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"Enlightenment and the Responsibilities of the Enlightened"

Room 200, TCSEQ, Stanford University
Tuesday, April 29, 2003, 5:15-6:30 pm

Edited by Peter Y. Chou

Preface: In the April 23rd issue of *Stanford Report* under Calendar of Events, the symposia titled **"Enlightenment and the Responsibilities of the Enlightened"** intrigued me. So I responded to the RSVP notice and registered for the symposia. Since enlightenment is the joy served at this web site— WisdomPortal, Prof. Shakhashiri's topic brought me here to learn more from a fellow chemist. This web page was assembled so that more people may enjoy the humor and insightful wisdom of Bassam's lecture. He's truly a messenger of the enlightened spirit.

Tuesday, April 29, 2003, 5:15 PM, Room 200, TCSEQ, Stanford University
Prof. Richard N. Zare (Stanford Chemistry Dept) introduced the speaker: " Stanford Graduate Fellowships is the crown jewel of Stanford University. This Research Symposium celebrates the achievements of the Stanford Graduate Fellows. Our keynote speaker is Professor Bassam Z. Shakhashiri from the University of Wisconsin-Madison. This person has made monumental contributions to the teaching of chemistry. He has a charismatic personality that enhances learning. The National Science Foundation had $13 million earmarked for fellowships in science. When Bassam became the NSF's assistant director for science & engineering education (1984-1990), the grants went up to $1 billion. The 1995 *Encyclopedia Britannica* says that Bassam is the 'reigning dean of American chemistry lecture demonstrators'. I'm happy to introduce to you— Prof. Bassam Shakhashiri— So let there be light!"

Bassam: "I'm looking around the room. Whom have I known here the longest? (several hands went up). Al is the fellow I've known the longest, and there is Richard [Scheller], Vice-President of Genetech, and my brother-in-law Frank Drake [SETI], sitting in the front row, who has heard my lectures many times." Prof. Shakhashiri then proceeded with his PowerPoint presentation.

Here are my notes jotted as quickly as possible before the slides went off the screen. (Bassam's comments on his slides are given in parenthesis). [My additions are included in brackets]. Many gaps were filled by consulting books on the sources of the quotes as well as the web for relevant links. I've enjoyed Bassam's talk— it is truly enlightening and energizing for the human spirit.

Part 1: PowerPoint Presentation

1 In seminar presentations, the difference between being bored or gored is the quality of the bull.
(My lecture is in two parts— serious and fun. You'll decide which is which.)

2 "Our task as educators is to show our children that science is a hexagonal mountain with three beautiful faces in addition to three ugly faces. The three beautiful faces of science are science as subversion of authority, science as an art form, and science as an international club. The way to attract young people into science is to show them all six faces and give them the freedom to explore the beautiful and the ugly as they please."
— Freeman Dyson, *From Eros to Gaia* (1992), p. 199 [Quoted on Web]
(The key word here is freedom— the childrens' minds must be free!)

[Bassam's slide didn't show three ugly faces of science: "The generation that is now young has three good reasons for turning away from science. Science is presented to our young people as a rigid and authoritarian discipline, tied to mercenary and utilitarian ends, and tainted by its association with weapons of mass murder. These three reasons for hating science are real and serious. It is useless to pretend to our children that these three ugly faces of science do not exist. Children will not be fooled. If we try to fool them, they will turn away from science even more." — *From Eros to Gaia*, pp. 198-199 (Quoted on Web)]

3 "The failure of science to produce benefits for the poor in recent decades is due to two factors working in combination, the pure scientists becoming more detached from the mundane needs of humanity, the applied scientists becoming more attached to immediate profitability." — Freeman Dyson, *Imagined Worlds* (1997) [Quoted on Web]

4 Clarity of Purpose
(You must be clear in what you do.)
["What is complementary to Truth?" Bohr's immediate reponse: "Clarity"]

5 What's the purpose of education?
To enable individuals to fulfill their human potential.
[Peter's answer: ENLIGHTENMENT!— Be Aware! Be Awake!]

6 The purpose of research:
To advance knowledge.
(PERIOD! We're a curious species— we want to KNOW!)
[Peter's answer: To find our Inner Garden and taste the Tree of Life!]

7 The purpose of technology:
To advance the human condition.

8 What differentiates our society now from all the previous societies?
(Bassam: I want your answer.
Audience: information, sophistication, intercultural communication)

9 My Response: SCIENCE
(In ancient days, technology preceded science. They build pyramids in Egypt.
Today [with nanotechnology], we can build pyramids at the atomic level.)

