean Piaget, the noted Swiss developmental psychologist said, "...**the element of surprise is an essential motor in education**." Rockcastle adds: "When surprise is genuine, the result unexpected and contrary to convention, an acute observer simply cannot dismiss what was observed, must mull over the observation, and try to accommodate it into a (revised) conceptual framework."

Two Views on Magic

In the July/August 1993 issue of the *Aims Newsletter*, Verne Rockcastle discusses magic in these terms: "Some discrepant events, such as those engineered, practiced, and performed by magicians, are simply accepted as magic. They are relegated to the store of 'tricks' because they happen only in the hands of a magician. In this 'world of magic,' the audience expects to be tricked, wants to be tricked, and is disappointed if it isn't tricked. The observers may share their amazement with others, but because the discrepant events they witness are expected to be discrepant, the events do not upset any cognitive scheme, nor do they challenge or dislodge a prior conceptual framework. Learning beyond the most superficial and ephemeral level probably does not occur as a result of magic performed by a magician."

Another View: I agree with Rockcastle but I do not believe he goes far enough in dealing with the use of magic.[12] A teacher can employ certain magic devices in a little different way than a magician does them. They can be used as a discrepant event, **not** done as magic, **not** done as a trick, **not** performed so as to fool the audience. Like any other discrepant event, certain magic devices (e.g., "The Atomic Bulb" or "The Magic Coloring Book") can titillate, surprise, perplex, capture attention, motivate wonder and thought, and **eventually lead to learning**.

---

[12]Verne Rockcastle and I are old friends. I respect him so much that I would drive all night to hear him speak or to attend one of his workshops. So, having said that, I can take exception to one of his views!

Magicians never tell how a magic trick is done. Never! But the situation is (or should be) different when a teacher uses a magic device as a discrepant event. The objective is to have it motivate and lead to learning. Although I do not believe pupils have to be told or arrive at an explanation the same day the discrepant event is presented, **eventually they should arrive at a reasonable explanation to account for the observed phenomenon**. Thus, the teacher may **start** with a magic device but does **not** use it as a magician uses it.

Psychology and Philosophy of Using Discrepant Events

Almost thirty years ago, J. Richard Suchman, at the University of Illinois, had this to say: "...the teacher presents the student with a series of objects or events. These events are puzzling. They run counter to the student's expectations; they are discrepant with his beliefs about reality. The student faced with a **discrepant event** sets out to find some explanation, some theory, that will close the gap between his beliefs and his observations. He begins to gather more data about the event and about similar events, and attempts to find some theory that will account for his new data. If the teacher **now** suggests an appropriate organizer, the student immediately realizes that the organizer helps him to make sense of what he is seeing. It adds more meaning to the data he is collecting. Thus, in an inquiry program, the teacher first lets the student discover a problem and begin the search for a solution and then, **at an appropriate moment**, introduces a useful organizer. The student has an intrinsic motivation for learning the concept—it assists him in his attempt to increase the meaningfulness of the data he is gathering." (J. Richard Suchman. *Developing Inquiry*. Chicago: Science Research Associates, Inc., 1966. Page 70.)

A PERPLEXING QUESTION LEADING TO AN IMPRESSIVE FACT. WHAT IS THE MASS OF A CUBIC METER OF WATER (OR CHINESE SOUP!)?

An Impressive Fact. A cubic meter of water has a mass of <u>one ton</u>. It's easy to remember by Wonton Soup! This is why water and ice have such destructive effects. They are very heavy! The significant part of this comes in doing the arithmetic and seeing that it is really so. A cubic meter = 100 x 100 x 100 cm = 1,000,000 cm or 10^6 cm.

$$10^6\,\text{cm} \times \frac{1\ \text{gm}}{\text{cm}} \times \frac{1\ \text{k}}{10^3\ \text{gm}} \times \frac{2.2\ \text{lbs}}{1\ \text{k}} \times \frac{1\ \text{ton}}{2\text{x}10^3\ \text{lbs}}$$

$$= \frac{10^6 \times 2.2}{10^3 \cdot 2 \times 10^3} = \frac{10^6 \times 2.2}{10^6 \times 2} = 1.1\ \text{tons}$$

Quantitative evidence is more convincing than qualitative statements.

$$10^2 \times 10^2 \times 10^2\ \frac{\text{cc}}{\text{m}^3} = \frac{10^6\ \text{cc}}{\text{m}^3} \times \frac{1\ \text{gm}}{\text{cc}} \times \frac{1\text{k}}{10^3\ \text{gm}} \times \frac{2.2\ \text{lbs}}{1\ \text{k}} \times \frac{1\ \text{ton}}{2\text{x}10^3\ \text{lbs}} = \frac{2.2 \times 10^6\ \text{ton}}{2 \times 10^6\ \text{m}^3} = 1.1\ \frac{\text{ton}}{\text{m}^3}$$

1+2+3+4+5+6+7+8+9+10+11+12+13+14+15+16+

17+18+19+20+21+22+23+24+25+26+27+28+

29+30+31+32+33+34+35+36+37+38+39+40+

41+42+43+44+45+46+47+48+49+50+51+52+

53+54+55+56+57+58+59+60+61+62+63+64+

65+66+67+68+69+70+71+72+73+74+75+76+

77+78+79+80+81+82+83+84+85+86+87+88+

89+90+91+92+93+94+95+96+97+98+99+100

SEEDS NUMBERS, YOUNG CARL FRIEDRICH GAUSS ...AND A SURPRISE

WORKSHEET

After you have heard the famous story of young Carl Gauss, "play around" with some numbers. See if you can envisage some of the structural qualities of an equation, some of the relationships that Gauss saw in arriving at a theorem in a formula that he used to solve the problem, all in a flash! Eureka! Can you experience a Eureka that young Carl experienced? Give it a try.

1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 + 10