

Atoms and Stars IST 2420 and IST 1990

Class #12: November 28 and 30

Fall 2005 sections 001, 005, 010 and 981

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Course web site: www.is.wayne.edu/drbowen/aasf05

Moodle: techtools.culma.wayne.edu/moodle

Tonight...

- Pick up
 - Notes for Class 12
 - Corrected Experiment 13 for next week
 - “Where Is” for Final Exam
- Initial the attendance sheet
- Report due for Lab 7 (Specific Gravity)
- “Grade What-If” on course web site
 - Save to a disk or diskette to keep your results
 - In-class demonstration during Class 13
 - Brief “tour” now

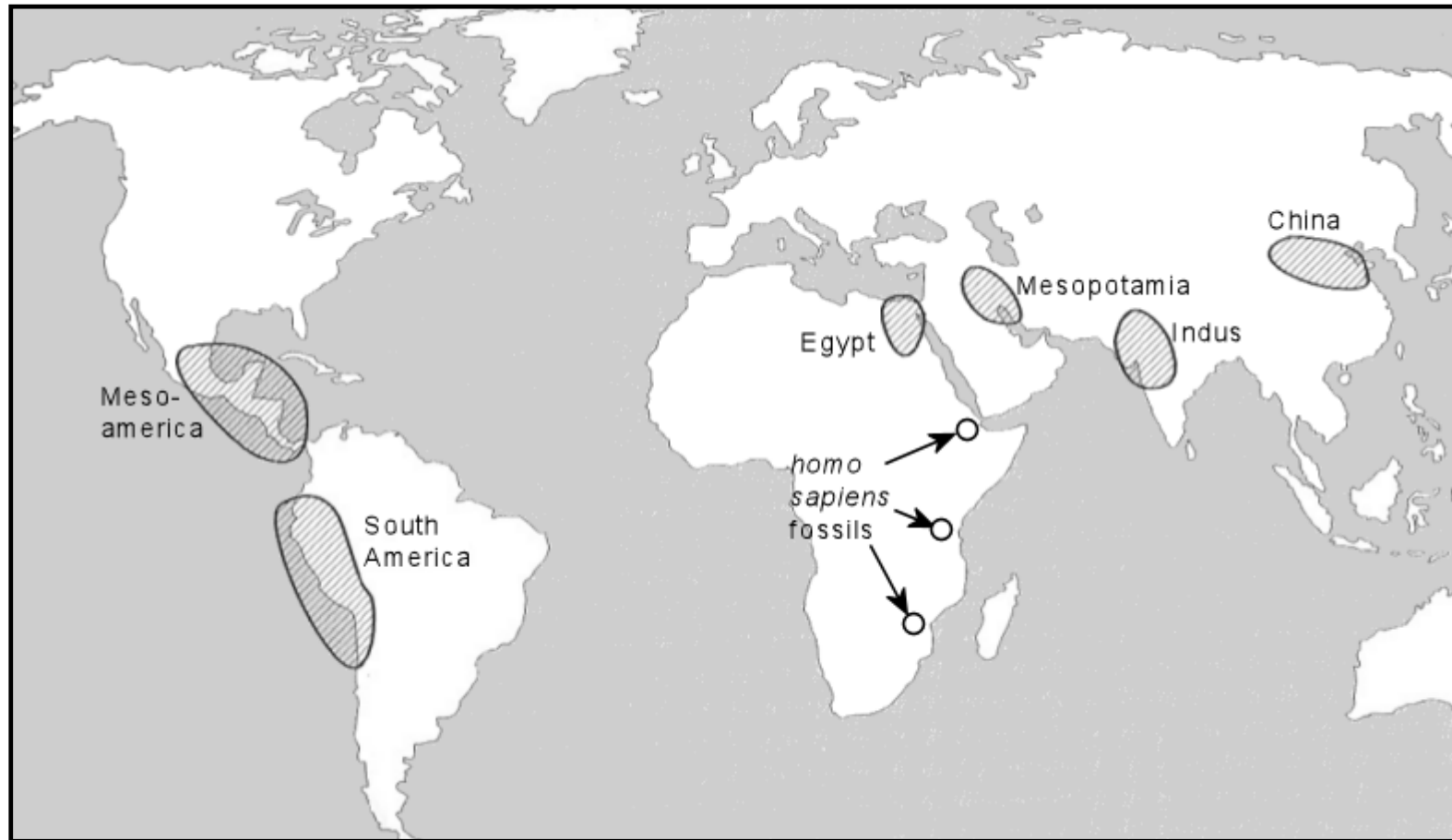
Before the Greeks...

