Lecture

A Brief History of a Few "Smart Scientists"
Carl W. Sundbeck

Short quote page for 3/26/03 lecture

"If you expect science to give you all the answers to the wonderful questions about: what we are, where we're going, what the meaning of the universe is (and so on), then I think you can easily become disillusioned and then look for some mystical answer to these problems . . . If you think of it the way I think of it, as scientists, we're exploring! We're trying to find out as much as we can about the Universe."

Richard Feyman

"I always wanted to find out how the world is made, what it is made of, what holds it together, what makes it operate the way it does?"

Hans Bethe

"A very famous Jewish scholar wrote 'whatever is in your power, do with all your might, for there is no action, no reasoning, no learning, and no wisdom in hell.' There is nothing to be gained from not fully committing yourself if you are doing something without putting your soul in it, then it is a soulless act. Once you are doing something without your soul, then you are in a living hell."

Eli Raber

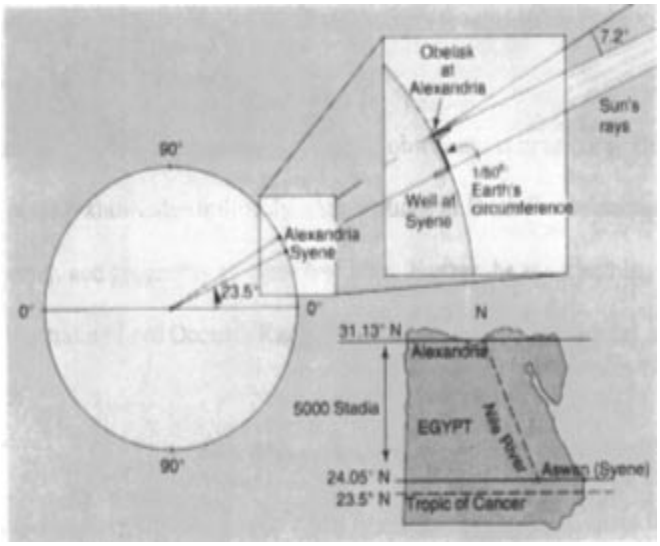
"In Thailand they believe in something called "Sanuk." Sanuk means 'fun.' Anything that is worth doing should have an element of fun in it. If there is nothing fun about it, then it's not worth doing."

Carl Sundbeck

DEDICATION

I dedicate my lecture to Roland Holmgren (1913 - 2001). He was my dad's best friend; later in his life he became my best friend. Roland had the courage to attempt to expose me to the world of listening!

Eratosthenes



(Map from Geosystems, Christopherson, 4th ed.)

Probably the greatest early geographer was Eratosthenes, the librarian of Alexandria in Egypt during the third century, BC. Alexandria's library was the finest in the ancient world; consequently, Eratosthenes was in a position of scientific advantage. His achievements included (247 BC) the calculation of Earth's polar circumference.

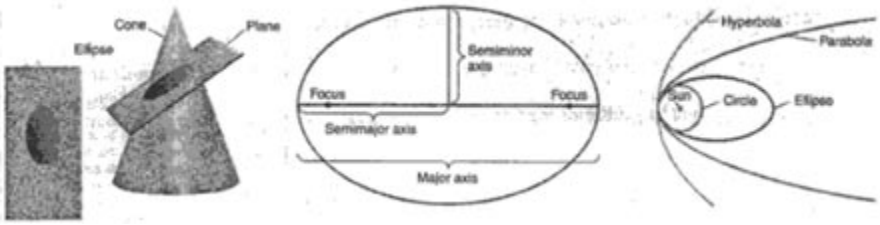
Camel drivers from Syene (refer to map) informed Eratosthenes that no shadow was cast in Syene at noon on June 21. The sun was certainly directly overhead. In Alexandria, on the same date, Eratosthenes observed that the sun was never at the zenith, even on the longest day of the year. There always was a noontime shadow. Go figure . . . Well, he did, and he surmised that the Earth was a sphere, and set up an experiment of sorts to figure out its size.

He simply measured the angle of a shadow cast by an obelisk on June 21 (an orthogonal column used for telling time by the Sun). The angle of the Sun's rays turned out to be 7.2° as opposed to 0° in Syene. As 7.2° is about 1/50 of 360°, he calculated that Earth's total circumference should be approximately 50 times the distance between the two cities (5000 Stadia). His answer, converted to metric, of 46,250 kilometers is remarkably close to the correct value we now know to be 40,008 kilometers.

