Science 'Teaching'--
A 20 Year Perspective…

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Chemistry Educators' Day Univ of Uppsala
May 15, 2003

The Beginning:

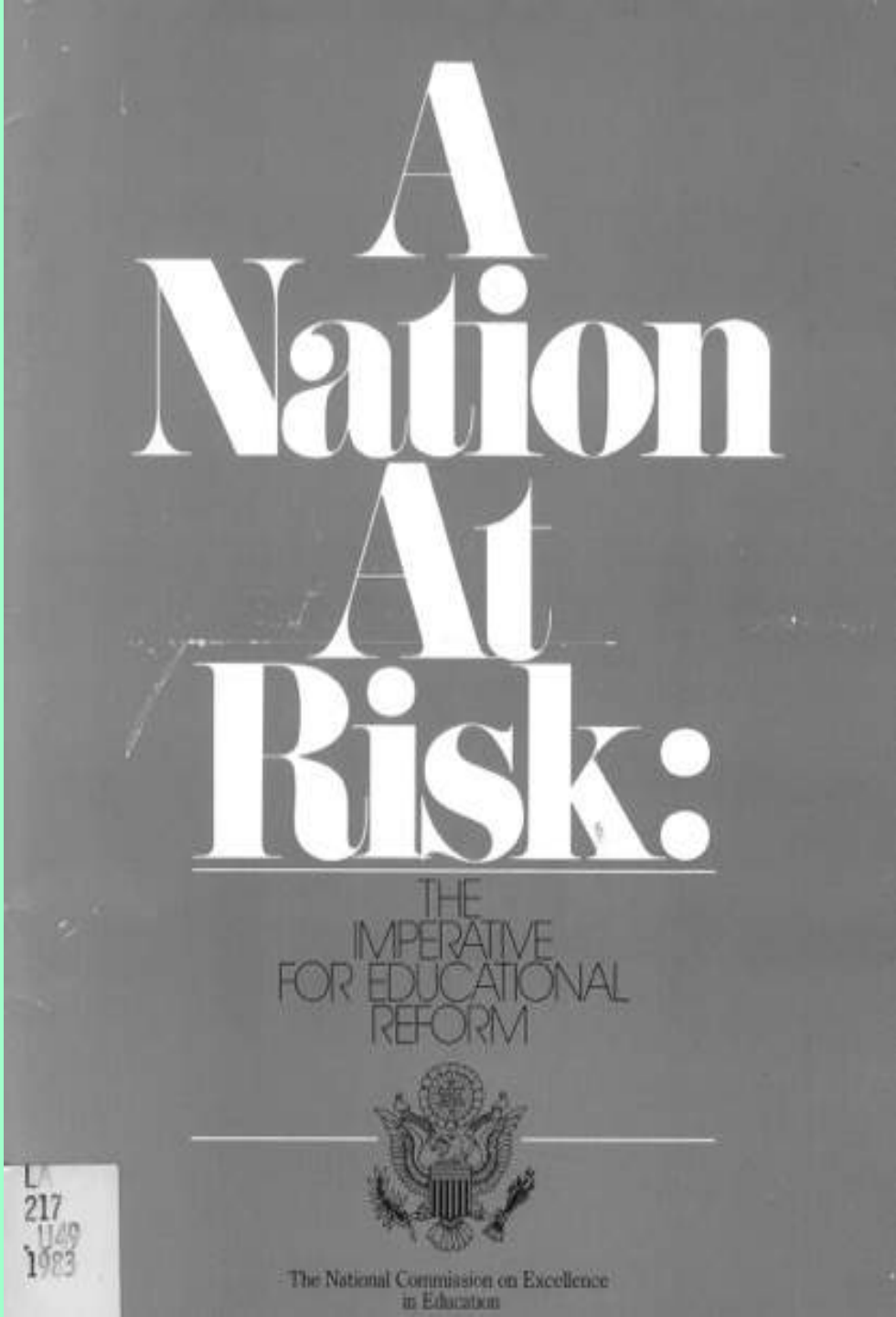
April, 1983: Dr. David Gardner, President, University of Utah:

"Our nation is at risk…The educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future as a nation and as a people…

A high level of shared education is essential to a free democratic society and to the fostering of a common culture… citizens must be able to reach some common understandings on complex issues, often on short notice and on the basis of conflicting or incomplete evidence.

America is at risk."

Twenty years -- a generation later -- the situation is no better.



The Scientific and Engineering Community has been largely uninterested and uninvolved in the education and awareness of the general public

The lack of effective science and technology education in the K-12 years over the past several or more decades has resulted in:

- an electorate which is largely scientifically, technologically, and numerically/mathematically illiterate,…
- an electorate which can not deal objectively with a wide range of issues, and
- decreasing numbers of students electing to study the sciences.

MY Focus today is:

- NOT on those students who choose to study science, math, or engineering
- NOT on those teachers who have motivated and educated them
- NOT on their supportive and interested parents.

Most advanced countries have many excellent programs for these groups

Rather, MY Focus is:

- ON those students who are DIS-interested
- ON those parents who are DIS-interested
- ON those teachers who are DIS-interested, afraid, and/or apathetic
- ON the general populace, particularly the political, business, economic, and highly religious communities.

Most countries tend to ignore the education of these important populations

Please appreciate that my comments are based on a USA/Utah perspective

The public deals with science and technology in three ways:

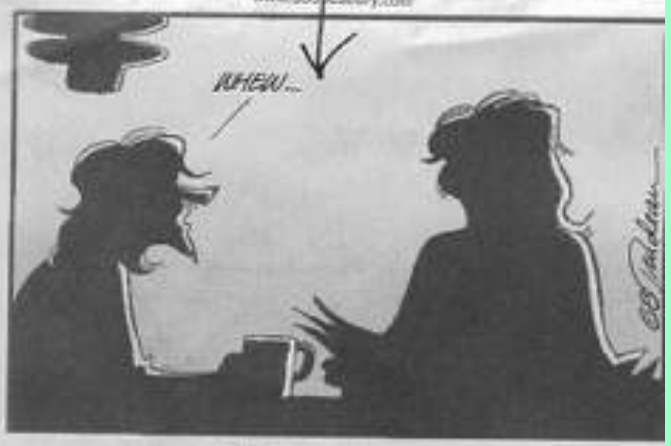
- --they are fascinated by it, desire it, and even demand it – especially for their own health and medical needs;

- --they have little understanding of its bases, fundamentals, limitations, assumptions, or statistics – and therefore treat science/technology critically and suspiciously, often blaming it for undesirable outcomes; and

- --they often depend on mysticism, magic, pseudo-science, etc. to compensate for their lack of -- or unwillingness to accept -- scientific principles or processes.

These attitudes are common in the United States – often in the same person and including most of our business and political leaders!

DOONESBURY
BY GARRY TRUDEAU



Why is there such wide-spread science illiteracy?

Because the Public rarely *experiences* science in relevant, personal settings, and

Because the Public has been 'taught' that Science is difficult and that only 'smart' people can do it;

Science as normally taught and experienced in a traditional classroom/laboratory environment is neither personal nor relevant--

therefore, it is irrelevant;

therefore, it is not important.

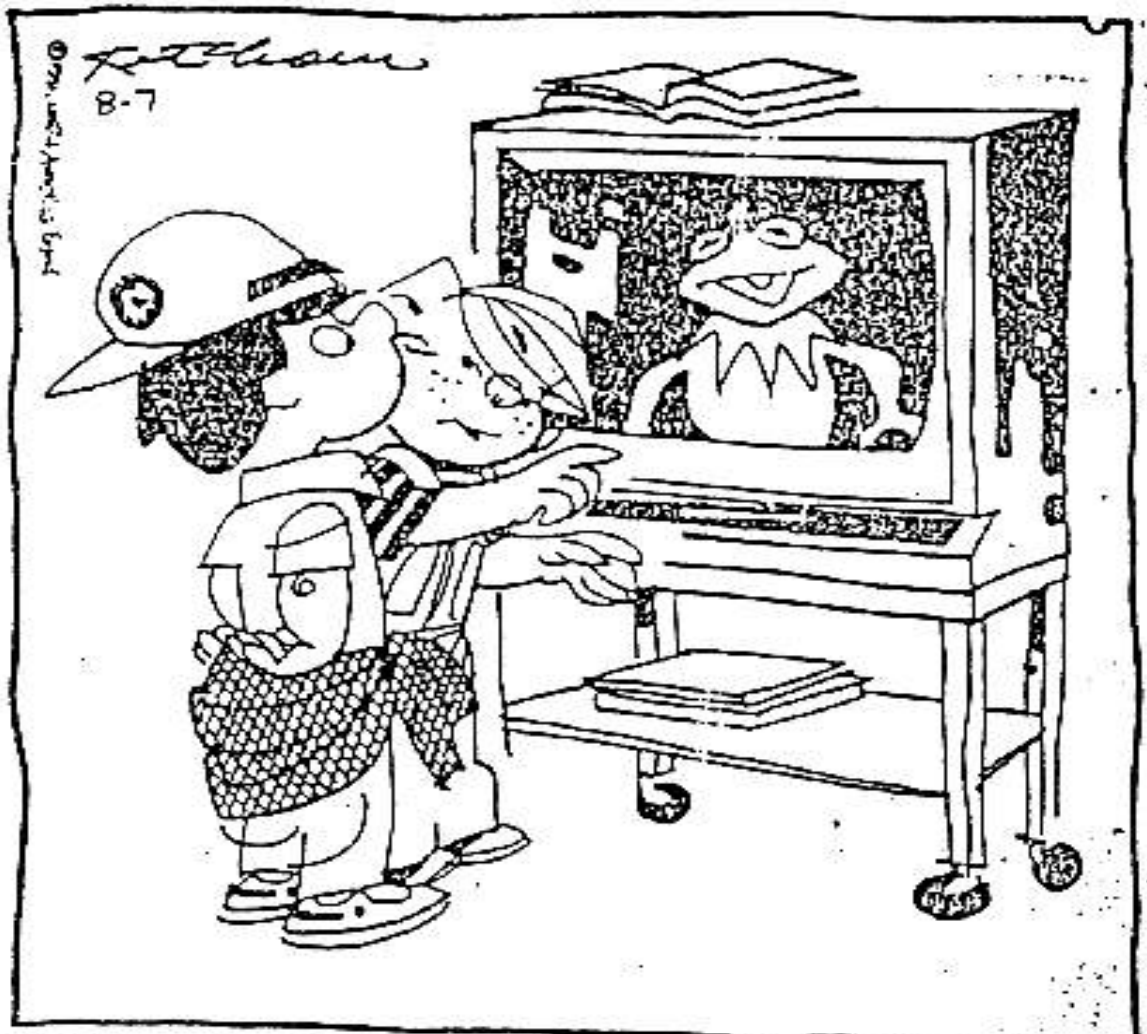
The Public's Conclusion: "Science is done by scientists, in science laboratories, and -- although practical and important-- is not interesting, relevant, or appropriate for ME."

Leonardo da Vinci:
"Study without a liking for it
spoils the memory, and
it retains nothing it takes in."

The key question is:
how to 'teach' science to those who are *disinterested* in it?

The 'answer':
'teach' it through something which *does* interest them.

Dennis The Menace by Hank Ketcham



"WATCH THIS, DEWEY... WHEN THAT FROG THINKS HE'S GOT OUR ATTENTION, HE'S GONNA TRY TO TEACH US TO COUNT OR SOMETHING."

My Approaches/Ideas on Science 'Education':

- Personal relevance can lead to interest
- Minimize Hypocrisy
- Science is Easy--just 'common sense'
- TV/Video provides 'convenience' and visualization
- LabLess Lab facilitates private experiments and experience
- Relevant projects facilitate personal motivation
- and involvement
- Team projects are even more effective
- Contests and competitions can be very effective
- Multi-sensory, multi-variate private/personal experiences
- lead to Eureka! moments--personal revelations
- It is only through such Private Revelations that
- true understanding can develop

Nearly 10 years ago: Television Course and Textbook:

Science without Walls: Science in YOUR World

www.utah.edu/cseo and click on

Science without Walls

See also The Scientist, April 27, 1998

Commentary by J Andrade:

Science without Walls:

Science in YOUR World

joeandrade@uofu.net

Airs every semester on Utah's Educational TV Channel

Andr-62

COMMENTARY

by J.D. Andrade

Science Without Walls: Science In Your World

How should one teach nonscience majors science? In the modern university, nontechnical majors are, almost by definition, majors in the fine arts, the humanities, or the social sciences. Graduates from nonscience/nontechnical programs will not find work in laboratories, nor will they wear white lab coats or be involved with technical apparatuses, manipulations, or calculations. Their interaction with science will be in their everyday world. They should experience science in their university courses in a manner and environment that are indeed relevant to *their* everyday world—which is not necessarily the world of science or engineering faculty.

