Handout I
What Is Science?

by
Larry E. Fink, M.S.
Waterwise Consulting, LLC

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What is Science?

- Do you like to solve puzzles, figure out riddles, make or break codes?
- Do you like to pick out and predict patterns in words, notes, colors, or numbers?
- If "Yes" to either, then you are a budding scientist.
- Science is a logical, systematic, unbiased, reproducible, open, self-correcting process for collecting, organizing, and relating sensory data from the natural world, translating those data into information, information into knowledge, and knowledge into understanding of the structure, function, and organizing principles of the natural world for its own sake (basic science) and to improve the human condition (applied science).

What is the Scientific Process?

- Ask "How?" or "Why?" something occurs as it does.
- Design studies to identify, characterize, and quantify the phenomenon of interest.
- Use existing or design, test & validate new data collection tools to carry out studies.
- Collect, screen, summarize, analyze, and interpret the data collected using old/new tools.
- Write a scientific paper transmitting your results and interpretation to scientists in your field.
- Submit paper to widely-read scientific journal.
- Respond to peer review (unbiased, constructive criticism from published scientists in same field).
- Publish revised paper; respond to comments

What is the Scientific Process?

- Successively refine questions, study designs, methods, tools, results, and interpretations.
- Develop a hypothesis of the cause-effect relationship that produces the phenomenon of interest (e.g., the sky is blue because light scatters from gas molecules or particles) or the variables that influence that relationship (e.g., the composition, temperature, pressure of the atmosphere determines the shade of sky blue).
- Design an experiment to test your hypothesis.
- Collect, screen, summarize, analyze, and interpret the data; publish the paper; respond to comment.
- Self-report errors in results, interpretation, or publication.

What is the Scientific Process?

- Successively refine hypotheses, experimental designs, methods, tools, results, interpretations.
- Develop a theory of the general cause-effect relationship that produces all similar phenomenon of interest (e.g., the degree of light scattering from gas molecules or particles can be predicted by quantum field interactions) and variables that influence that relationship (e.g.,nuclear charge, no. of electrons, light freq. & incidence angle).
- Design experiments to test your theory.
- Collect, screen, summarize, analyze, and interpret the data; publish the paper; respond to comment.
- Over time, if theory cannot be falsified by any future observations, it becomes a law of nature.

A Brief History of Science

- Og observes that salt lick, not paintings on caves, routinely attracts game to hunt.
- Og's granddaughter discovers heat kills parasites.
- Og's great^2 granddaughter discovers boiling water extracts healing drugs from leaves & bark.
- Og's great^4 grandson discovers round stones under a sledge made of small logs tied together with sinew easily moves very heavy objects.
- Og's great^3034 grandson, Galileo Galiei, discovers laws governing the motion of pendulums and rolling balls, including friction.

A Brief History of Science

- Og's great ^3038 grandson, Johannes Kepler, discovers the mathematical patterns in planetary motion from data collected by Og's great^3036 grandson Tycho Brahe using Galileo's telescope.
- Og's great^3040 grandson, Isaac Newton, develops the calculus to verify his geometric derivation of Kepler's equations based on gravity force decreasing as square of distance.
- Og's great^3045 grandson, James Clerk Maxwell, discovers the equations that unite electricity and magnetism into electromagnetism.

A Brief History of Science

- Og's great^3047 grandson, Albert Einstein, in 1915 publishes general theory of relativity, which modifies Newton's equations to account for mass's speed limit (light) and bending of space by gravity and accelerating mass.
- Og's great^3047 grandson Schrodinger and great^3048 grandson Heisenberg develop two different versions of quantum mechanics, shown equivalent by great^3047 grandson Max Born.
- Og's great^3048 grandson, Tomonaga, and great^3049 grandsons Schwinger and Feynman independently develop quantum electrodynamics.

A Brief Future of Science

- Science is a house of understanding built brick-by-brick, layer-by-layer by individuals educated, apprenticed, and experienced in the applications of its concepts, principles, practices, and ethics.
- The goal is to integrate related empirical observations into a more general synthesis (theory) that predicts future observations before they occur.
- e.g., Einstein used general relativity to predict sun's gravity would bend light rays, which was observed several years after its publication.
- As Einstein said, if I saw a little farther than most, it was because I stood on the shoulders of giants.
- How far can you see as a scientist?

Why do Science?

- Observing new patterns or understanding how things work is fun.
- Discovering new patterns or how things work is even more fun.
- This lays the foundation for new hypotheses, theories, and laws.
- This lays the foundation for new applications.
- Science is the longest, productive adventure in the history of the human race.
- That adventure has taken us to the edge of the micro-universe (quarks and string theory) to the edge of the macro-universe (big bang, inflation, dark matter & energy, evolution of stars, black holes, galaxies, planets, and life)

Why do Basic Science?

Basic science answers such questions as:

- How did the early universe evolve? … by observing the frequencies and distribution of the radiation left over from the big bang.
- What is the temperature of a star a million light-years away? … by observing the frequencies of radiation it emits.
- How old is a rock or a piece of wood? … by observing ratio of it's radioactive isotopes.
- How is the genetic code read and translated into proteins, subcellular structures, cells, organelles, organs, organ systems, and whole organisms?
- How much energy is extractable from a fuel? … by using the equations of thermodynamics.

Why do Applied Science?

Applied science answers such questions as:

- Whodunnit? … to crack the criminal case.
- What causes a disease? … to develop a new drug that saves thousands to millions of lives.
- What makes materials hard? … to develop a new, light-weight material that stops bullets.
- What makes a material conduct electricity? … to make a wire without resistance at room temp.
- How do structures change when they absorb radiation? …to develop a material that changes its properties in a controlled way in response to light, electricity, or magnetism.

Why do Applied Science?

Applied science answers such questions as:

- How are gems formed? … to develop harder or cheaper drill bits and saws for industry.
- How old is a rock, bone, pottery, tools, or clothing? … to aid archaeologists in dating sites.
- How were oil paints or water colors made at the time the artist worked? … to assist a modern artist in ethical restoration a fading masterpiece.
- How were musical instruments made? … to guide artisans in selecting the right materials and adhesives to repair them.
- What are the properties of prime numbers? … to develop password protection algorithms or detect changes to digital photos.

Why do Applied Science?

Applied science answers such questions as:

- What processes and influential factors govern water flow and wave amplitude and frequency? … to develop a predictive mathematical model that guides emergency managers in establishing hurricane building codes and evacuation plans to save thousands of lives and protect property?
- What processes and influential factors govern the way a nutrient or chemical moves, accumulates, and dissipates in the environment? … to develop a predictive mathematical model that guides source control or cleanup decision-making to save Lake Okeechobee, the Everglades, or Florida Bay?