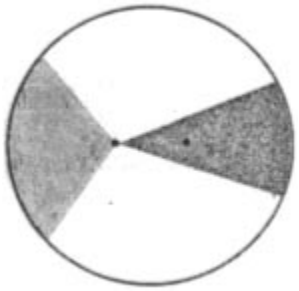
Eratosthenes ' work illustrates the value of careful observations in science. He integrated his findings with previous knowledge brilliantly. Applications of Earth-Sun relationships, geometry, trigonometry, and geography all came into play. Further, he spent nothing on his work but thought, illustrating Lord Occam's Razor, "'Tis vain to do with much what can be done with a little." (1640)

Johannes Kepler

Three laws of planetary motion. Kepler's first law, published in 1609, states that planets orbit the sun in ellipses (with the sun at one focus).



Kepler's second law states that planets sweep out equal areas in equal times (Law of the Areas). The two shaded sections, which represent the areas covered by a line drawn from the sun to planet in a given time, are equal.



Kepler's third law states that the square of the period of revolution is proportional to the cube of the semi-major axis of the ellipse.

$$\frac{P^2 \text{ Planet}}{P^2 \text{ Earth}} = \frac{R^3 \text{ Planet}}{R^3 \text{ Earth}}$$

Johannes Kepler, Keppler, Khepler, Khepler, Keplerus, the founder of modern astronomy was conceived on May 16, 1571 at 4:37 a.m. and was born on December 27 at 2:30 p.m., after a pregnancy lasting 224 days, 9 hours, and 53 minutes. The five different ways of spelling his name are all his own, and so are the figures relating to conception, pregnancy, and birth recorded in a horoscope which he cast for himself. The contrast between his carelessness about his name, and his extreme precision about dates reflects, from the very outset, a mind to which all ultimate reality, the essence of religion, of truth and beauty, was contained in the language of numbers!

Johannes Kepler's father was a mercenary adventurer who narrowly escaped the gallows. His mother, Katherine, an innkeeper's daughter, was brought up by an aunt who was burned alive as a witch, and Katherine herself accused in old age of consorting with the devil, had as narrow an escape from the stake as the father had from the gallows!

His grandmother, as described by Kepler, was "restless, clever, and lying (but devoted to religion), slim and of a fiery nature; vivacious, an inveterate troublemaker, jealous, extreme in her hatreds, violent, a bearer of grudges . . . all her children have something of this . . ."
Kepler's description of his father: "Henrich, born 1547. 19. January, a mean, vicious, inflexible, quarrelsome and doomed to a bad end! Venus and Mars increased his malice. He had many enemies and ran the constant risk of hanging. In 1578 he sold his house and started a tavern where a hard jar of gunpowder burst and lacerated his face. In 1589 he treated my mother extremely ill, finally went into exile and died."

Heinrich, brother to Johannes, was an epileptic and victim of the psychopathic streak running through the family. An exasperating problem child, his youth seemed to have been a long succession of beatings, misadventures and illness. He was bitten by animals, nearly drowned, and nearly burned alive. He was apprenticed to a draper, then a baker, and finally ran away from home when his loving father threatened to sell him!

In subsequent years he was a camp follower with the Hungarian army in the Turkish wars, street singer, baker, valet, beggar, and drummer. Throughout this checkered career, he remained the hapless victim of one misadventure after another, always ill, sacked from every job, robbed by thieves, beaten by highwaymen, until he finally gave up, begged his way home to his mother, and hung onto her apron strings until he died at age forty-two.

In his childhood, Johannes conspicuously shared some of his younger brother's attributes, particularly his grotesque accident-proneness and constant ill health combined with hypochondria. Kepler was a sickly child, with thin limbs and a large, pasty face surrounded by dark curly hair. He was born with defective eyesight: myopia plus multiple vision.

Kepler's own notes on his childhood, "1575 (age four), I almost died of smallpox, was in very bad health, and my hands were badly crippled. 1577 (age six), on my birthday I lost a tooth, breaking it off with a string which I pulled with my own hands. When I was fourteen and fifteen, I suffered continually from skin ailments, often severe sores, often from the scales of chronic putrid wounds in my feet which healed badly and kept breaking out again. On the middle finger of my right hand, I had a worm, on the left a huge sore. When I was nineteen I began to suffer terribly from headaches and a disturbance of my limbs. At age twenty, a cold brought on prolonged mange.

Only two brief memories mitigate the gloom and squalor of his childhood:

1. "1577: I heard much of the comet that year, and was taken by my mother to a high place to look at it."
2. "1580: Age nine, I was called outdoors by my parents to look at an eclipse of the moon. It appeared quite red."