- McClellan and Dorn, Science and Technology in World History
- (Class 10: Jared Diamond, Guns, Germs and Steel)
- Earliest human-like animals (humanoids) evolved in southern Africa about 5 million years ago
 - Several humanoid species and expansions
- *Homo sapiens* (modern humans) evolved there
 - 100k to 400k years ago
 - Little genetic change since then
 - Expansions north, then East and West to Europe and Asia
 - Signs of early astronomy – phases of the moon
 - Likely “animate” or polytheistic view of nature

Before the Greeks (cont'd)...

- Science developed with agriculture, large cities, complex and specialized societies
 - Areas shown on next slide (Diamond's thesis)
 - “Hydraulic civilizations” – irrigation or drainage
 - Large (monumental) building projects, e.g. pyramids (Egypt), canals
 - Highly efficient food production allowed cities
 - Strong central governments
 - American ones “incomplete” – no cattle, wheel, plow or (later) metal tools (but had metal jewelry)

Before the Greeks (cont'd)...



Before the Greeks (cont'd)...

- Some areas (Egypt) one nation, others (Mesopotamia) several (Sumer, Babylonia)
- Each lasted 1 – 2 thousand years
- Each developed empirical science (no theories) in math, astronomy, geometry, medicine, but with different strengths
 - E.g place-value numbers in Sumeria but not Egypt. Egypt had geometry for Nile flooding.
- Scientific theory arose with Greeks

Before the Greeks (cont'd)...

- Diamond's thesis:
 - East-west orientation of Europe, Middle East and Asia meant agriculture could be shared
 - Cites evidence that these developments are rare
 - Links formed early, continued for technology and immunity to diseases
 - Guns, germs and steel (technology) were what the West used to conquer other civilizations
 - Cites evidence that 90% of American Indians died from disease before being conquered by weapons

Why Europe?

- Why did modern science arise in Europe?
- One idea – two influences came together
 - Theoretical movement from the Church drive for clear doctrines (often said to be characteristic of Western Christianity)
 - Reliable commercial procedures, documented, for faster commercial production and training, driven by trade – apprenticeship too slow
- The two pillars of science – experiment and theory

Axiomatic Evolution

- Campus class asked how Evolution happens
 1. All species produce more offspring than can survive (some human societies self-limit)
 2. There are characteristics that improve an individual's ability to leave fertile offspring
 3. Many of these characteristics are heritable through genes
- ∴ Genes that lead to more (fertile) offspring will increase from one generation to the next
- That's Evolution – if 1, 2 & 3 are correct, Evolution happens

Status of Newton's Laws

- Are scientific theories reliable? Many hedges in this course, for example:
 - Scientific knowledge is provisional
 - Experiments do not prove theories
 - One experiment can overturn a theory
 - Science has a limited scope – a boundary
 - Science is not an adequate basis for living
 - Scientists often do not follow scientific method
- Maybe only foolish people use science? Not!

Status of Newton's Laws

- Range of authority for Newton's Laws:
 - Objects moving slower than about three million miles per hour
 - Objects weighing more than about 0.000,000,000,000,000,000,01 pounds (19 zeroes)
 - Objects weighing less than about (31 zeroes) 40,000,000,000,000,000,000,000,000,000,000 lb
- Within this range of authority, Newton's Laws are extremely reliable and precise

Status of Newton's Laws

- Newton's Laws have passed stringent tests
 - Predicting mass and orbit of Neptune from its effect on the orbit of Uranus
 - Control of spacecraft
 - Use in design and control of countless machines
- For very small masses (molecular), Quantum Mechanics is needed instead
- For very fast objects, Special Relativity
- For very massive objects, General Relativity