"Science Without Walls: Science in Your World," a video-intensive telecourse, is designed as an integrated, coherent, interrelated science experience for undergraduates not intending to major in science or engineering. No such course or project has previously been attempted, to our knowledge, although the book by James Trefil and Robert M. Hazen, *The Sciences: An Integrated Approach* (New York, John Wiley & Sons, 1995; 2d ed. 1998), has similar objectives.

The content was organized into 40 half-hour programs in six general sections or units: Science and Art; Physics; Chemistry; Biology; Earth; and You! To get to the wider student- and general-population audience, the course was developed for television and is now regularly broadcast on Utah's statewide educational TV channel. It uses video segments to illustrate and demonstrate processes and phenomena. The objective from the very beginning was that, wherever possible, video clips would be on the screen rather than a professor's talking head.

The design and content of the course were based on a number of pedagogical strategies. Students learn best and most effectively when the content is practical and directly relevant to their everyday needs and lives. To *experience* science, one has to *do* science. Science cannot be learned or appreciated in a spectator role. Most laboratories and researchers' technical jargon reinforce students' preconceptions that science is different from and unrelated to their interests and their world.

We minimize the use of formal laboratories, emphasizing kitchens, bathrooms, garages, and the natural outdoor world. Scientists are treated as informal, friendly, fallible, and human—and they don't wear white coats! Homework and personal laboratory experiments emphasize involvement with local museums and related institutions. Assignments also involve interaction with public and other agencies and sources as well as direct communication with local, accessible professionals, such as pharmacists and physicians.

The Labless Lab for "Science Without Walls" is a small science kit of generally available materials that the students use to conduct the experiments and observations associated with each of the 40 programs. There always has been considerable concern in offering science or other experience-based courses via television with the argument that students cannot gain the hands-on experience normally required in the laboratory components of on-campus courses. This is certainly true, but everyday materials and living situations can be far more relevant and meaningful than a formal or standard laboratory.

The normal high school sequence for the teaching of the sciences—biology to chemistry to physics—is inappropriate and illogical. We use the sequence of *first* physics, *then* chemistry, and *then* biology. This is because physics provides the fundamental rules and laws of the natural world, upon which both biology and chemistry are dependent. Chemistry provides the understanding of the elements, the molecules, and the materials of the natural world, upon which biology is dependent. Biology, although a unique science, is dependent on the rules and understanding derived from both physics and chemistry.

The various sciences are historically treated as distinct and separate in high school and even in junior high, divorced from the students' everyday world. Science must be viewed and experienced in the context of the nonsciences for nonscience students to accept and understand the relevance of science to their everyday lives. Nonscience students are interested generally in the fine arts, the humanities, or the social sciences; thus, science must be made relevant to these disciplines and areas of study. There is particular emphasis in "Science Without Walls" on the connections and similarities between the sciences and the arts.

Students need heroes and role models. They need people and individuals with whom they can identify and whom they can emulate. We have made extensive use of individual personalities.

A unique aspect of the course is an emphasis on music. Each of the programs concludes with music tied to the content of that particular program. The pedagogical rationale here is that most students are interested in music, particularly various forms of popular music. If they can begin to see and experience the connections between science topics and the music to which they listen everyday, they will start to appreciate science and its connections to their everyday lives.

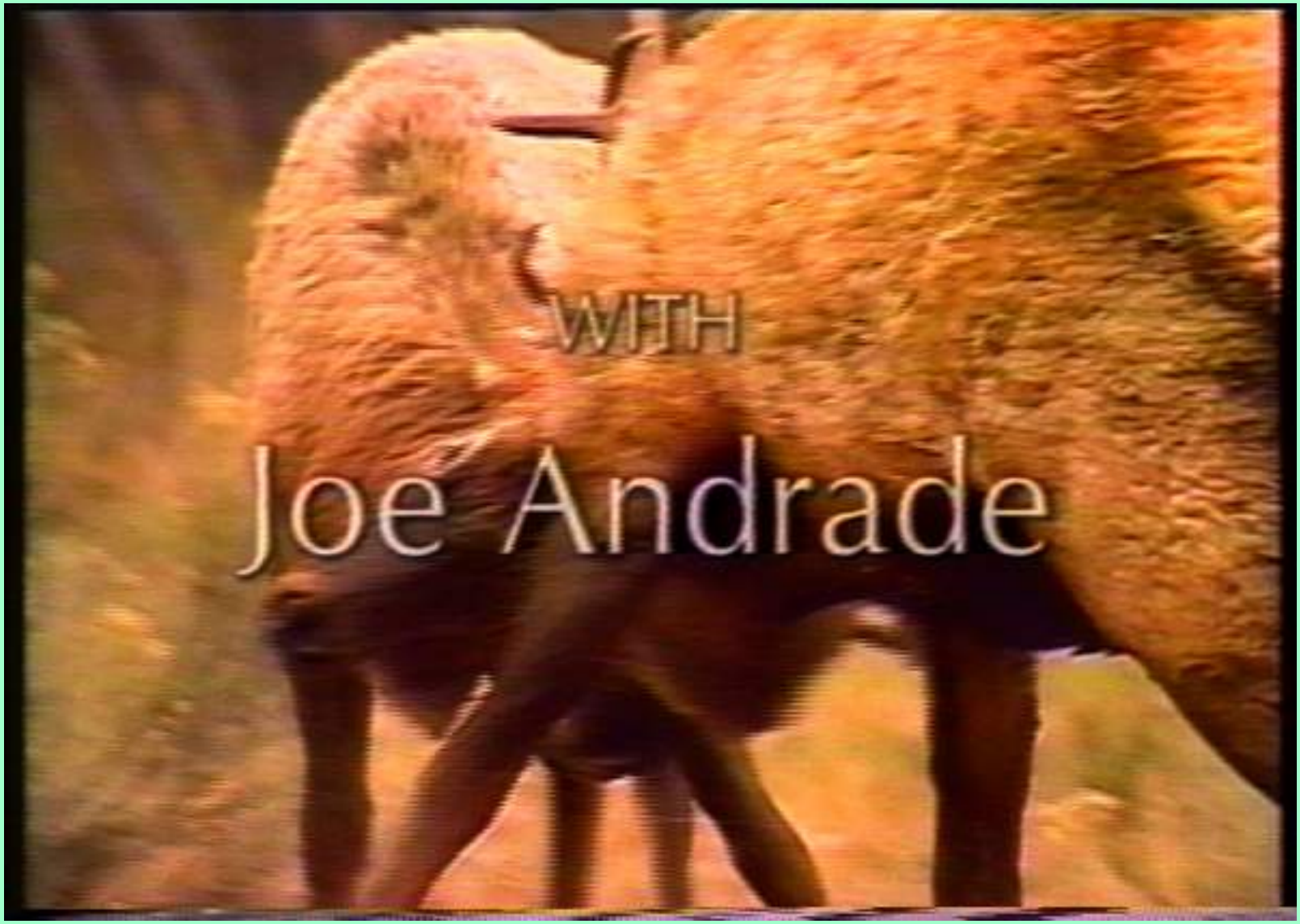
"Science Without Walls" shows that students must be responsible. University telecourses tend to attract older students with a myriad of commitments and responsibilities. The course is targeted to adults, with the goal of empowering them to act as concerned, literate, educated members of a democratic society. The course gives them the background and motivation to become appropriately involved with such issues.

The major objective of "Science Without Walls" is to provide minimum scientific literacy for the general population, including university undergraduates. The goal is not to make scientists out of them or to teach them to solve physics or chemistry problems, but to get them to understand the basic concepts and themes that underlie our natural world and to provide them with the background and confidence to take additional science courses and to become involved in the scientific and technological issues important to their nation, state, community, and family. ●

J.D. Andrade is a professor of bioengineering at the University of Utah. For more information, contact him at (801) 581-4379 or Joe.Andrade@m.cc.utah.edu. Course materials can be seen at www.utah.edu/cine.

S W/O W ‘Pedagogy’:

- Topics must be RELEVANT, PRACTICAL, BRIEF
  - Science in YOUR World
- DOING is required; not a spectator activity
- Common English--minimize jargon
- No formal Labs or White Coats
- Local Museums and Science-related activities
- Kitchen, Bathroom, Garage, … LabLess Lab:
- Physics first, then Chemistry, then Biology but
  - Science WITHOUT Walls
- Heroes/Role Models
- Music
- Minimal Hypocrisy

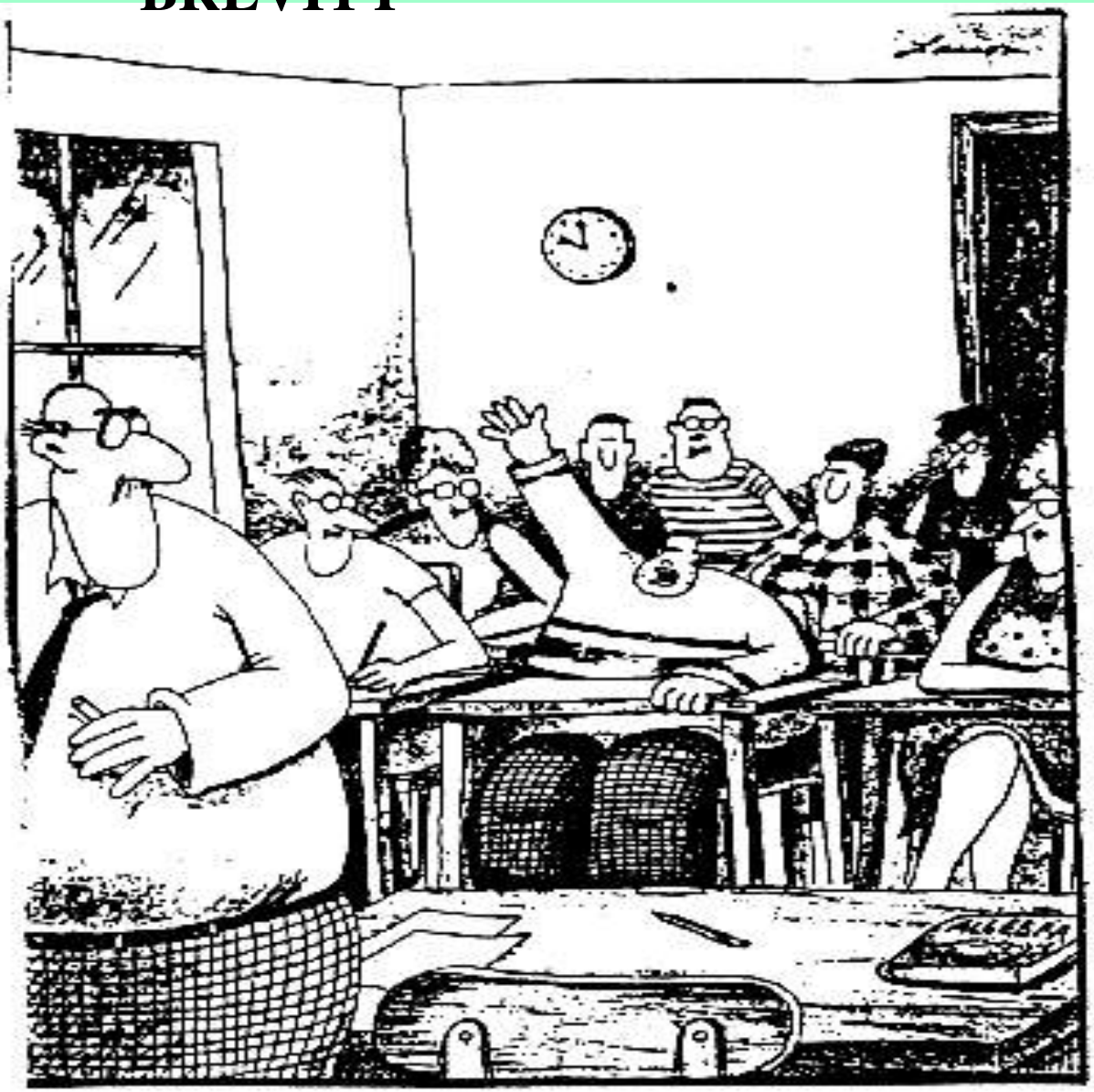


Utilize Music

PERSONAL **RELEVANCE**

Calvin and Hobbs

BREVITY



The Far Side,
Gary Larsen

Get them 'hooked' -- motivated -- then deal with the rest of the 'material'

Some of the 40 Chapter/Video Titles
(remember, it has to be Science in THEIR World!):

- Physicists in the Wild
- Highway Physics (or Physics on the M4)
- Your Personal Periodic Table
- Very Personal Chemistry
- Guns and Bombs
- What is Life? From Bacteria to YOU
- YOUR Stuff: Cars and Transportation
- Luck and Risk: Private Statistics

Science without Walls emphasizes the differences between Science and the Humanities--and the similarities between Science and Art

The **Basic Assumptions of Science** are made very clear (important, as most people have beliefs in contradiction to these assumptions):

- Assumption: There are 'Rules' which are universal and constant (God is not capricious and doesn't play favorites).
- Assumption: We can discover and learn the Rules (Creator endowed us with brains, curiosity, senses);

(We have to directly **address God and Religion**, as a high proportion of the US population has strong religious beliefs--and especially in Utah)

Rules are Common Sense

Hard Rules -- “Soft” Rules

- The Hard Rules -- The Sciences
  - The way the physical and natural World works;
  - The Rules of the Game -- apply everywhere, all the time, to all; no favorites; no supernatural stuff.
- The “Soft” Rules -- The Humanities
  - Societies and Cultures;
  - Philosophies and Religions;
  - Politics and Law.