When Kepler became a high school teacher, his friends in Graz had found a prospective bride for the young scientist, in the daughter of a rich mill owner, twice widowed at the age of twenty-three. Barbara, described by Kepler as "simple of mind and fat of body," now lived with her parents who could not have had very high expectations for her future. Yet, when Kepler presented his suit, he was refused on the grounds that Barbara and her dowry could not be entrusted to a man of such lowly standing and miserable pay.

Eventually, the marriage was consummated. Kepler said his wife had a constant "stupid, sulking, lonely, melancholy complexion." She was "a woman entirely imprisoned by maternal (or material?) love." As for her husband, "not much love came my way." She nagged him constantly. Nine months after the wedding, their first child was born, a little boy, who died after two months, of cerebral meningitis. The next, a little girl, died after only one month of the same disease. Barbara bore three more children of which two survived. Altogether, their marriage lasted fourteen years. Barbara died at the age of thirty-seven. The three laws of planetary motion were born! From: The Watershed by Arthur Koestler.

Carl Sagan

Carl Sagan was the poet of exobiology, a theorist whose faith in the possibility of alien life inspired a generation of young researchers, a leading figure in the search for extraterrestrial intelligence and a liberal political conscience whose vision of a nuclear winter helped defuse the Cold War.

Sagan was also a disloyal friend, a cynical careerist and a security risk, an abusive husband and absent father, a scientist who eschewed experiment, an educator who avoided students, a goofy pothead, a smug, self-important, smarty-pants pencil-neck geek, the Sister Wendy of astronomy.

In the spring semester of 1973, my freshman year at Cornell University, I took "Introductory Astronomy" from Carl Sagan. This is the same class I have taught at Santa Barbara City College for 22 years. As a wide-eyed, naive, "yute," I loved the class and his teaching. I have said many times that it was my favorite college class. Did it influence me? You bet! Geography and meteorology are really my areas of graduate work and expertise, and I love teaching in these fields, yet astronomy is still my favorite. After over 70 sections, it is really my signature class.

My old Polish immigrant mother, Apolonia Polabinska, made it to the seventh grade during the depression, not for lack of intellect. When "her boy" made it to the Ivy League, she vicariously lived through me with the help of Carl Sagan. He was a regular on Johnny Carson in the early 70s. She loved to watch the Tonight Show and discuss what she had seen and learned with me. She also loved Carl's writing. The Dragons of Eden was her favorite book and she faithfully read Sagan's column in the Sunday Parade section of the newspaper. As a popularist of science, I have selected a short piece from *When Worlds Collide*:

In the late 1960s, at a scientific meeting, I was asked to summarize the outstanding problems in planetary science. One, I offered, was the question of why, of all the planets in the solar system, only Saturn had rings. This, it turns out, is a nonquestion. No one then knew that all four giant planets in our solar system--Jupiter, Saturn, Uranus and Neptune--in fact, have rings.

Each ring-system has distinctive features. Jupiter's rings are tenuous and made mainly of dark particles the size of those in cigarette smoke. The bright rings of Saturn are composed mainly of frozen water and could be described as made of snowballs or ice balls; Saturn has thousands of rings, some twisted, exhibiting strange, dusky, spokelike markings that form and dissipate. The dark rings of Uranus seem to be composed of elemental carbon and organic molecules--something like charcoal or chimney soot; Uranus has nine main rings, a few of which sometimes seem to "breathe," expanding and contracting. Neptune's rings are the most tenuous of all, varying so much in thickness that, when detected from Earth, they appear only as partial arcs and not complete circles. Each ring-system displays an austere, appropriately unearthly beauty.

In a way unique to his generation of scientists, Sagan stood at the confluence of science and popular entertainment: He was more the rightful heir to Mr. Wizard, perhaps, than to any of the historic astronomers he so admired, such as Christiaan Huygens, the versatile 17th century Dutch mathematician and physicist who discovered Titan, improved the optics of telescopes and formulated several important theories of the behavior of light.

As an astronomer, Sagan was among that first generation of planetary explorers able to extend their reach to the fringes of the solar system with robotic sensors and imaging probes. He helped design experiments on the Mariner, Viking, Voyager and Galileo space missions. As a theoretician, Sagan found key pieces of several planetary puzzles. For example, he correctly attributed Venus' high temperature to a massive greenhouse effect. He also was among those who showed that the intricate carbon-based chemicals that could be the precursors of living things are common in the cosmos.