10 the latest... [missed this quote]
(Quote in connection to the recent war)

11 Science-rich Sector (colleges & corporations)
|
(This gap is widening)
|
Science-poor Sector (everyone else)

12 Scientific Literacy (what scientific practioners do & their skills)
Science Literacy (appreciation of science without understanding science)
(Analogy from Sports: Sports fans support the professional athletes in sports.
We need science fans to support science. Not for them to come onto the field
and do science. The second distinction, science literacy, is more difficult.
We live in this age of specialization. One needs to be strongly focused to
remain competitive. But we also need to put our specialty in a bigger context.)

13 "The worst sin toward our fellow creatures is not to hate them,
but to be indifferent to them: that's the essence of inhumanity."
— George Bernard Shaw [*The Devil's Disciple* (1901), Act II]

14 Humane
Humanitarian
(Te people in the science-poor sector are supporting
the science-rich sector through taxes.)

15 What is Science Literacy?
Science for All Americans (1989) defines a science-leterate person as one who:
- is familiar with the natural world
- understands key concepts and principles of science
- recognizes both its diversity and unity of science
- aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations
- uses scientific knowledge and ways of thinking for individual & social purposes.

16 Communicating Science:

Formal	**Informal**
• Classroom	• Radio, TV

- Journals
- Books
- Professional Meetings
- The Web
- Print Media
- Schools
- Shopping Malls
- Museums & Science Centers
- Political Conventions
- State Governments
- Halls of Congress

(I was invited to the 1996 Democratic Convention and told the delegates: "I have a handout for you.") [laughter]

17 Science literacy is a measure of our value in society the way we view ourself and others

18 Your Ph.D. Thesis should include:
Chapter as educational experiment
- K-21
- Museums/Science Centers
- Public Media

(Think about what constitutes scholarly work.)

19 Your Ph.D. Thesis should also include a chapter explaining the research to:
- Family members
- Friends
- Civic groups
- Newspaper reporters
- Legislators
- Members of Congress

20 Problem-Solving Skills
Good Judgment
(Life is about judgment & good judgment.
Send me email and we'll discuss it more.)

21 Desirable Qualifications of Faculty Members
- Integrity of character
- Scholarship
- Both must be present if the faculty member is to be useful to the university.
- Other qualities

(I bet you all thought scholarship was #1, but integrity is more important.
This list came from Mark H. Ingram of University of Wisconsin.)

22 **Integrity** (Either full or not full)
RESPECT
Responsibility
(Either you have integrity or you don't—
it's like pregnacy— either pregnant or not.
You can't respect someone unless you have Self-Respect)
[Scientific Integrity, AAAS 2-18-2001]

23 Trust
Accountability

24 Characteristics of Scholarship:
- should be made public
- susceptible to critical review and evaluation
- could be used and built upon by other

(This came from Lee Shulman,
President of the Carnegie Foundation for the Advancement of Teaching,
"The Scholarship of Teaching for Meaningful Learning"
Center for Innovative Learning Technologies [CILT], May 2, 1999)

25 Jaron Lanier, computer scientist who coined the term "virtual reality" said:
"To me, teaching is the ultimate performing art, and all performing arts are interactive. You always have to connect with the people, you don't just present, you have to connect."
[*Chronicle of Higher Education* (Dec. 20, 2001)]

26 Faculty owes it to themselves to teach what they love.
In so doing, they nourish their students' desire for learning.

27 Diane Chapman Walsh, President of Wellesley College:
"technology, experiential learning, global education, multiculturalism,
and other innovations on the new agenda need to be understood as secondary,
not primary. They are not valuable as ends themselves, but as pathways to a
larger endódeveloping students who are lifelong critical thinkers and learners."
[*Change* (1999) (Quoted on Web)]

28 Teaching of Scholarship

29 "There is no higher or lower knowledge, but one only, flowing out of experimentation."
— Leonardo da Vinci [1452-1519] [Quoted on Web]