BUT…"soft" eventually hardens…

E. O. Wilson

Consilience: The Unity of Knowledge, Knopf, 1998

Carl Sagan:

"Science as a Candle in the Dark"

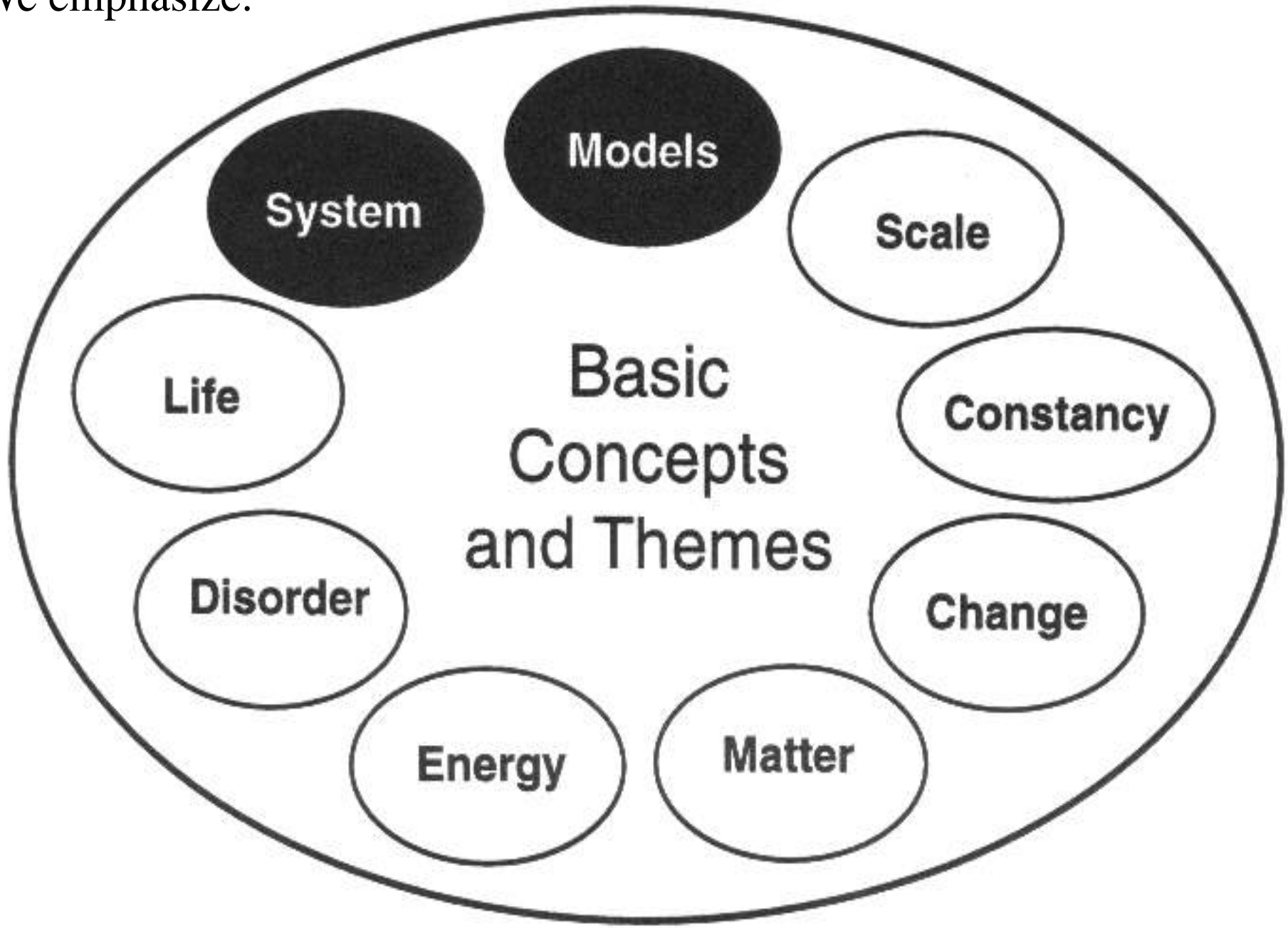
(subtitle of A Demon Haunted World)

We admit, and celebrate, that the Natural World is
Rational but often Complex and therefore Uncertain:

We emphasize--

- The Rules of the Game:
  What We Know and Can Know;
- The Scientific Process:
  How We Know and Can Know
- Uncertainty and Risk:
  What We Can't Know
- But…

We emphasize:



Organized into 40 half-hour TV programs and text chapters:

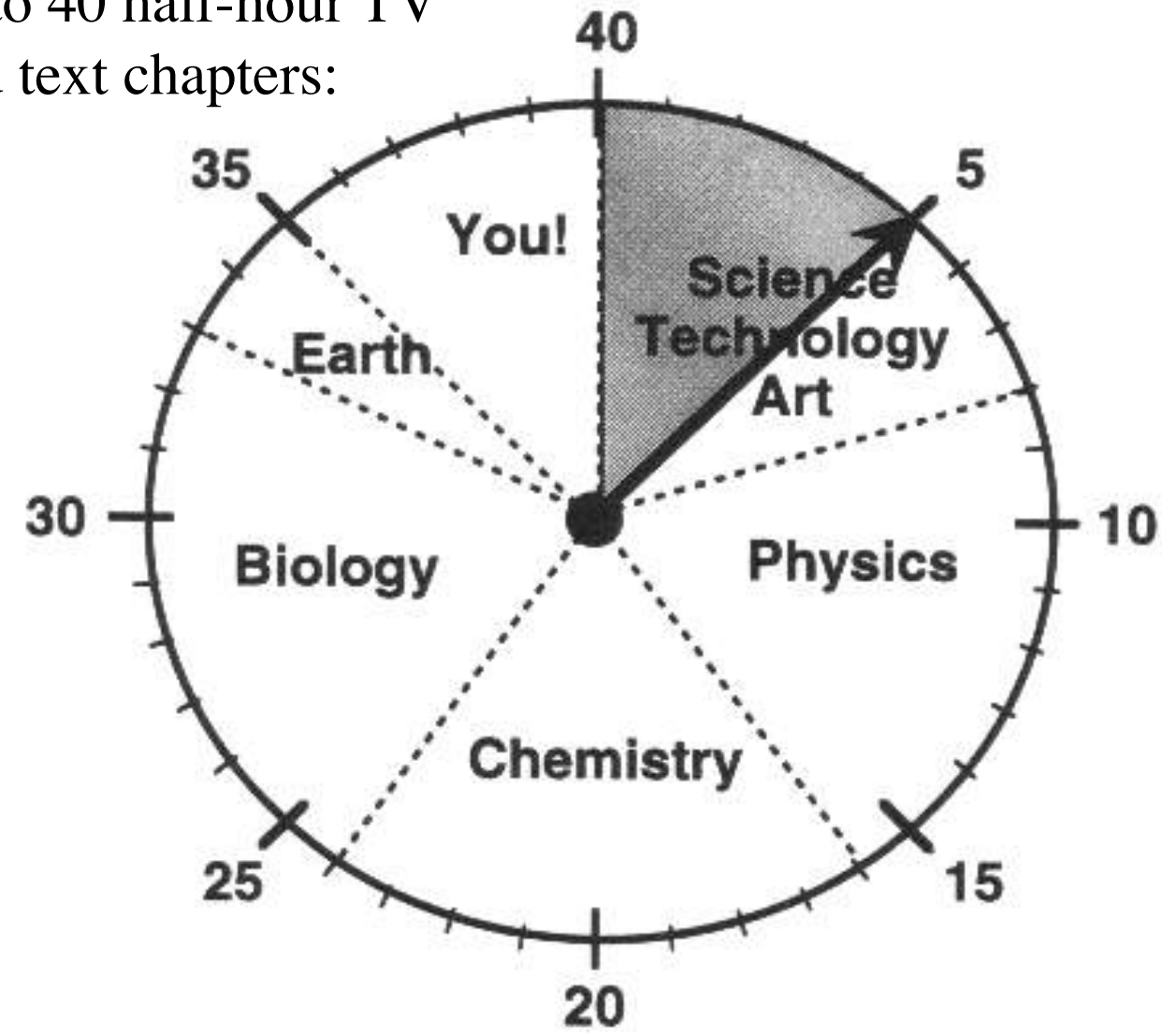


Figure 5-1 *You have already covered ten percent of the book!*

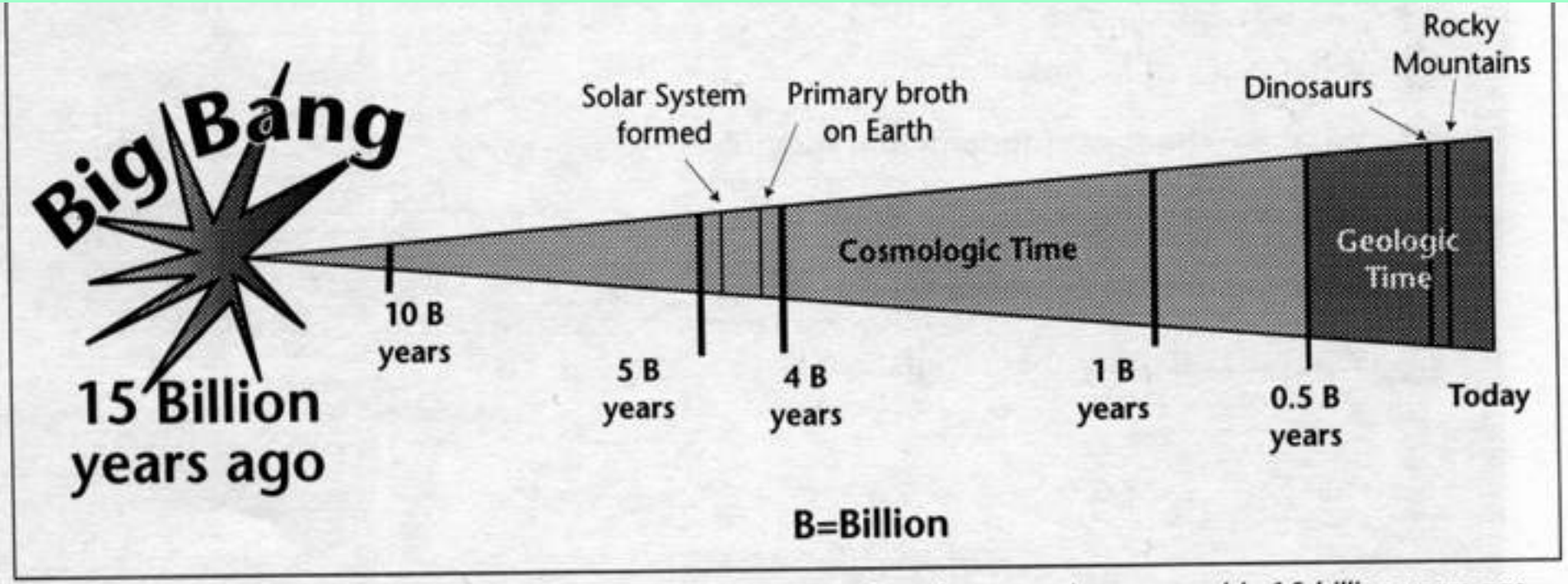


Figure 3-1 *The scientist's time frame begins with the creation of our known universe, roughly 15 billion years ago. Not too many people worry about what happened before then. Lots of people don't worry about what happened before the earth was formed, perhaps five billion years ago. Some scientists like to focus on more modern events, perhaps the last hundred million years. If you are only interested in your immediate ancestors, then your time frame can shorten to a million years or so.*

SCALING--in time and distance

Powers of Ten!