Readings - Chemistry

- Chemistry developed after Newton (physics)
 - Alchemy – transmutation of elements
 - Medicine
 - Industry – much demand for chemicals 1700s
 - Mechanical approach from Descartes & Newton
- 1700 still Aristotelian elements
 - Earth – fixed volume & shape
 - Water – fixed volume only

Chemistry

- 1700 still Aristotelian elements
 - Air – volume & shape expanded to container
 - Fire passed through container walls
- 1727 – Stephen Hale: released “fixed” air (put out flames) from solids, much interest
- 1749 Jean-Jacques DeMairan evaporated liquids (e.g. ether) in a vacuum, froze water
 - But liquids supposed to evaporate into air
 - Fire combined with liquid = air? Many types?
 - Water could be solid, liquid, vapor –differ by fire?

Chemistry

- How could “big four” be elements?
- 1750s Joseph Black experiments with “magnesia alba,” gave off “fixed air” that extinguished flame (CO_2), denser than “common air,” turned limewater cloudy
 - Use limewater test to show fixed air came from fermentation & charcoal combustion, would not support life
 - “Fixed air” became specific name for this gas (CO_2)

Chemistry

- 1766 Henry Cavendish: “inflammable air” H
- 1772 Joseph Priestley obtained “fixed air” in other ways, demonstrated solubility in water (& taste – birth of carbonated beverage industry)
 - Many other types of air – “dephlogisticated air” O
 - Phlogiston theory of combustion – burning releases phlogiston – from Germany, industrially useful
 - When air is saturated with phlogiston, combustion and life cease

Chemistry

- Antoine Lavoisier (1743 – 1794)
 - Graduated in law but continued science studies
 - Accurate weighing, also many practical results
 - (Calcination – turn a metal to powder (“calx”) by heating in air below melting point – phlogiston theory explained this as driving off phlogiston)
 - But Lavoisier’s weighing showed that weight of calx increased, for all metals – a problem for phlogiston theory of combustion

Chemistry

- Calx of mercury (oxide of mercury) when heated gave off air (gas) that supported combustion and life
 - Priestley found this air better (5×) for combustion and life than “common air” (air) – “eminently respirable air”
 - Lavoisier had assumed it was common air
 - Lavoisier confirmed this, but common air was then a mixture

Chemistry

- 1778 Lavoisier showed this air also formed acids, named it oxygen (“acid former”) (but we now know that hydrogen makes acid)
- 1783 Cavendish’s assistant told Lavoisier about Cavendish’s experiment of applying spark to inflammable air (H), finding dew which was identified as water
 - Lavoisier – water was not an element, combination with oxygen for all combustion

Chemistry

- Lavoisier named flammable air “hydrogen” for “water former”
- Lavoisier and others formed new chemical terminology – speaking well was like reasoning well
 - Oxide – combination with oxygen
 - Names indicated amount of oxygen (ous > ic)
 - Sulfurous acid H_2SO_3
 - Sulfuric acid H_2SO_4

Chemistry

- Lavoisier terminology
 - Gas – any vapor
 - Air – the atmosphere, a mixture (80% N, 20% O)
 - Fire was *caloric* (no correct theory until 19th century – started by Count Rumford)
- John Dalton (1766 – 1844), meteorologist
 - Converted to chemistry when he understood air was a mixture – why didn't different gases separate by gravity?

Chemistry

- John Dalton (1766 – 1844), meteorologist
 - Also gases dissolved in water proportional to pressure – why?
 - Hypothesized gases composed of atoms, each gas interacted with itself
 - “Law of definite proportions” – chemicals combined by weight in simple ratios
 - Dalton proposed formulae based on these – *chemical atomism*

Readings – Big Bang

Emails on Big Bang

- #1 from George Gale (1999)
 - Kansas school board rejected Big Bang and radioactive dating along with evolution
 - “Young earth creationists” – 6,000 years for age of earth Vs 4.5 billion years from radioactive dating

Evidence for Big Bang

- #2, Neil De Grasse Tyson
 - “Theories” instead of “Laws” – humble now
 - 1929 Edwin Hubble, galaxies receding, further galaxies receding faster
 - Gravitational lenses – focused object receding faster than focusing object (further away)
 - “Time dilation” from Einstein’s Special Theory of Relativity – time slows down if motion faster