30 FISHING: THEORY AND EXPERIMENT
"I tried to teach Fermi to fish, and it seemed to me he liked it.
However, he once returned from Chicago with a lake fishing rod and reel.
I told him that it was not suitable for mountain streams, but to no avail.
Fermi developed a theory on how trout should bite and on how to catch them.
The theory was disproved by experiment, but this did not impress him in the least.
Ultimately he abandoned fishing, but not his theory."
— Emilio Segrè, *A Mind Always in Motion: The Autobiography of Emilio Segrè*
University of California Press, Berkeley, 1993, p. 191
[Quoted on Web: Pastel et. al., *Am. J. Phys.* Vol. 68 (Nov. 2000), p. 1001]

31 Four Volumes of *Chemical Demonstrations*
(These are handbooks for chemistry teachers to do classroom experiments demos)

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Part 2: Chemistry Demonstrations

Bassam held up a match:
"I drop a match, it bounces— that's physics."
"I light the match, it's on fire— that's chemistry."
"Physics is no match for chemistry!" [laughter]
"I'm joking— both physics & chemistry are important."
"Now I bet none of you can predict if I will drop the match,
or when will I drop it. You can't predict my intentions.
We need the neurobiologist to explain this mystery of free will."

"Michael Faraday [1791-1867] is well known for his pioneering work in electricity and magnetism. He also began 'The Royal Institution Christmas Lectures' for children in 1826 which continue to this day. Faraday asked 'How does the candle stay lit?' [A series of six children's lectures was published in 1860 as *The Chemical History of a Candle*] In the same spirit, I started the 'Once Upon a Christmas Cheery, in the Lab of Shakhashiri' chemistry demos some 30 years ago. It's a great way to get kids interested in science. Now, let's have some fun!" [Before doing any experiments, Bassam puts on his goggles, and points to the fire extinguisher to his left: "Even though I've done these experiments hundreds of times, one should always be cautious."]

Experiment #1: Burning a $1 Bill
Bassam took a $1 bill out of his wallet. Lit a match to it.
And POOF! it was consumed in flames without any ashes dropping!
"You want to see it again?" Bassam asked.
And POOF!— GONE WITH THE WIND— like the first one.
Bassam asked, "Something is wrong— it burned too quickly.
This is the magician's trick— hands quicker than your eyes."

Experiment #2: Not-Burning $1 Bill

Bassam: "Now, I want a volunteer from the audience who'll give me his or her $1 bill to burn. Nobody?" After awhile, a co-ed Kate came down from her seat and handed Bassam her $1 bill. Bassam asked her: "Have we ever met before?" Kate shook her head "No." Bassam said, "Just to be sure that I don't have a confederate in the audience." He then dipped Kate's bill in a beaker containing a transparent liquid. Bassam lit a match to the wet $1 bill which was surrounded by flames, but it didn't burn. "Why not?" The liquid solution he dipped the bill in was a mixture of 50% water and 50% isopropyl alcohol. Since isopropyl alcohol has a lower boiling point 82.4^{o}, it burned off before the $1 bill could [flash

point = 451°F]. Any heat that may have been able to ignite the dollar bill was absorbed by the water [detailed explanation]. Bassam gave back Kate her non-burning $1 bill and thanked her for being a good sport.

Experiment #3: Exploding Corks from Liquid Bottles
Three corked bottles with liquids on the bottom and a nail driven through the top above the liquid surface were placed side by side. Bassam used a spark plug and touched the nail on 1st bottle. The cork popped out a few inches above the bottle. He sparked the nail in the 2nd bottle, the cork popped up a few feet above the bottle. He sparked the nail in the 3rd bottle, the cork popped up with a loud bang and hit the ceiling! Explanation: The 3rd bottle contained ethyl alcohol. The heat from the spark plug and the alcohol vapor created a simulation of the combustion engine where chemical energy was converted to mechanical energy.
[Properties of Gases]

Experiment #4: Genie in the Bottle
Two one-liter bottles were placed side by side both containing liquid at the bottom. Bassam tossed in a few pellets in both bottles. The left bottle remained motionless, but the right bottle became foggy and soon plumes of white smoke puffed out like a Genie from Aladdin's Lamp. Explanation: The left bottle contained water. The right bottle contained 30% hydrogen peroxide (drug store variety has only 3%). The grains Bassam threw in were pellets of manganese dioxide (MnO_2) which acted as a catalyst for conversion of hydrogen peroxide to water & oxygen:

$$2H_2O_2 \Longrightarrow 2H_2O + O_2$$

This is a highly exothermic reaction with hot steam (water vapor) and oxygen gas bubbling out. The plastic bottle containing the fog has shrunk dramatically (50%) due to the extreme heat.
[Why does hydrogen peroxide foam when you put it on a cut?]