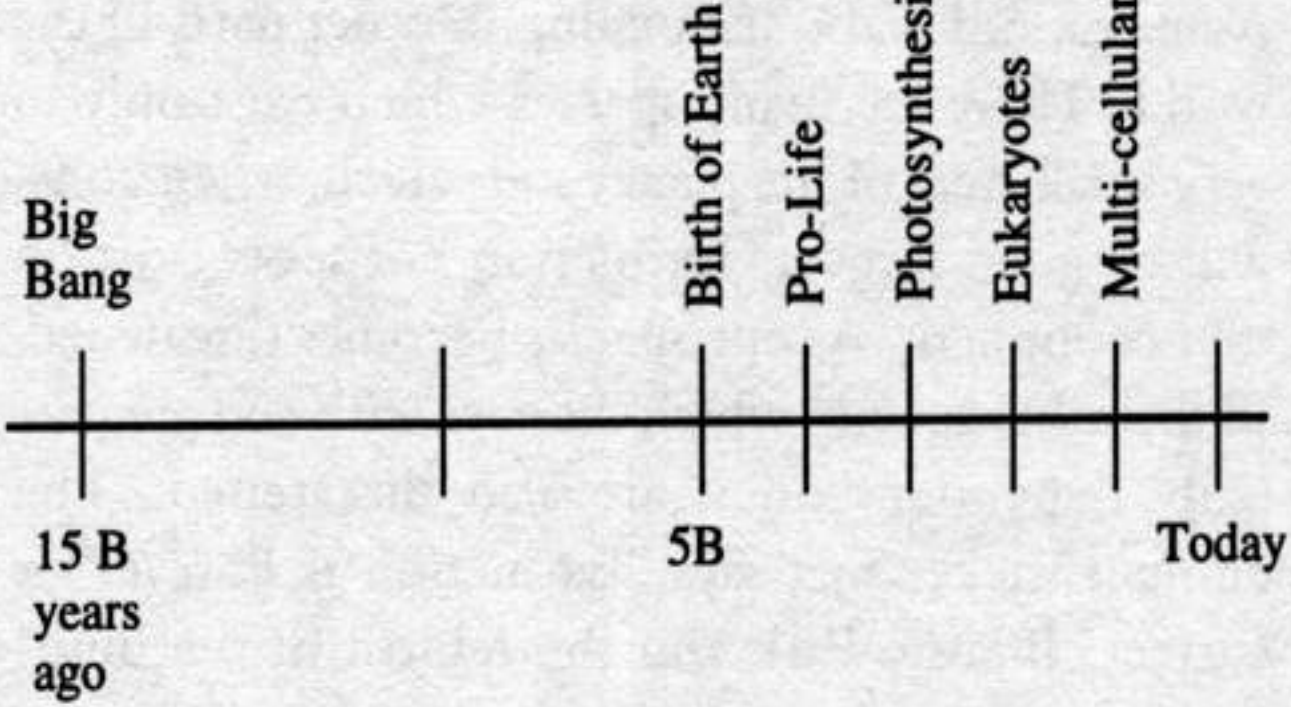


Figure 26-13 *A very rough clock! In billions of years.*

Four Billion Years is a VERY Long Time!

Science: Discovering How the World Works

- Physics-- the really Simple rules
- Chemistry--Stuff: Gas, Liquid, Solid
- Biology--Living Stuff
- Engineering--Problem Solving

Character of Physical Law

Rules: Physics

What is REALLY Basic and Important?

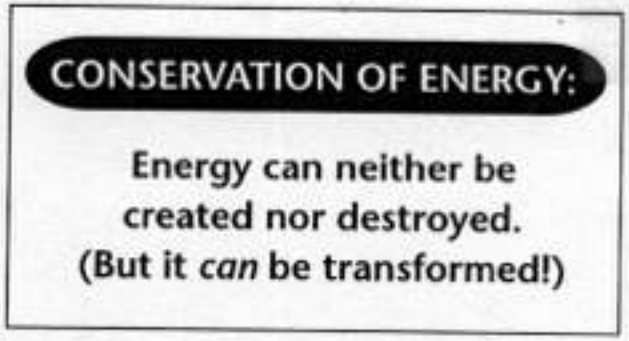


Figure 8-4 *One of the basic conservation laws of physics is conservation of energy. Although we can transform energy from various forms to other forms, we cannot create it from scratch, or completely get rid of it. Conservation of mass is the other great conservation law. Yes, if we deal with nuclear processes, with fission or fusion, matter and energy can indeed be converted from one to the other. To be completely general, we should say it is mass plus energy which is conserved. In your everyday world, outside of nuclear reactors and stars, we can treat matter and energy separately, and they are each independently conserved.*

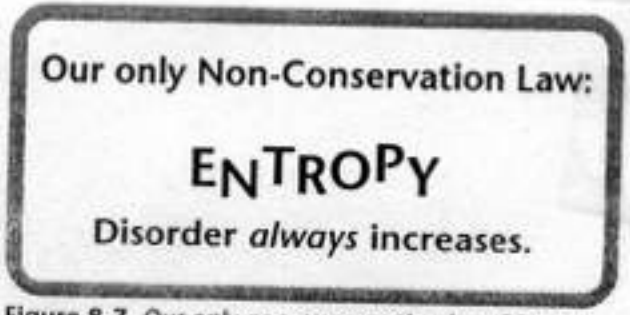


Figure 8-7 *Our only non-conservation law. Disorder always increases. Since scientists like to have a name for everything, we call that disorder* entropy.

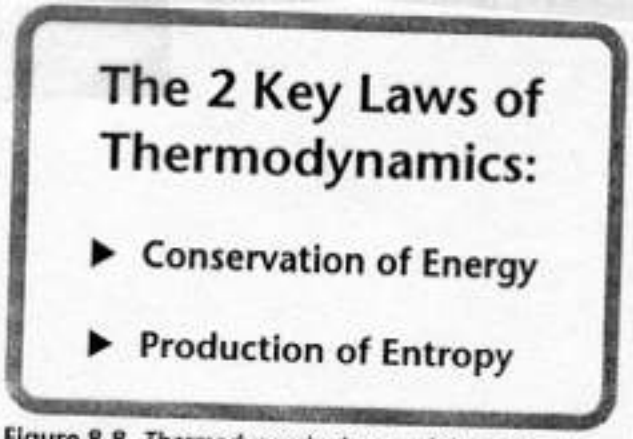


Figure 8-8 *Thermodynamics is one of the fields of physics and chemistry and biology. The two key laws and principles on which thermodynamics is based are conservation of energy and production of entropy.*

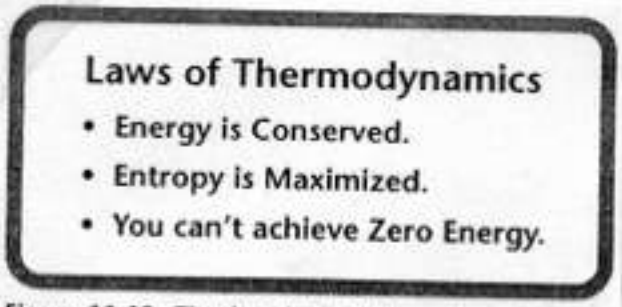


Figure 11-13 *The three laws of thermodynamics.*

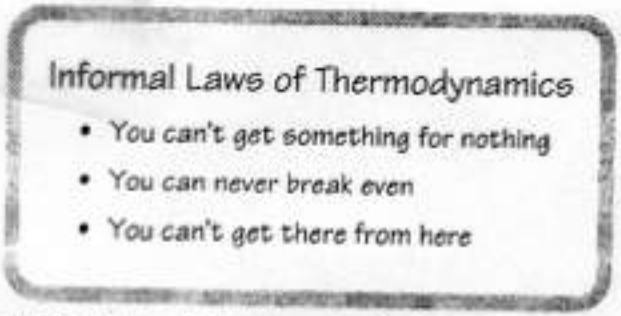


Figure 11-14 *The more popular (and probably most easily remembered) laws of thermodynamics.*

More Rules: Physics

Newton's Laws of Motion:

1. Inertia
2. a = F/m; F = ma
3. Action/Reaction

Figure 11-4 *Newton's three laws of motion. The first is inertia; the second is F = ma, which he really figured out from his considerations of gravity; and the third is action/reaction, or "all forces come in pairs."*

Newton's Laws, rephrased:

1. Things will keep doing what they're doing unless they're bothered.
2. Things change what they're doing based on how much they're bothered.
3. When things are pushed, they push back.

Figure 11-6 *A more everyday way of expressing Newton's Laws.*

Conservation Laws
from Newton's Laws of Motion

- Conservation of **Mass**
- Conservation of **Linear Momentum**
- Conservation of **Angular Momentum**
- Conservation of **Energy**

Figure 11-7 *The Conservation Laws that are a consequence of Newton's Laws of Motion.*

Uncertainty Principle

"The intrinsic graininess of things means there's a graininess to the accuracy with which we can measure things."

Figure 16-18 *A restatement of the uncertainty principle. (Morrison,* Nothing is Too Wonderful to Be True*)*

Stuff:
Chemistry

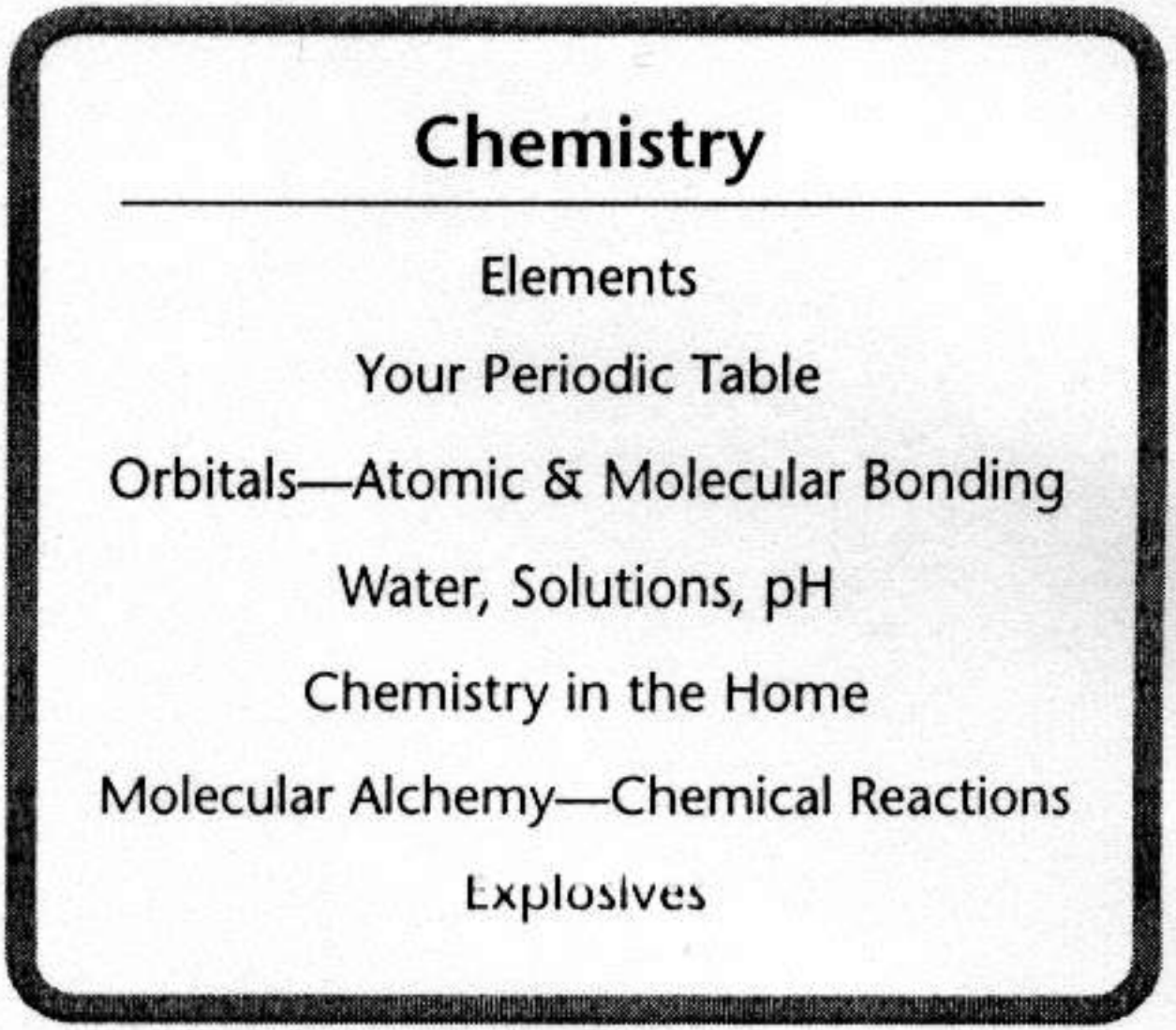


Figure 24-23 *Key topics of chemistry.*

Arrhenius and grand-daughter

Principles:

Biology

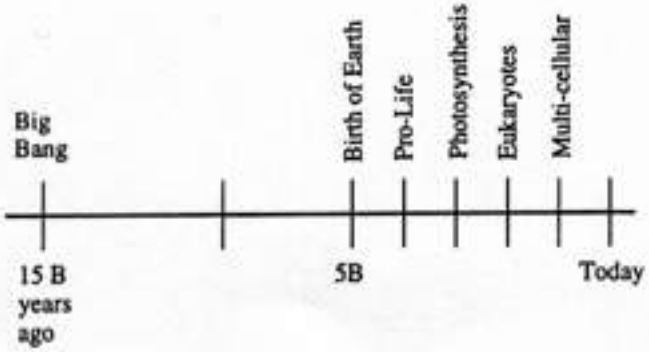
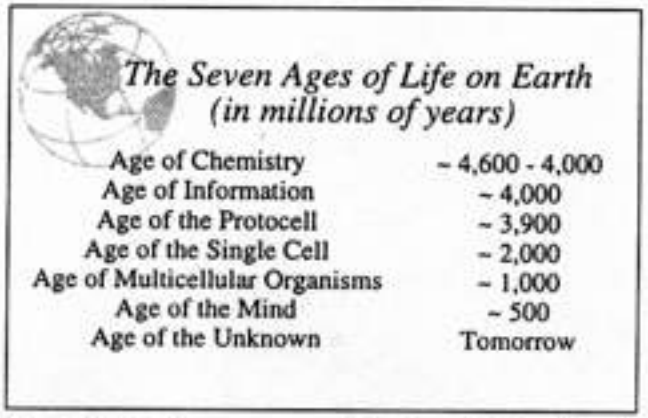


Figure 26-13 *A very rough clock! In billions of years.*



The Seven Ages of Life on Earth (in millions of years)

Age of Chemistry	~ 4,600 - 4,000
Age of Information	~ 4,000
Age of the Protocell	~ 3,900
Age of the Single Cell	~ 2,000
Age of Multicellular Organisms	~ 1,000
Age of the Mind	~ 500
Age of the Unknown	Tomorrow

Figure 27-3 *The seven ages of life, from de Duve's book.*

Five Kingdoms

Monera	Prokaryotes: Bacteria
Protoctista ..	Eukaryotes: Mainly single cell protists
Fungi	Multi-celled Eukaryotes: Mainly molds & mushrooms
Animalia	Multi-celled Eukaryotes: The Animals
Plantae	Multi-celled Eukaryotes: Green Plants

Figure 26-5 *A summary of the Five Kingdoms.*

Bioenergetics

Photosynthesis:

$$CO_2 + H_2O + \text{light} \longrightarrow \text{sugar} + O_2$$

Respiration:

$$\text{Sugar} + O_2 \longrightarrow CO_2 + H_2O$$

Figure 29-1 *Bioenergetics is that part of biology and biochemistry which deals with transformations of energy. There are two major fields of bioenergetics: photosynthesis, which produces oxygen and "fuels," and respiration, which produces CO_2 and water.*

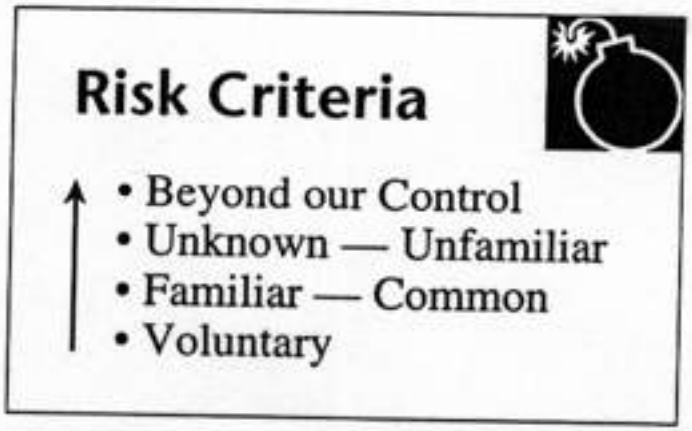


Figure 37-12 *Risk perception factors. Things which are voluntary are perceived as far less risky (a thousand times less!) than unfamiliar risks or risks completely beyond your control.*

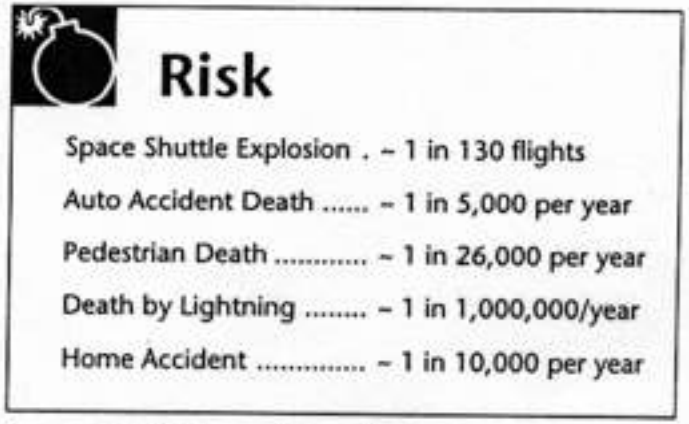


Figure 37-13 *Some risk numbers .*

We cover perceptions and facts related to risk and uncertainty:

Climbers seek summits in the shadow of death

Mount Everest victims knew risks of their journey to the top of the world.

Associated Press

NEW YORK — The eight men and women who died in a blizzard on Mount Everest knew before they started that even if they reached the world's highest peak, it could all end in disaster.

So why did they spend $60,000

Blizzard rescue

Nepalese army helicopters evacuated two people from Mount Everest on Wednesday after one of the deadliest blizzards ever on the peak.

The helicopters carried Charlotte Fox of Aspen, Colo., and Michael Groom of Australia to Katmandu's airport. They left with represen-

Figure 37-14 *Mountain climbers know the risks. Adventure is generally tied to risk; if it wasn't risky, it wouldn't be an adventure! (From Deseret News, Salt Lake City, May 15-16, 1996.)*

We cover:
Entropy, Disorder, Unpredictability, Statistics
Graininess -- Quantum Mechanics

Concluding that…
Uncertainty and risk --
not necessarily anyone's fault!!

Summary--

Rules and

Principles

Physics: Laws of Motion
Conservation Laws
Laws of Thermodynamics

Chemistry: The Periodic Table
92+ Elements

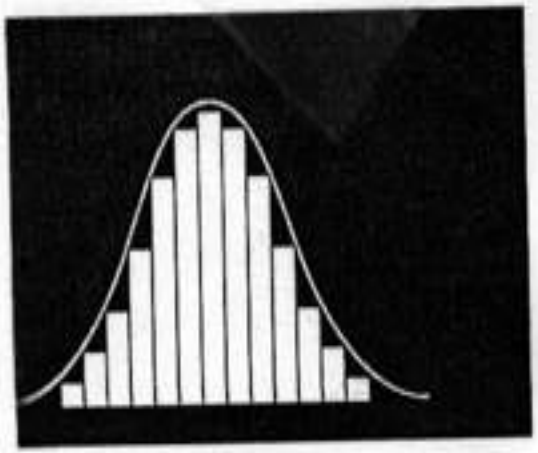
Biology: 5 Kingdoms
100+ Phyla

Figure 26-4 *Basic facts of the three basic sciences.*

Planetary Pathology

Major CO2 Increases
Major Ozone Depletion
Dramatic Extinction

Figure 40-8 *Planetary pathologies learned by—and caused by—*Homo sapiens.



10 *The bell curve again*

Very Basic Concepts:

- “We are evaporating our coal mines into the air.”

  Svante Arrhenius, 1896

- Hydrocarbons + O_2 = Lots of CO_2 + H_2O

  Combustion and Respiration

S W/O W ‘Pedagogy’:

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- Common English--minimize jargon
- No formal Labs or White Coats
- Local Museums and Science-related activities
- Kitchen, Bathroom, Garage, … LabLess Lab:
- Physics first, then Chemistry, then Biology but
  - Science WITHOUT Walls
- Heroes/Role Models
- Music
- See last paragraph of PDF

MUSIC

So Why doesn't this approach work better?:

- Because Television is not an interactive, experiential medium (although we do provide a Lableess Lab-- a kit with which the students DO a variety of simple, relevant experiments and scientific observations).

- Is a better 'solution' via interactive, hands-on, experiential science 'centres'?
  - Heureka in Helsinki;
  - Experimentarium in Copenhagen;
  - Glasgow Science Centre;
  - many others
- I am trying to answer that question.

But, Science Centres are often Criticized as being too ‘Edutainment’--oriented, with little true learning or understanding, and...

- Science Centres historically focus on ‘dry’ activities:
  - Mechanics
  - Optics
  - Electricity and magnetism
  - Astronomy and Cosmology
  - Computer simulation and ‘virtual reality’ experiences.
- ‘Wet’ activities, including Chemistry and Biology, are usually not well represented.

Remember Leonardo:
“Study without a liking for it
spoils the memory, and
it retains nothing it takes in.”

‘Teach’ through something which interests THEM.

AFTER they are interested and motivated, then they will work commit and hard.

What REALLY interests most people?

- Themselves--THEIR body, physiology, activities, hobbies…
- For teenagers: sex, hormones, acne, AIDS, cars, sports, …
- For the elderly: health, risk, economics,..
- For the not so old (you and me!): safety, medicine, menopause, prostate cancer, breast cancer, sports, gambling, drugs,
- For newly marrieds (or unmarried): pregnancy, genetics, diapers, housing, transportation,…
- For Texans: guns and chili, and oil depletion…
- For travelers: SARS
- For Utahans?
- For Swedes?
- For YOU??

A ‘Third Generation’ Science Centre

1st Generation: Traditional Natural History Museums

Static, non-interactive

2nd Generation: Interactive--YOU control the activity/experiment

- Exploratorium (San Francisco)
- Ontario Science Centre (Toronto)
- Heureka
- Experimentarium
- Many others

3rd Generation: YOU ARE the Experiment

Utah Science Center--the First of the Third Generation Science Centers

BIOENGINEERING and Technology to the rescue…

We know how to make measurements on people--non-invasively;

We know how to acquire, process, and visualize data;

We can now deal with multi-parametric and even multi-sensory approaches to complex problems;

We have wonderful visualization and virtual reality tools and technologies;

We can even deal with Complexity.

The incredible array of measurement and analysis tools developed and applied over the last half-century makes possible measurements and experiments which were literally impossible-- or incredibly expensive-- not so long ago.

Bioengineering and Technology make possible the Third Generation Science Center

Typical science center activities involve the already interested*--

they become more interested and more involved, but

the disinterested generally walk on by.

*So why waste time talking to -- and trying to educate the 'choir'-- we need to get to the (initially) disinterested, uninvolved, apathetic, uneducated --

But HOW to reach them?