Displaying an almost religious faith in the existence of alien life, he searched in vain for evidence of it. He predicted there would be polar bear-like creatures on the surface of Mars and aerial jellyfish in the atmosphere of Jupiter. His theories were debunked by the data returned from the space probes he so assiduously publicized on NASA's behalf. As the solar system itself proved remarkably inhospitable to life, Sagan simply shifted the focus of his hopes to more distant star systems. This was more a measure of his unconventional romance with the idea of alien life than soundly based science.

His success as a popularizer hinged on his perceived stature as a scientist, and there his public reputation was at odds with the more informed judgment of his peers. Despite his impressive intellectual breadth, he was unexpectedly shallow as a scientist, his biographers suggest. To be sure, no one ever questioned Sagan's technical acumen or his flair for scientific discourse. Sagan, however, appeared to lack the discipline for careful experiments or the sustained focus that is at the heart of scientific accomplishment. No single scientific question seemed to hold his attention long enough. He devoted more energy to scolding the unenlightened than to advancing the frontier of knowledge. He was, in the view of even those who liked him best, a man who liked the grand, arm-waving ideas of science far more than its messy, thankless bench work.

Sagan was never accessible to students before or after class nor during alleged office hours. "He was a pompous, arrogant prima donna. You want the answers to the origin, structure, and evolution of the universe? You've come to the right place: Carl Sagan's class!" Yeah, right . . . at age 18, I bought it 'cause I didn't know any better! As my teaching career progressed in science from time to time, I used Sagan as an anti-role model; I hopefully learned not to "play God." Perhaps a short video clip of Sagan will help illustrate this point of view and his rather large ego!

Richard Feynman

Thoughts on Being a Scientist:

I have a friend who's an artist and he's sometimes taken a view which I don't agree with very well. He'll hold up a flower and say, "Look how beautiful it is," and I'll agree, I think. And he says, "You see, I, as an artist, can see how beautiful this is, but you, as a scientist, take this all apart and it becomes a dull thing." I think he's kind of nutty. First of all, the beauty that he sees is available to other people and to me too, I believe, although I might not be quite as refined aesthetically as he is. But I can appreciate the beauty of a flower. At the same time, I see much more about the flower than he sees. I can imagine the cells in there, the complicated actions inside which also have a beauty. I mean, it's not just beauty at this dimension of one centimeter; there is also beauty at the smaller dimension, the inner structure . . . also the processes. The fact that the

colors in the flower have evolved in order to attract insects to pollinate it is interesting; it means that insects can see the color. I add a question. Does this aesthetic sense also exist in lower forms? Interesting questions which a science knowledge only adds to the excitement and mystery and awe of a flower. It only adds; I don't understand how it subtracts."

Thoughts on Being a Science Teacher:

All those students are in the class. Now you ask me how I should best teach them. Should I teach them from the point of view of the history of science? From the applications? My theory is that the best way to teach is to have no philosophy; to be chaotic, and confuse it in the sense that you use every possible way of doing it. That's the only way I can see to answer it . . . so as to catch this guy or that guy on different hooks as you go along. That during the time when the fellow who's interested in history is being bored by the abstract mathematics, on the other hand, the fellow who likes the abstractions is being bored another time by the history. If you can do it so you don't bore them all, all the time, perhaps you're better off. I really don't have all answers, I don't know how to answer this question of different kinds of minds with different kinds of interests. What hooks them on? What makes them interested? How do you direct them to become interested? One way is a kind of force: You have to take this examination, you have to pass this course. It's a very effective way. Many, many people go through school that way. There may be a more effective way. I'm sorry, after many years of trying to teach science, and trying all different kinds of methods, I really don't know how to do it!

Thoughts on The Nobel Prize:

I don't know anything about the Nobel Prize. I don't understand what it's all about or what it's worth. If the people in the Swedish Academy decide that X, Y or Z wins the Nobel Prize, then so be it. I won't have anything to do with the Nobel Prize. It's a pain in the ass. I don't like honors. I appreciate it for the work I did and for the people who appreciate it. I know there are lots of physicists who use my work. I don't need anything else. I don't think there is any sense to anything else. I don't see that it makes any point that someone in Sweden decides that his or her work is noble enough to receive a prize. I've already got the prize! The prize is the pleasure of finding the thing out; the kick is the discovery. The observation that other people are using it. Those are real things; the honors are unreal to me. My Papa brought me up this way. I can't stand it. It hurts me . . .