Experiment #5: Faster Reaction for the Genie
Bassam repeated Experiment #4 by dropping powdered manganese dioxide into the hydrogen peroxide solution. The fog formed quicker and huge plumes of white smoke puffed out like a volcanic eruption. Explanation: The more fine the powder, the faster it will react or burn because of more surface area. In this case, the manganese dioxide increased its catalytic rate for the hydrogen peroxide reaction.

Experiment #6: Solution Color Changes in Six Graduated Cylinders This demo is

similar to the photo at left that Bassam performed at the Boston Museum of Science (11-4-2001). Six 1-liter graduated cylinders were arranged in three pairs colored purple, pink, and blue. Bassam wore gloves as he dropped dry ice chips into the glass cylinders. "What's going on here?" Bassam asks, "Do you want a hint or clue?" "You all know the difference between hint & clue—A hint is something given to you. A clue is something you find yourself to solve the problem." Bassam then tells us: "You're seeing sublimation— CO_2 solid (dry ice) is turning directly into CO_2 gas that is colorless and odorless. All colored gases are poisonous, but not all colorless gases are. Sublimation is the basis of frost-free refigeration. Fog is condensed water vapor. Bubbles are CO_2 gas which is denser than air. The temperature of dry ice is -78°C. Bassam told the audience the chemical indicators used in the cylinders. The purple liquid changes to green then to yellow (universal indicator). The pink liquid turns colorless (phenolphthalein). The blue liquid turns yellow (thymol blue). [Discoverers: Universal Indicator, H.M. van Urk (1928); Phenolphthalein, Adolf Von Baeyer (1871); Thymol Blue (?); Acid-Base Indicators]

Experiment #7: Dry Ice Added to Boiling Water in Plastic Tub
A white plastic pan is filled with a 5-liter flask of boiling water. Bassam then adds dry ice to the hot pan. Clouds of fog rises above the pan, and then sinks as fog pours over the pan's edge and onto the floor. Explanation: CO_2 is denser than air so it sinks. Bassam says "This is how they do those foggy scenes in Hollywood films." [Dry Ice Info]

Experiment #8: Color Changes of Solution in a 4-Liter Beaker
A giant 4-liter beaker was set on top of magnetic platform. A coated teflon bar at the bottom of the beaker was set spinning in a counterclockwise direction. Bassam asks "If a ceiling fan is spinning in the same direction as the magnetic teflor bar would it be CW or CCW? Is the sundial in the Northern Hemisphere the same as in the Southern Hemisphere?" Meanwhile the color of the solution was turning from yellow to blue and blue to yellow, reversing itself every few seconds. Bassam says "Two high school teachers discovered this reaction. It took chemists 9 years to figure it out. It's a 24-step process— yellow color is iodine, and there is potato starch and several other indicators in the mixture.

Experiment #9: Suspending a Mug in the Air Without Touching It
Bassam shows the audience a ceramic mug and asks "Can I suspend this mug in the air without touching it?" He then blows a balloon into the cup and the balloon's suction holds up the cup. Bassam then holds the balloon and voila— the mug is held up without Bassam's hands touching it!

Experiment #10: Suspending a Balloon in the Air Without Touching It
Now Bassam asks "Can I suspend this balloon in the air without touching it?" He jokingly holds the mug with the balloon on top, but that's cheating. Then he blows the balloon and lifts it in the air for a few seconds. Now he turns on a hair-dryer and directs it at the balloon — and it's aloft in the air as long as the hair-dryer is on and pointing in its direction. Bassam says "That's the Bernoulli principle working— the basis of flight. The air pressure above the wing is lower than below the wing, so the plane stays aloft.

Experiment #11: Blowing Air into a Long Plastic Bag
Bassam asks Kate again to come down and lend a hand in his last experiment. He holds a long thin plastic bag at one end and asks Kate to blow air through the other end. After two huffs & puffs, Kate was tired and managed to fill air in only 20% of the 9-foot plastic bag. Then Bassam demonstrates how to do it properly. He does not put the bag in his mouth but opens the bag's edges wide and blows right in the middle— and it fills up instantly! Kate tries it his way and does it with ease. Bassam gives the plastic bag to Kate as a souvenir as the audience cheers Bassam's magic demos.