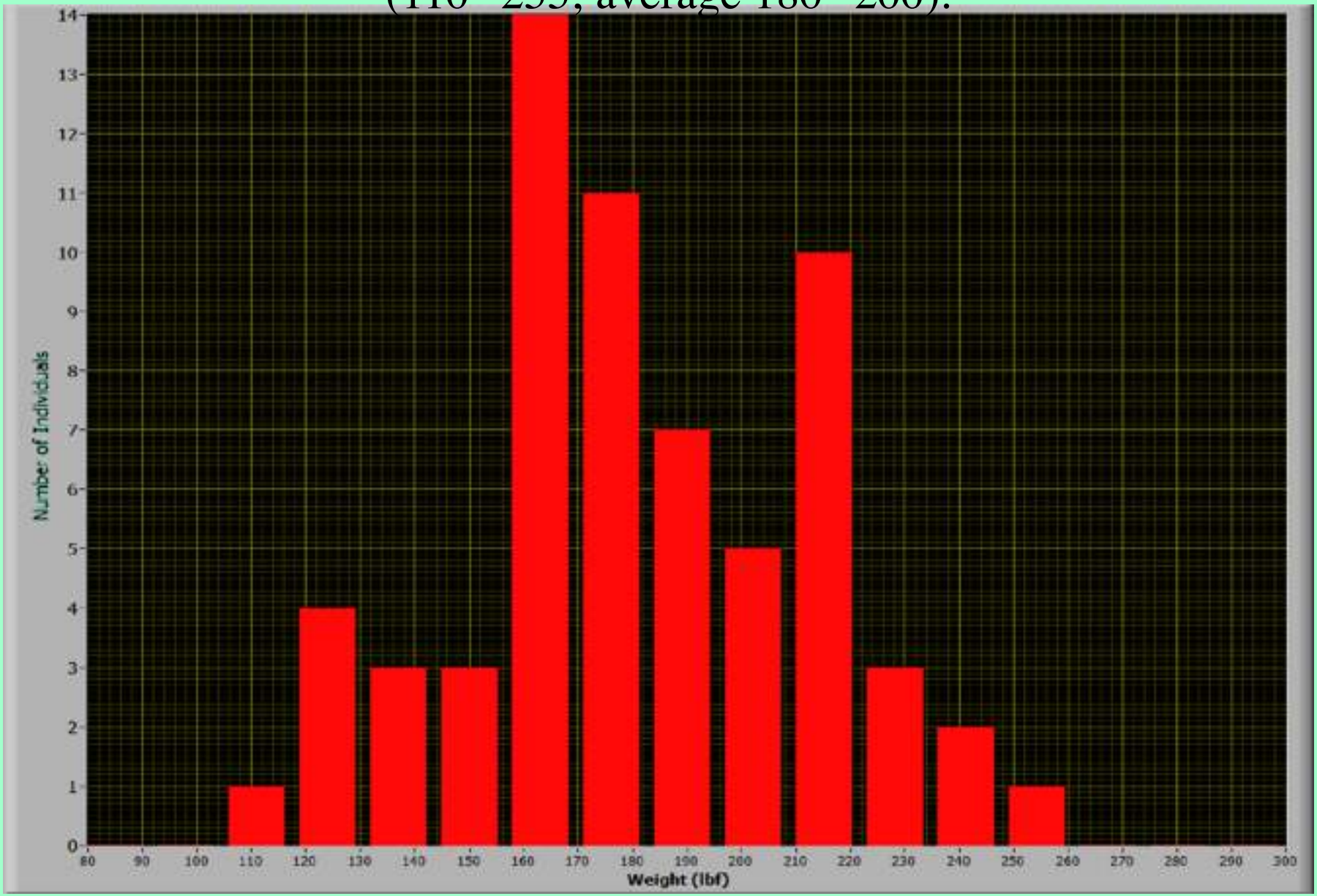
Involve them--personally and directly:

Downtown Salt Lake City, prior to a Breakfast Buffet:

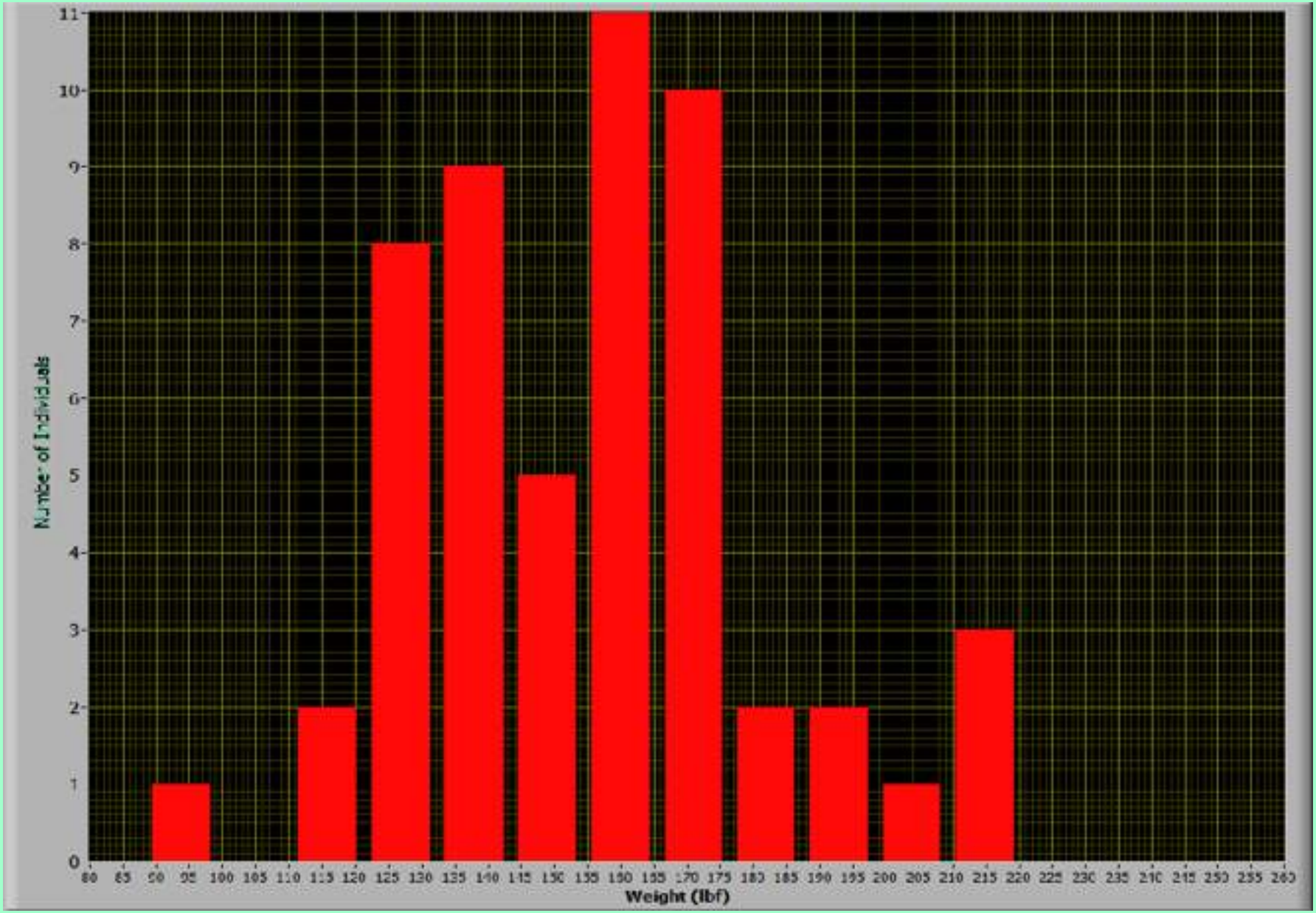
Note the histogram--
number of individuals (vertical) vs
their weights (horizontal)--
Important to numeracy, statistics, risk,…
YOU are the data @ Utah Science Center

Thanks to Chad Brokopp, Daniel Bartholomeusz, and Jeremy Abernathy,
U of U Bioengineering Students

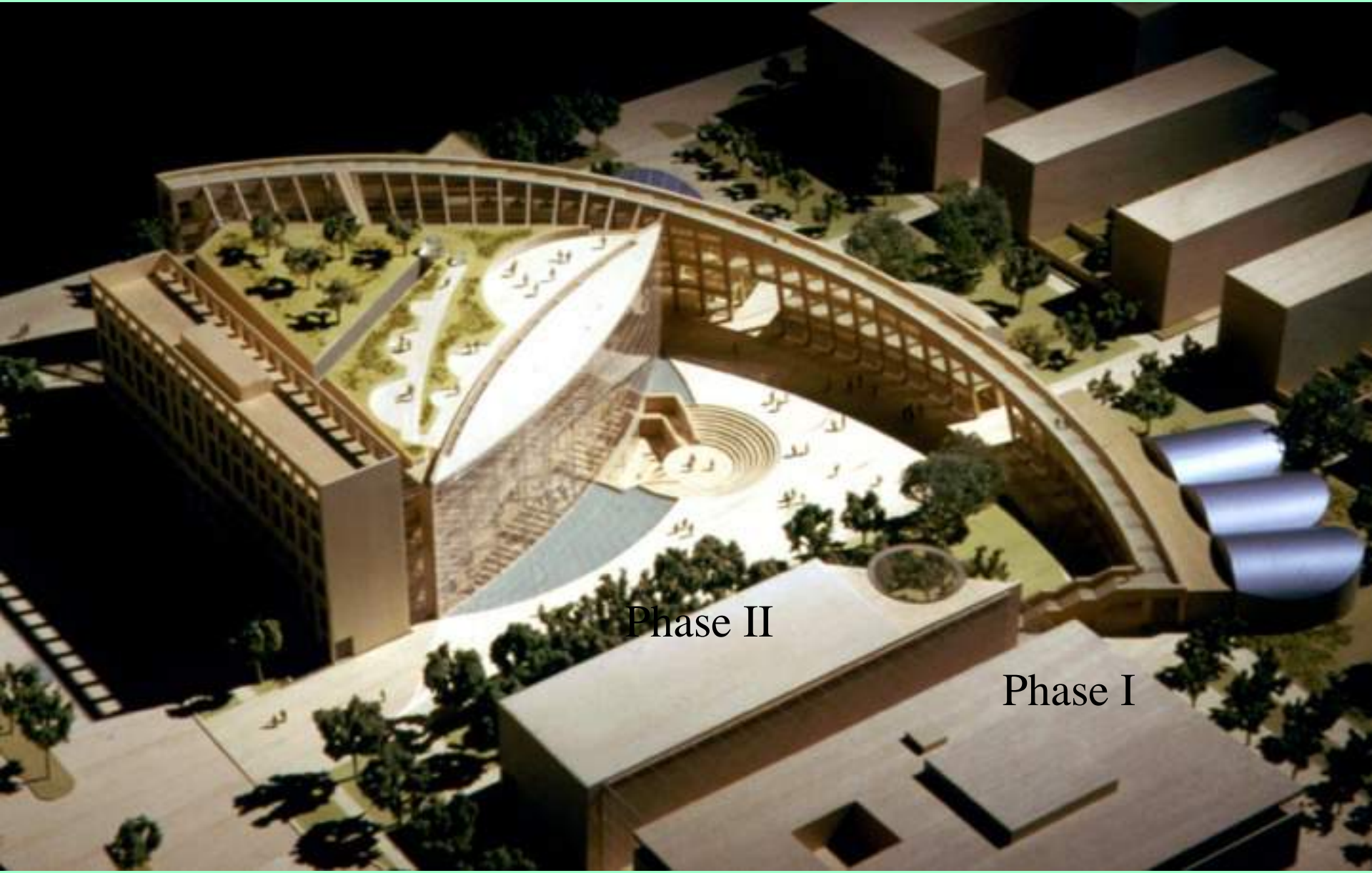
Salt Lake Businessmen and Scientists approaching a Breakfast Buffet (110--255; average 180--200):