Evidence for Big Bang

- “Time dilation” from Einstein’s Special Theory of Relativity – time slows down if motion faster
 - Distant supernovae do explode and age more slowly compared to near ones (Big Bang says moving faster)
- Cosmic Microwave Background predicted , discovered 1965
 - A peak location and spectrum (shape of intensity Vs wavelength) that matches measurements
 - Has a distant source – we see it heated when passes through matter

Evidence for Big Bang

- Cosmic Microwave Background predicted , discovered 1965 (cont'd)
 - Molecular “thermometers” show background radiation hotter from distant (older) galaxies
- Also consistent with mix of atomic species
 - Consistent with accelerator laboratory experiments
- But background radiation too uniform
 - “Inflationary universe” explains this, and more
 - (DB: some non-uniformity observed this year)

Evidence for Big Bang

- But required mass is missing
 - (DB: dark matter is being discovered)
- #3: Gregg Esterbrook
 - Modern science chance-based, seems not to require God, also death of the universe
 - 1999 conference at Berkeley CA
 - Astronomer Allan Sandage: majesty of Big Bang helped make him a believer
 - Ian Barbour: physical law seems to favor life (Anthropic Principle)

Evidence for Big Bang

- #3: Gregg Esterbrook (cont'd)
 - Consilience by E.O. Wilson: can reconcile technical and spiritual, along with other books
 - Creation “ex nihilo” consistent with latest Big Bang theories
 - Parallel between God creating existence from “waters” with H being most abundant element
 - “Existence may be ... prewired ... for life”
 - If we came late, still may be early in time span of universe

Evidence for Big Bang

- #4: Thomas Diana
 - More and more can be explained with action of God
 - Ancients had gods, each with own area
 - Geocentric theory – we were at center of universe
 - Now we are displaced from central position
 - Quantum Mechanics lets Big Bang be created from empty space (quantum fluctuations)

Evidence for Big Bang

- #4: Thomas Diana (cont'd)
 - At one point, science said life impossible without extraordinary coincidences in physical constants (Anthropic Principle)
 - Now inflationary theory of universe makes this less necessary
 - How to retain belief?
 - Not a belief in anthropomorphic God, but one that transcends as science transcends the ordinary
 - Scientific mastery of universe results in separation

Evidence for Big Bang

- #4: Thomas Diana (cont'd)
 - How to retain belief?
 - Scientific mastery of universe results in separation
 - Separation has led some to seek immanent God
 - “immanent” (Theology): present throughout the universe, as opposed to transcendent (existing apart from the universe)
 - We can achieve this – experience power greater than ourselves
 - Rituals
 - Gazing at starlit sky – experience not diminished by knowledge

The Big Bang...

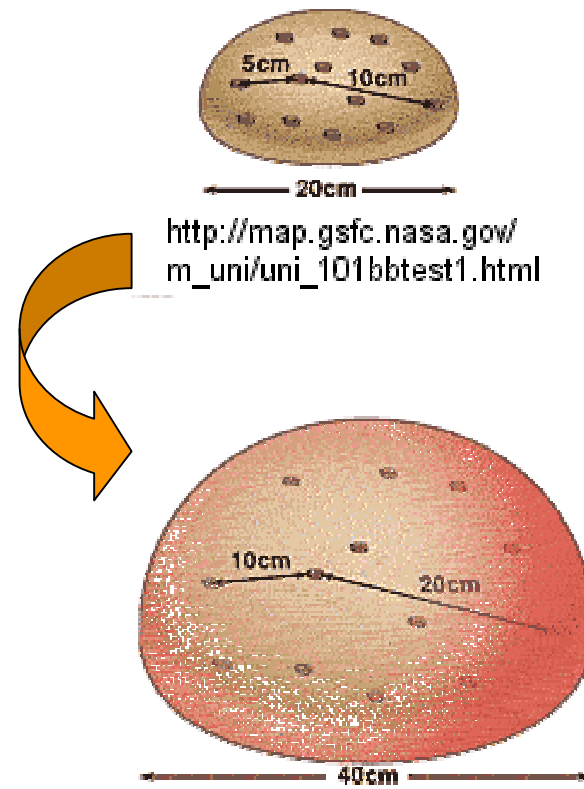
Big Bang, expansion of universe

- 3-D analogy to a rising loaf of raisin bread
 - Expansion with no center (but this bread has edges, unlike the universe)
 - <http://www.is.wayne.edu/drbowen/aasw05/BigBangAnalogies.htm>
- 2-D analogy to the surface of an expanding balloon
 - <http://www.astro.ucla.edu/~wright/Balloon2.html>

The Big Bang...