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Q & A Session (6:30 pm)

Q: Do you think there will be a time that Hispanics will be in science in greater number?
I ask this question because I think I'm the only Hispanic person in this audience.
I was not taught science at home. I majored in the sociology at UC Berkeley and
studied law. I believe statistics show that 80% of scientists in this country
are recruited from outside the United States (mainly from the Orient).
How can we increase the number of Hispanics to become scientists?

A: This is a very important question. It is our human society's responsibility.
Everyone has the opportunity in this country for higher education.
We need to develop an attitude of inquiry and curiosity.
Try to nurture the talent of children from all cultures.
I was born in Lebanon [1939] and came to the U.S. in 1957.
Why native-born Americans don't take the opportunities here?
[**Note**: I should have spoken out and shared this gem with the audience.
It's about Isidor Rabi (1898-1988), the 1944 Physics Nobel Laureate,
who inspired many others at Columbia University to Nobel Prizes.
When asked what was the source of his creativity, Rabi said
"When I came home from school, my mom would say to me:
'Issy— Did you ask a good question in class today?'" (Poem)
If every parent did that, more young minds would be induced
to "holy curiosity". This last phrase is from Albert Einstein:
*"The important thing is not to stop questioning. Curiosity
has its own reason for existing. One cannot help but be in awe
when he contemplates the mysteries of eternity, of life, of the
marvelous structure of reality. Never lose holy curiosity."*]

Q: I want to know the chemistry behind the first experiment?
[Before introducing Bassam, Prof. Zare poured liquid from one beaker to another,
then back again, but it solidified and didn't pour. He said Bassam would shed light on it.]

A: The solution used was a polymer acrylamide. Same as those used in diapers.
If I add salt to the gel in the beaker— it melts after some stirring.
Urine has electrolytes and salt in the sample.

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Professor Zare thanked Prof. Shakhashiri for his entertaining lecture and chemistry demos, and the audience gave a cheering applause. Then Prof. Zare asked Dean Charles Kruger (Stanford's Vice Provost & Head of the Stanford Graduate Fellowships Program) to come to the front. The students from the program presented him with two framed photos bearing the autographs of all the fellows from the last two years. Dean Kruger is retiring from Stanford, and received a standing ovation from the audience.

I went to the first row and shook hands with Dr. Frank Drake, who says "We meet again." (referring to our first meeting on April 21 at Christopher Chyba's "Extraterrestial Life" lecture).
Then I congratulated Bassam and told him how much I enjoyed his enlightening lecture. When I mentioned my career change from biochemistry to poetry, Bassam gave me his business card and told me to keep in touch. I gave him my WisdomPortal business card, and told him that my mentor at Cornell, Prof. Harold Scheraga is 81 and still active researching protein folding. Bassam said "Harold will be lecturing at University of Wisconsin next month. What a wonderful feeling to be with minds always in the pursuit of learning! Bassam reminds me of the last scene in the *Ten Oxherd Drawings*— "The Sage in the Marketplace". The Zen Master is not in a cave enjoying the bliss of his enlightenment, but actively engaged in the world sharing the fruits of his wisdom so that others will partake in the joy, beauty and the wonders of the cosmos all around us.

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Web Links to Professor Bassam Z. Shakhashiri:
- Prof. Bassam Z. Shakhashiri (University of Wisconsin-Madison)
- Science Is Fun (in the Lab of Shakhashiri)
- Bassam Z. Shakhashiri's Biographical Sketch
- Once Upon a Christmas Cheery in the Lab of Shakhashiri
- Home Experiments to Add Joy to Your Science Experience
- Chemical Demonstrations: A Handbook for Teachers of Chemistry
- Institute for Chemical Education (founded in 1983 by Prof. Shakhashiri)
- "Shakhashiri— the reigning dean of American chemistry lecture demonstrators" (*Encyclopaedia Britannica 1995 Yearbook of Science and the Future*)
- 'Science is Fun' lecture-demonstration coming to UCSC (UC-Santa Cruz *Currents*, March 2, 1998)
- Three eTeach Videos from Shakhashiri's Chemistry Lectures (1998) (Electrical Conductivity of Liquids, Multiple Ammonia Fountain, Reactions of Carbon Dioxide in Aqueous Solutions)
- Prof. Shakhashiri's Syllabus for Chemistry 104 (University of Wisconsin-Madison, Jan. 24, 2002)
- Stanford's Web Page on Prof. Shakhashiri's Lecture (Keynote Lecture at Stanford Graduate Fellowships, April 29, 2003)

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