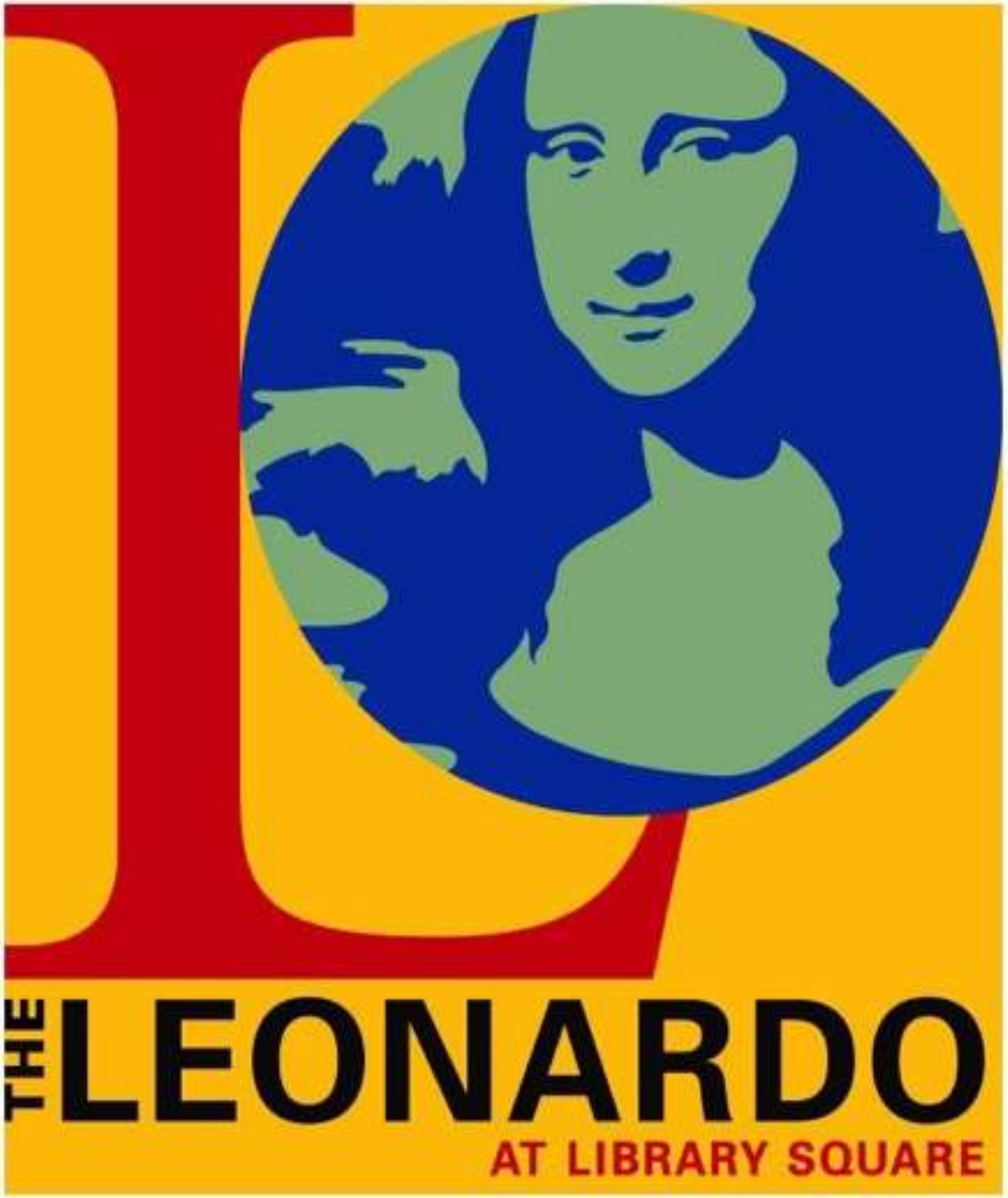


Joe's Freshman Bioeng Class (90--215; Average 155); 35 lbs lighter!



Salt Lake City is now developing a Science Center in an existing building (Phase I, bottom right) to be known as TheLeonardo:





Mission:

The Leonardo at Library Square celebrates the spirit of wonder and humanity that guided the Renaissance master Leonardo da Vinci and that inspires our own exploration of the world. The Leonardo is committed to connecting and revealing the worlds of Art, Science, and Culture to enrich our lives, expand our consciousness, and enhance our community.

utah science center

Mission and Objectives:

"...to enhance each visitor's imagination, motivation, education, and citizenship, and

to foster creativity, critical and objective thinking, and problem solving skills,

using highly interactive exhibits and experiences drawn from the sciences and engineering.

Our audience is adults, and children and youth who prefer to be treated as adults."

utah science center

Integrating, interconnecting themes*

- **YOU!--** your uniqueness: genealogy, genetics, traits, talents, ambitions, physiology, health, problems, dreams, creativity
- **ENERGY--**fusion, the Sun, photosynthesis, electricity, magnetism, nuclear fission, respiration, fossil fuels, alternative sources, bioenergetics, diabetes, obesity
- **Your Planetary HOME--**Planet, climate, atmosphere, biosphere, resources, biodiversity

*For adults--and for kids who want to be treated as adults

Exhibit/Activity Philosophy

- Personal discoveries, ‘Eureka!’ moments, scientific and technological revelations
- Various levels of involvement and interaction:
  - Beginner
    Experienced
    Near Expert

  to encourage repeat visits and more intensive involvement (science projects,contests, ‘camps’, short courses, etc.) and to
  earn access to special activities,
  to the ‘inner sanctums’…
- Personalize everything...

A personalized photo-mosaic

from the Columbus, Ohio Museum of Science, COSI

Where are YOU?!

from the Columbus, Ohio Museum of Science, COSI

YOU-Based Exhibit/Activity Clusters

- The Training Place--power the building!!
- VERY Private Chemistry--toilet chemistry!
- The Body Electric--body surface electricity
- Acoustic Aberrations--where did the music go?
- Why am I there?--scaling, risk, luck
- Where's my Train?--Transit Center
- Why can't I?--Homework and SmartCards
- Who am I?--Genealogy and Genetics
- Don't tell me!--obesity, diabetes, osteoporosis, ..

all with an emphasis on numeracy and statistics.

The Body Electric--body surface electricity*

You are an electricity generating machine, with auras and voltages on your body surfaces.

Put on the electrode gloves – they pick up your ECG signals and transmit them to a nearby computer.

The computer uses the signals to produce an image projected on the wall behind you-- a computer visualization of your own ECG. See it pulse? Expand and contract?

Change your ECG signals (by holding your breath, or doing 10 fast knee bends)—the projected image “responds”.

Get a little creative! Make that image change by doing more exercise, even dance.

The computer can also use your ECG signals to generate sound-- ‘music’ you are “composing” with your own ECG. A new way to communicate?

*ECG, EEG, EMG, GSR, etc.

EEG

EMG

Activity Examples-- VERY Private Chemistry:

We must not artificially separate the real world from
the science centre ‘world’:
so, drinking fountains, toilets, urinals will all
be instrumented--they are real world laboratories.

Five different drinking fountains:

de-ionized ‘soft’ water;
local ‘hard’ drinking water;
water with moderately high arsenic (common in Utah!);
bottled ‘spring’ water;
salt water (physiologic, 1/3 that of oceans).

Taste, measure, feel the waters...

Activity Examples-- VERY Private Chemistry:

Toilet Chemistry:

We measure

urine pH and color

urine glucose

(1 in 100 visitors is either a diabetic or a likely future diabetic -- this is the growing diabetes ‘epidemic’).

Our objective is NOT diagnosis but awareness and education (each flush will output the amount of water used!).

Energy and YOU

- What IS Energy? as defined by Richard Feynman
- Good News--Energy is “Conserved” (1st Law)
- Bad News--Energy is “Lost” (2nd Law)
  - Inefficiency, Entropy
- Our Energy Hierarchies:
  - Sun--fusion--”Solar”
  - Gravitational (Hydroelectric)
  - Photosynthesis--Biomass, Fossil Fuels, Bio-Hydrogen
  - Fission, Fusion?
  - Chemical (You! Respiration, Calories)

Energy -- IS the Utah Science Center

- **Energy** is the most basic concept in Science and Engineering.
- It is the basis of all physics, all chemistry, all biology -- fundamental.
- Richard Feynman, one of the greatest physicists of the 20th century, says that if a single word could define the domain of physics, it is **Energy**.
- What single word most defines biology? Most biologists would say: **Energy**.

Energy and YOU!

Basic Sedentary Living (right now!)--

About 1.2 Cal/min (1 Cal=1000 cal)

Minimal Activity

About 2.6 Cal/min

Walking, Physical Work

About 4 Cal/min

Bicycling, Dancing, Fast Walk,…

About 5 Cal/min

Conservation of Energy!….Let's Move!

(Really--everyone get up and fidget, please!)

Infrared Camera

Energy and YOU!

The Utah Science Center "Diet":

Don't Diet---DO!!

move, fidget, stand

A key to attention deficit disorder (ADD) is curing

motion deficit disorder (MDD);

the "disorder" is NOT moving

Conservation Laws

What goes in, stays in (90% of it)

If you don't burn the mass, it stays as MASS

Conservation of Mass and Energy!….Keep Moving!

THE LEONARDO™
AT LIBRARY SQUARE

Main Level

Second Level

Energy and YOU!

Cafeteria: Chips to Calorimeter---> Measure Energy Content

Go to exercise bike--Work it off!!

Exercise bike rotates electrical generator; electricity generated powers building--how much is being generated?

from Calories to Watts to Kilowatt--seconds

Efficiency, Quantity, Costs,…

100 watts for 10 hours =1 kiloWatt-hour = $0.10 in Utah!)

Power the Building?

Tie it all together--don't look at Energy as disconnected, isolated examples! Every switch, light, motor, etc. will 'tell' its energy consumption and inefficiency. There is no escape from the first and second laws of thermo!

Energy -- IS the Utah Science Center: the Hydrogen Connection

- You will generate hydrogen, combust hydrogen, and use hydrogen -- via fuel cells-- to directly generate electricity (Geoffrey Ballard's 'Hydricity' vision)..
- We will experience the beginning of the hydrogen economy, minimizing the production of carbon dioxide, the greenhouse effect, and the escalation of global warming.

Hydrogen and Energy Generation

Hydrogen + Oxygen =

Water + Lots of heat

No CO2 -- No Greenhouse Effect

Hydrogen + Oxygen =

Electricity + Water

Fuel Cells

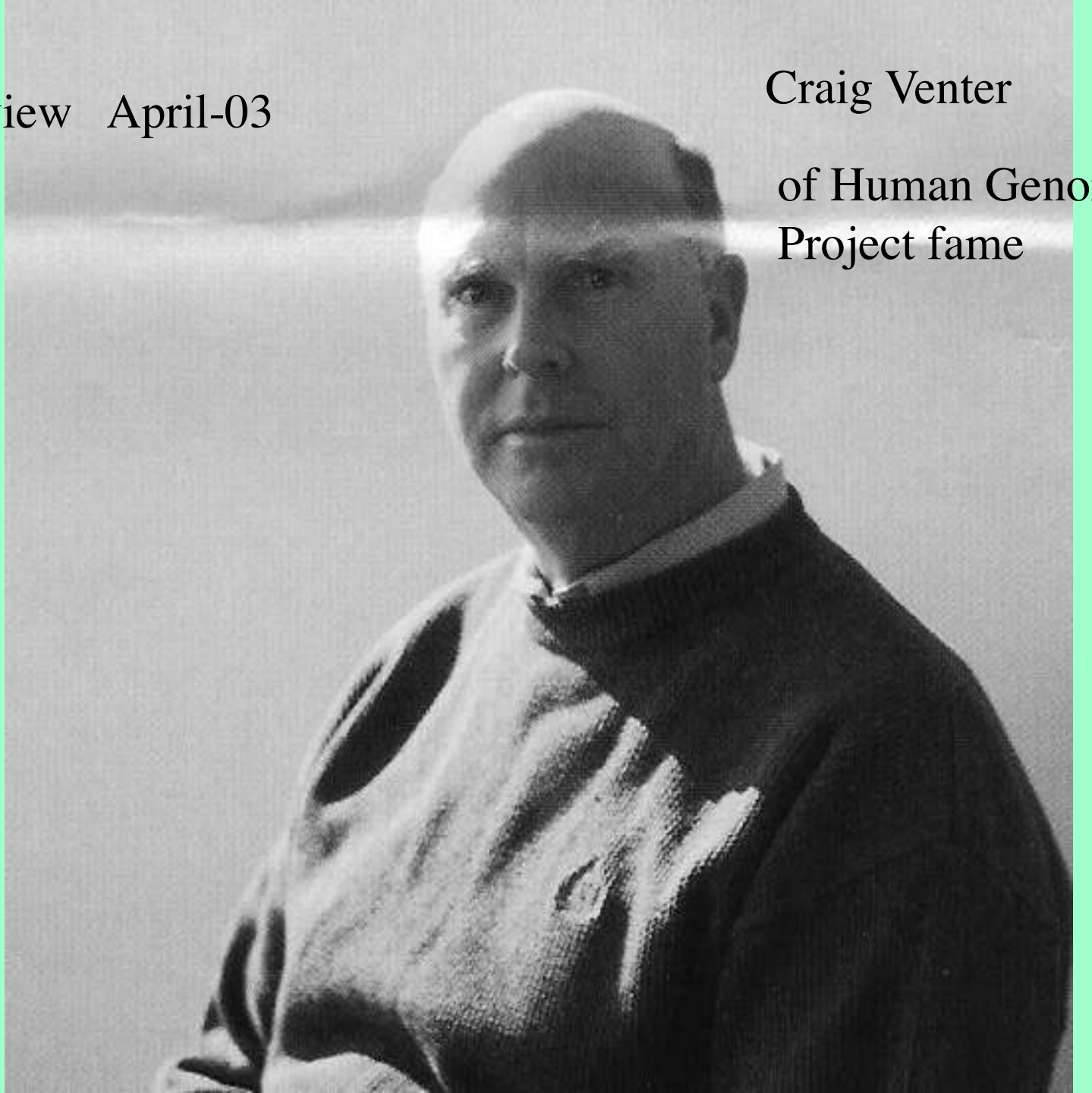
No CO2--No Greenhouse Effect

Problem: Where to get the Hydrogen??