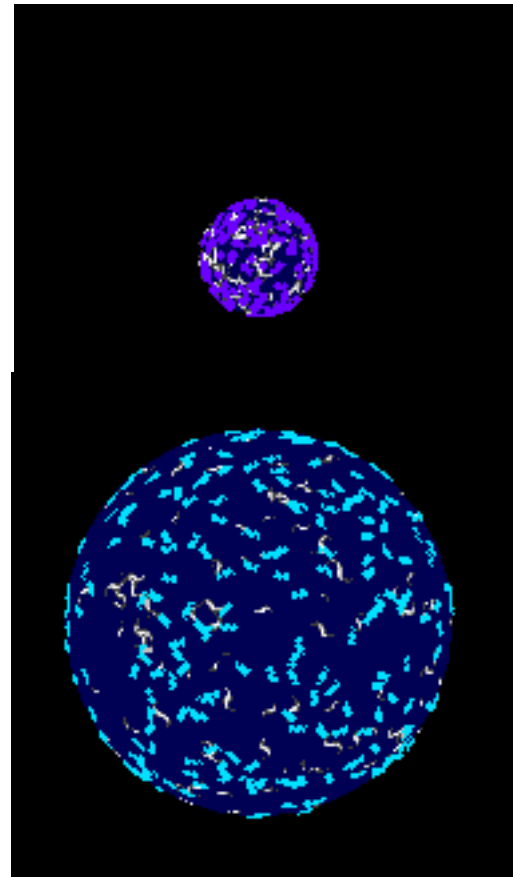
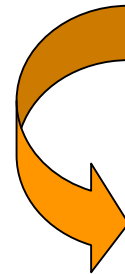
Big Bang, expansion of universe

- 3-D *analogy* to a rising loaf of raisin bread
 - Expansion with no center (but this bread has edges, unlike the universe)



The Big Bang...

- 2-D *analogy* to the surface of an expanding balloon
 - No edge but cannot go off the balloon surface