Teaching students about science:

I got a kick out of my father telling me things. So, I tried to tell my son things that are interesting about the world. When he was very small, we used to rock him to bed and tell him stories. I'd make up a story about little people that were about "so" high. They would walk along and go on picnics, and so on. They'd go through these woods that had tall blue stalks (with no leaves). He'd gradually catch on that that was a rug; the nap of a blue rug. He loved this game because I would describe all these things from an odd point of view. The little people even went into a moist cave, where the wind kept going in and out. It was coming in cool and went out warm. It was the inside of a dog's nose. I could tell him all about physiology this way. He just loved this approach, so I told him

lots of stuff. I enjoyed it because I was telling stuff that I liked. And then I had a daughter!! I tried the same thing! Well . . . my daughter's personality was different. She didn't want to hear stories about little people. She wanted the story that was in the book repeated again and re-read to her. So, if I were to say that a very good method for teaching children about science is to make up these stories about the little people, it doesn't always work. It happened to work on my son, but it didn't work with my daughter's personality.

Science:

If you expect science to give you all the answers to the wonderful questions about what we are, where we're going, what the meaning of the universe is (and so on), then I think you can easily become disillusioned, and then look for some mystic answer to these problems. How a scientist can take a mystic answer I don't know, because the whole spirit is to understand. But anyhow, I think of it, what we're doing is: exploring. We're trying to find out as much as we can about the universe. People say to me "are you looking for the ultimate laws of physics?" NO, I'M NOT! I'm just looking to find out more about the world. And, if it turns out there is a simple ultimate law which explains everything, so be it! That would be nice to discover! If it turns out it's like an onion with millions of layers and we get sick and tired of looking through layers, then that's the way it is. But, whatever way it comes out, it's nature, and she's going to come out the way she is!

From: NOVA

1. "The Pleasure of Finding Things Out' (1986)
2. "What Do You Care What Other People Think?"
3. "Surely You're Joking, Mr. Feyman."

Hans Bethe

The entire idea that stars form at all is only about 200 years old. The way in which stars generate their energy we now know is a process called "nuclear fusion." That process was elucidated by Hans Bethe in 1938 at Cornell University, Ithaca, New York, now the home of the man who discovered how stars shine.

"*I was born July 2, 1906 in Strasborg which was then Germany and later became French. I always wanted to find out how the world is made, what it's made of; what holds it together, what makes it operate the way it does.*"

Growing up during the first two decades in this century in Germany, Hans Bethe showed an early brilliance in mathematics and physics. He began his career as a lecturer in the German university system. When the Nazis came into power he learned that his Jewish ancestry disqualified him from teaching. He emigrated to England then to the United States. He arrived in February 1935 to become an assistant professor at Cornell University. He took to Cornell immediately.

"*I became a member of a very friendly group at the physics department. I found it most satisfactory work; I liked them very much, so I stayed.*"

In 1938 Bethe attended a conference of physicists in Washington, D.C. It had a profound effect on his life and work.
"They thought it would be nice to discuss the nuclear reactions in stars; how the energy in stars was generated. No one knew, really (at the time) what nuclear reactions take place; what generates the energy. That was something that I thought I might be able to work on and might be able to solve."

Six weeks of concentrated effort led Bethe to the answer. Bethe knew that the Sun shines by nuclear fusion. Hydrogen, the basic ingredient of all stars is fused into more complex elements. Matter is converted into energy in accordance with Einstein's famous equation:
E = mc2. Bethe's achievement was to determine the exact sequence of nuclear reactions that occur and the precise rate of energy's production. At the center of the Sun, four million tons of matter are converted into energy each second!

"*In this reaction an enormous amount of energy is set free; enough certainly to keep the Sun and the stars burning for a long, long time!!! In the case of the Sun, for instance, it will last for a total of about ten billion years. Once, when I gave a talk on this subject, someone in the audience asked whether I said 'millions or billions.' ' Billions', I said. 'Oh,' he said, 'I'm relieved.'*

In the summer of 1938, Bethe published his work in a journal that offered a prize for the best paper. He used the $500 he received to help his mother emigrate from Nazi Germany. It was not the only prize he would win for the work he did that year. He was awarded the Nobel Prize in physics in 1967. Soon after his discoveries of how stars produce energy, Bethe and many other scientists provided awesome possibilities for warfare. Hydrogen bombs were the result . . .

Video clip from PBS video "the Astronomers," Episode 5, "Stardust"
Plus
Hubble space telescope images.