Tech Review April-03

Craig Venter

of Human Genome Project fame



C Venter:
Institute for Biological Energy Alternatives (IBEA)

"As far as I know, there is no existing organism that can either capture carbon dioxide or produce hydrogen efficiently enough with its existing metabolism to make it economically feasible."…

BUT…

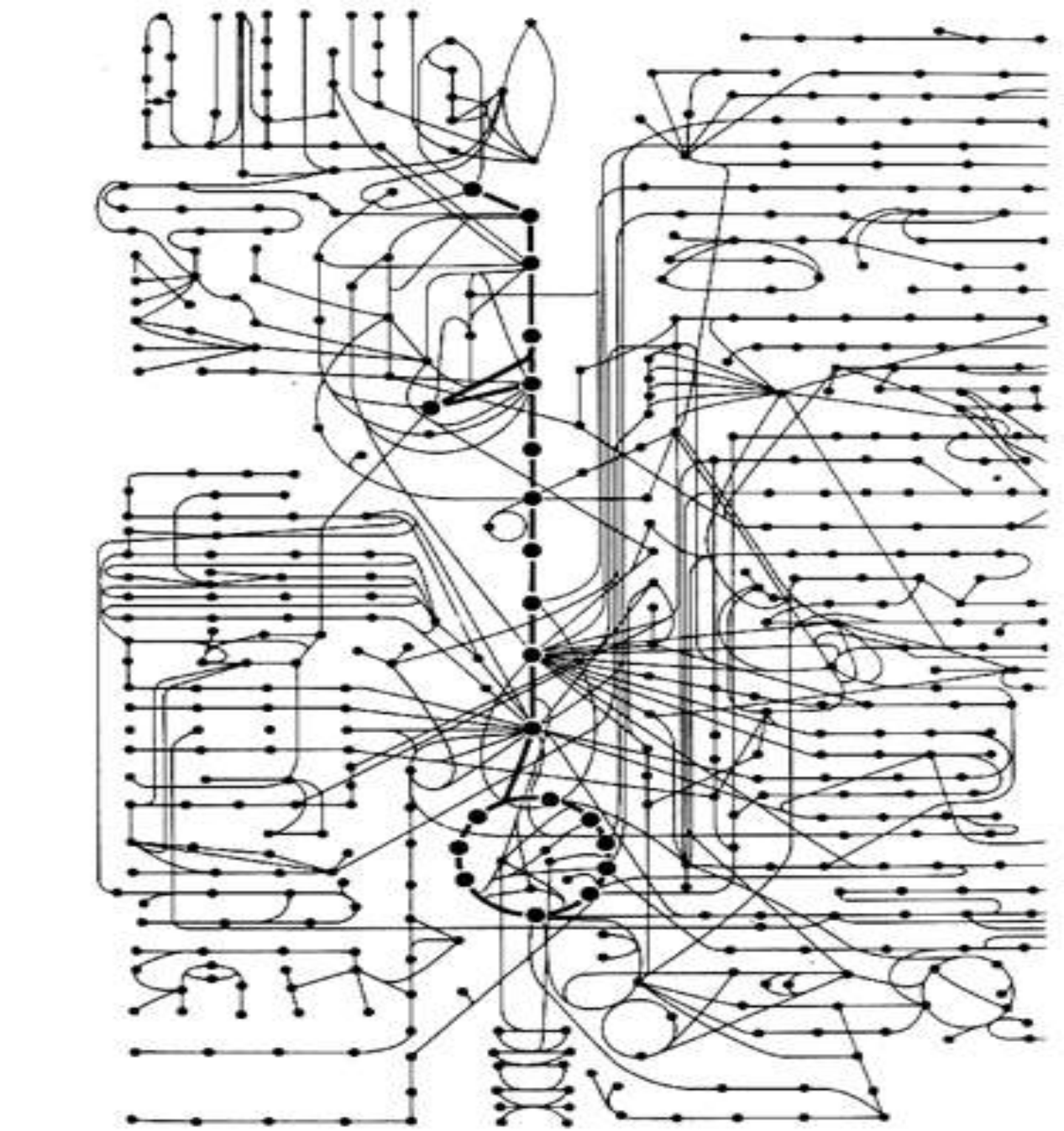


Figure 8.1 Representation of intermediate metabolism. Points correspond to metabo chemical transformations. (From Alberts, Bray, et al. 1983)

The tip of the biochemical iceberg -- see chart

An Energy Demonstration and Education Building-- Phase II

From Bugs to Hydrogen…Bio-Hydrogen
(Venter's Inst. for Biological Energy Alternatives)

From Hydrogen to Heat…Burn Hydrogen

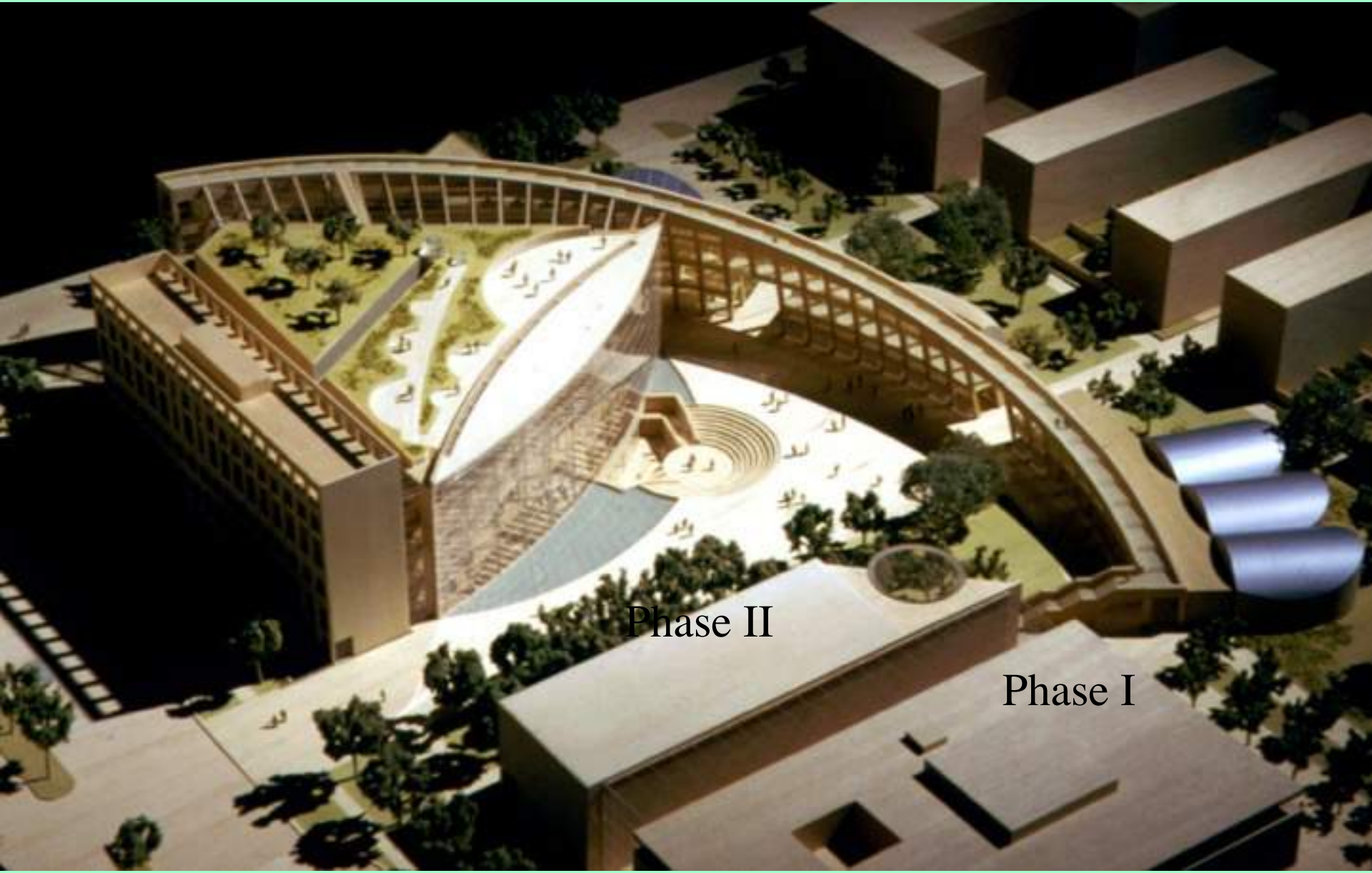
From Hydrogen to Electricity….Fuel Cells (Ballard and others)

From Solar to Electricity…PhotoVoltaic Cells (BP Solar, others)

From Ground to Energy….Geotechnical Heat Pumps

Salt Lake City is now developing a Science Center in an existing building--Phase I.

Phase II (bottom, center) will be a sustainable energy demonstration facility.



Health/Medicine

- Goal--Health Education and Awareness
  - Responsible, informed, concerned citizens
  - Self-inflicted ‘Epidemics’
    - Obesity--Diabetes…(too many Calories, not enough WORK)
    - Osteoporosis..(too little milk/Calcium, not enough movement)
    - Drugs and Livers…(too much drugs -- legal as well as illegal--read the very fine print!)

Conservation of mass and energy apply to YOU!!!

The Spread of the Obesity Epidemic in the United States, 1991-1998

Ali H. Mokdad, PhD
Mary K. Serdula, MD, MPH
William H. Dietz, MD, PhD
Barbara A. Bowman, PhD
James S. Marks, MD, MPH
Jeffrey P. Koplan, MD, MPH

Context The increasing prevalence of obesity is a major public health concern, since obesity is associated with several chronic diseases.

Objective To monitor trends in state-specific data and to examine changes in the prevalence of obesity among adults.

Design Cross-sectional random-digit telephone survey (Behavioral Risk Factor Surveillance System) of noninstitutionalized adults aged 18 years or older conducted by the Centers for Disease Control and Prevention and state health departments from 1991 to 1998.

Setting States that participated in the Behavioral Risk Factor Surveillance System.

Main Outcome Measures Body mass index calculated from self-reported weight and height.

Results The prevalence of obesity (defined as a body mass index ≥30 kg/m^2) increased from 12.0% in 1991 to 17.9% in 1998. A steady increase was observed in all states; in both sexes; across age groups, races, educational levels; and occurred regardless of smoking status. The greatest magnitude of increase was found in the following groups: 18- to 29-year-olds (7.1% to 12.1%), those with some college education (10.6% to 17.8%), and those of Hispanic ethnicity (11.6% to 20.8%). The magnitude of the increased prevalence varied by region (ranging from 31.9% for mid Atlantic to 67.2% for South Atlantic, the area with the greatest increases) and by state (ranging from 11.3% for Delaware to 101.8% for Georgia, the state with the greatest increases).

Conclusions Obesity continues to increase rapidly in the United States. To alter this trend, strategies and programs for weight maintenance as well as weight reduction must become a higher public health priority.

JAMA. 1999;282:1519-1522 www.jama.com

ALTHOUGH ATTEMPTS TO LOSE weight are common in the United States,[1,2] the prevalence of obesity has increased since the 1980s.[3,4] Such increases will tremendously affect public health since obesity is strongly associated with several chronic diseases, such as cardiovascular diseases and diabetes.[5,6] Recent estimates suggest that obesity-related morbidity may account for 6.8% of US health care costs.[7]

Recently published trend data from the National Health and Nutrition Examination Surveys (NHANES) show the percentage of obese persons has increased from 14.5% in the years 1976

Diabetes Screening with Professional Nurse

Health/Medicine

- Goal--Health Education and Awareness
  - Responsible, informed, concerned citizens
  - Self-inflicted ‘Epidemics’
    - Obesity--Diabetes…(too many Calories, not enough WORK)
    - Osteoporosis..(too little milk/Calcium, not enough movement)
    - Drugs and Livers…(too much drugs -- legal as well as illegal--read the very fine print!)

The Utah Science Center @ Library Square in Salt Lake City:

- Opens in late-2004;
- Will be the most bioengineering -- intensive (measurements on YOU!) science centre ever attempted;
- Will emphasize personalized activities and data;
- Will emphasize ENERGY as an integrated, inclusive subject; and
- Looks forward to welcoming You!

Major Cities with Science Centers and Bioengineering Programs

YOUR Ideas and Help???

- Really Basic and Important Concepts?
- How to develop Eureka! Experiences?
- Send ideas and comments to joeandrade@uofu.net
- Thanks to YOU and to Prof Karin Caldwell!


TRUCTIONS