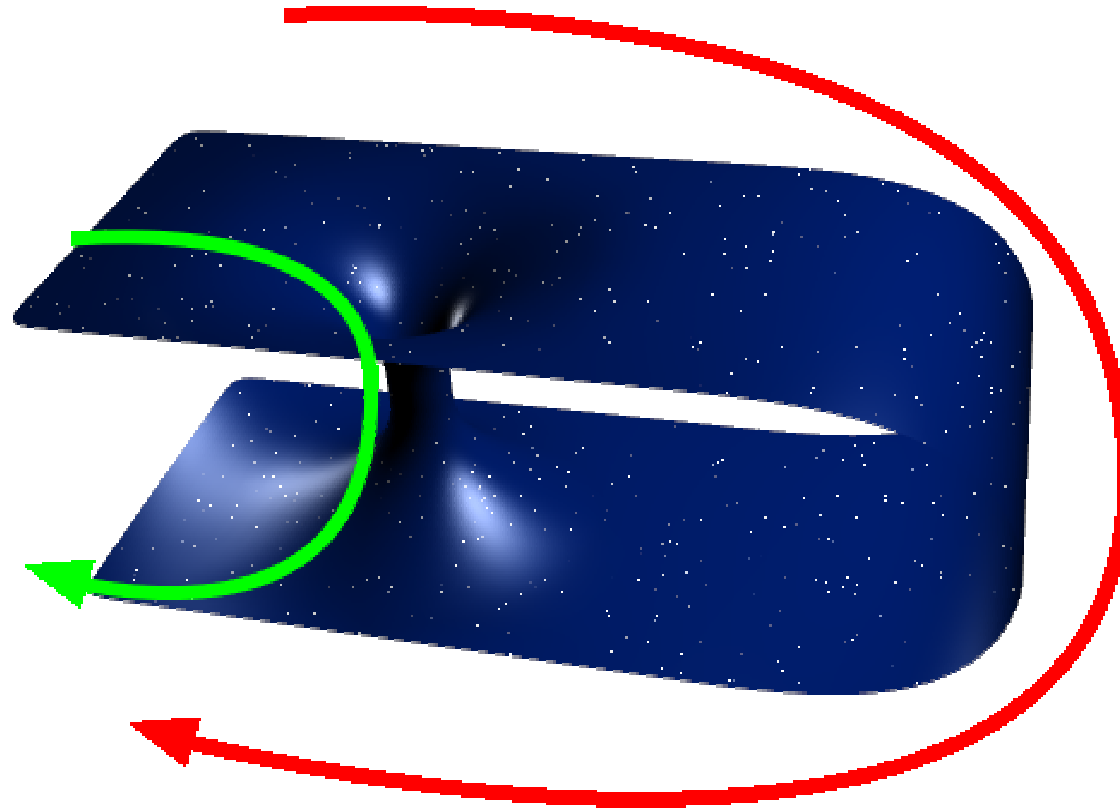


Brain Candy...

Wormhole

- A theoretical possibility within Einstein's General Theory of Relativity (1916)
 - A shortcut through 4-D space-time that could dramatically speed travel between points connected by the wormhole, and into the future
 - Requires an undiscovered form of exotic matter with negative energy density – a “white hole,” contrasts with a black hole
 - Wormhole could collapse on the traveler
- <http://en.wikipedia.org/wiki/Wormhole>

Wormhole



From Wikipedia (see link on previous slide)

Expanding Circles

Review:

- Greek and later science developed isolated areas of knowledge
 - Air and water pressure
 - Speed of light
 - Falling and sliding objects
 - Motions of the planets and stars
- Areas expanded and met (Newton, Maxwell)
 - Improved each area, plus a bonus

Expanding Circles

New (third) example: Statistical Mechanics

- Ludwig Boltzmann, end of 19th century
 - Physicists had never accepted idea of atoms
 - Boltzmann (Austrian physicist) one of first
 - Worked out Newtonian mechanics for a gas of colliding atoms and molecules - Statistical Mechanics
 - With J. Willard Gibbs – now his own stamp
 - DB: “Atomic Theory meets Isaac Newton”
 - Same results as Thermodynamics (accepted)
 - Also explained how those results came about (explanatory)
- Other physicists still sharply rejected these ideas
 - May have contributed to Boltzmann's 1906 suicide

Expanding Circles

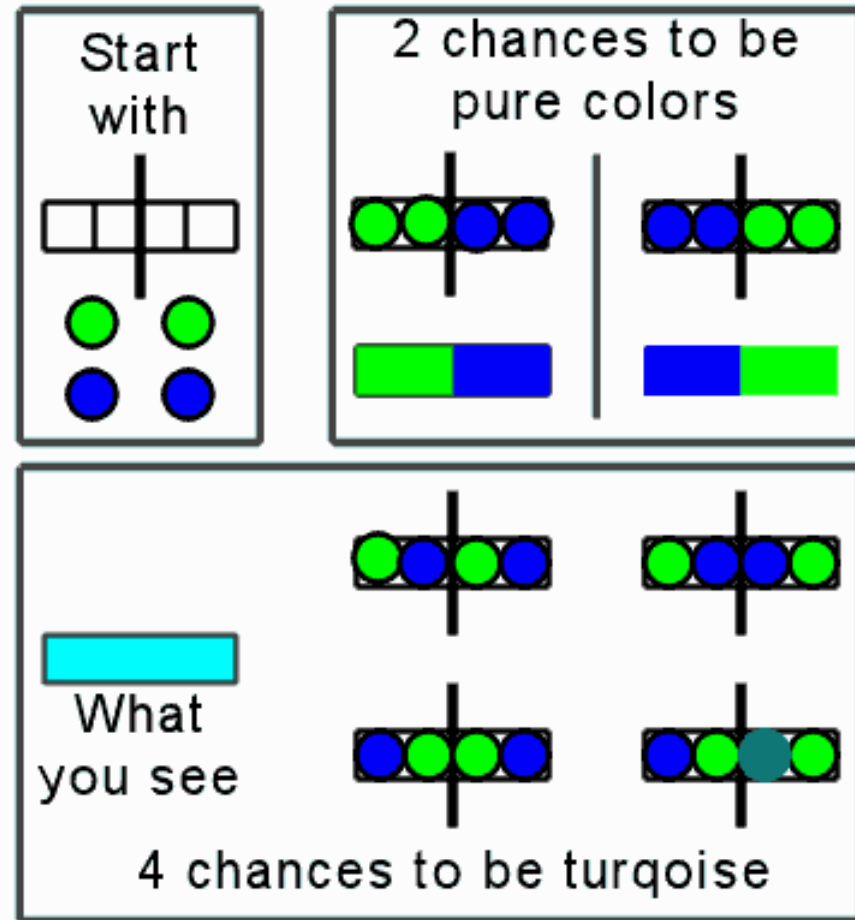
- Now Boltzmann honored as pioneer
 - Statistical Mechanics very important
 - Significantly modified by Quantum Mechanics.
- Second Law of Thermodynamics
 - If a hot object and a cold one are in contact, energy always goes from hot to cold
 - Atoms in hot object more energetic (Rumford), travel more
 - Slowed down by collisions with slower atoms from cold object, but these are sped up
 - Statistical Mechanics explains why this happens
 - Demonstration – diffusion – atoms of dye

A Taste of Statistical Mechanics

- See next slide, but here is the explanation”
 - “Gas” with spaces for 4 atoms
 - Gas divided into left & right halves
 - Two green atoms, two blue
 - In each half, the 4 atoms arrange randomly
 - Atoms too small to see, we see the average color in each half
 - One chance for left being green, right blue
 - Another chance for the opposite
 - 4 chances for mixed – turquoise
- Chances get more lopsided with more atoms

A Taste of Statistical Mechanics

- Start with gas (4 slots) and atoms
- We see average of color in each half
- Most common is mixed
- Odds more lopsided with more atoms



Back to: Expanding Circles

- Expanding Circles
 - When two domains meet, become fused into one with a bonus
- Implications:
 - This is additional evidence for science
 - If theories were imaginary, different imaginations would rule
 - Hard to attack just one area of science, since they are becoming more tightly tied together
 - Creationists finding they have to attack 4.5 billion year age of earth, Big Bang, etc. (readings)

Expanding Circles

- Implications (cont'd):
 - Joined circles expand to fill plane of knowledge
 - In earlier times, science and technology developed independently
 - When there were interactions, technology drove science
 - In 19th century, influence became mutual
 - Contribution of Thermodynamics to steam engine efficiency
 - In 20th century, science began to drive technology. These 20th-century technologies were predicted by science well ahead of time:
 - Atomic / nuclear energy (didn't understand that $E = mc^2$ made this prediction)
 - Laser
 - Computer, transistor, microchip, Internet
 - Radio, TV
 - Jet and rocket engines

Expanding Circles

- Implications (cont'd):
 - Science driving technology (cont'd):
 - Many scientists believe that US lead in science and technology is disappearing
 - Degrees granted
 - Science prizes e.g. Nobel
 - Scientific articles published
 - Patents granted, etc.
 - ... and that this threatens our technology and economy
 - Need a core of people who understand “big picture” for innovation

Doing the Labs

- Many people apparently think that you should work from my class notes on labs
- The primary source is the lab manual, or updates
 - Read beforehand for efficient lab sessions
- My class notes are only comments on lab manual
- Make sure you answer all questions in manual, unless notes specifically say not to

For next class (#13):

- Lab session – Experiment 13 (corrected), Finish 9
- Experiment 10 due
- 2420 Essay 2 due
- Student Evaluation of Teaching
- Moodlers: Postings

Upcoming...

- Class 14 (12/12 & 12/14) Review for Final, Experiment 9 due, 1990 Essay 3 due
- Final Exam: 12/19 & 12/21, Experiment 13

Upcoming...

- Watch for a printout of my records of your grades (probably Week 13 lab session)
 - If there is a difference, I will want to see graded assignment
- IST 1990 Reading: When Science Meets Religion

Reminder...

- If you turn in a lot of work right at the end, I may not get it graded in time for a regular grade. You will get an I, to be changed to a regular grade afterwards.