MARLIN ANDERSON
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Serendipity in Science and a few Interesting Facts

Though he may not wish to accept the compliment, Robert Sivley is, to some extent responsible for the topic of this paper. In his critique of the papers given at the October meeting, he indicated that while he was not that interested in the topics of the papers presented, he felt we were each free to choose from subjects that were of interest to us. We have had papers presented on the mystery novel, a shopping experience, Cubs baseball, etc. Even though I have read much of Edgar Allen Poe's work, I don't recall ever having read a mystery novel. I don't shop. If I need something, I purchase the first item meeting my need at the time and, while I would love to see the Cubs win the World Series, I don't care that much about baseball. I have always been interested in how things work.

As a child, the first thing I did with a new toy was to take it apart to see how it worked and, if I could, I would put it back together. I remember taking one of my mother's lamps apart when I was six or seven years old. I failed to replace the insulating cover between the internals and the outside of the socket as I put it back together. When testing it, I could not turn the darn thing loose or turn it off until I finally managed to pull the plug from the wall. Also, no one ever told me the "fly-back" transformer on a TV set would knock you on your butt even if the set were unplugged. Believe me, it will. I learned many things the hard way. A parachute made from four burlap feed sacks will not slow you very much when jumping from a hayloft, and a raft made from 2x6s will not support the weight of a twelve year old. My interest in how things worked, but also wanting to live, led me to the study of science.

In graduate school I spent seven years studying the low temperature, low pressure oxidation of what are called the noble metals: gold, silver, copper and nickel. I wrote a dissertation on the subject titled: Ellipsometry Studies of the Oxidation Kinetics of

Copper Single Crystals. Initially the title was much longer but a member of my committee convinced me to shorten it. As stated earlier, this subject consumed a long period of my life and interested me greatly. So, taking Dr. Sivley's advice, I thought a paper on the topic might be appropriate. But then I thought, a few of you might not know what an ellipsometer is and might not be too interested in how one works.

Staying with my basic interest, I decided that a paper on serendipity in science might be of interest. But, as I began to develop the paper, Serendipity in Science was not inclusive enough and I finally settled on the title: Serendipity in Science and a few Interesting Facts. It was initially a little longer but, on the advice of my former professor, I shortened it.

There have been many interesting people involved in the development of science, some famous and some not so famous. Chance or circumstance has led to fame for some and notoriety for others. I would like to introduce you to a few of the not so famous and present facts about a few of the more famous, starting with the not so famous.

The Physics Department at Auburn University had a Friday afternoon colloquium series where guest lectures were presented. Many of the top names in physics and in other fields gave papers at these events. I had the opportunity of meeting and hearing people like: Buckmister Fuller, the architect; John Wheeler, the developer of the concept of "black holes" in space; P.A.M. Dirac, one of the fathers of quantum mechanics; Edward Teller, the father of the hydrogen bomb, Ralph Nader and many others. Bucmister Fuller was very impressive. He was aristocratic in his bearing but very engaging on a personal level. Teller and Dirac were both of the absent-minded professor type. Teller looked as if he had slept in his suit for several nights. When asked a question, he would pause in thought for a considerable time, and then begin speaking on some tangent before realizing: "I am not answering the question." And ask: "What was your question?" He made a big impression on me with his predictions for the future. He indicated that if he were just starting out in his professional career, he would be working in the area of clean water or clean air. This was in 1966 or 1967, before the founding of the Environmental

Protection Agency. I followed his advice. John Wheeler gave you no indication that he was a Nobel Prize recipient. He was mild mannered and soft-spoken and very interested in talking about what we were involved in as graduate students. He was in his seventies at the time and was on his way to either Cambridge or Oxford, I don't remember which, to begin postdoctoral study in a different area from the one he had worked in for so many years. He said he had contributed all he could in that area and wanted a new challenge. I don't think he ever made a name for himself in his new field, but I admired his wanting to plow new ground at that stage of his life. Ralph Nader was arrogant and opinionated to the point of bias. He was past the: "Unsafe at Any Speed" controversy with GM about the Corvair and was after the processed meat industry at the time. He was adversarial with us even though we were, for the most part, a sympathetic audience. As a lawyer, I might want him on my side in litigation, but I would not want him as president. In general, papers that I enjoyed most were given by the not so famous.

All doctoral candidates were required to present a paper on their research at one of these colloquiums. A student who loved practical jokes gave one of the most memorable. He presented all of the historical work behind his research, but rather than attributing it to the persons who had done the work, he used in their names' stead the names of German beers. Many of us student had been let in on the joke and had trouble containing ourselves as his major professor nodded his head in approval with each reference.

Dr. Knox Milsaps, a research physicist at the Air Force Research Center in Dayton Ohio gave a paper on separating male and female sperm in cow semen. You might wonder why the Air Force was interested in the separation of sperm. They were not. The research was funded by the Department of Agriculture. The purpose of the research was to reduce the number of bull calves born to dairy herds. The female sperm are much larger than their male counterpart and easily separated by use of a centrifuge. That is you can remove more than 90% of the male sperm by this technique. Removing 90% of the male sperm did not greatly improve the ratio of male-to-female calves, however. I guess the male "tadpoles" were better swimmers. Sperm look a little like tadpoles. Dr. Milsaps had tried several other methods but none had been able to beat the male sperm to the punch. The female-to-male ratio of calf births remained about the same. Dr. Milsaps was not deterred; however, he was still trying. I don't know if he ever succeeded but he left us with: "You don't fall in the outhouse unless you are stomping around in the backward". He used a more descriptive term for outhouse.

Some discoveries have been made by stomping around in the backyard. Carl Anderson, no relation to me, was using a cloud chamber to study nuclear disintegration of matter caused by cosmic ray showers. Beta particles are high-energy electrons and their paths will deviate from a straight line in a magnetic field. Anderson and others had noticed that some particles having similar ionization potential to the electron curved in the opposite direction from that expected. Most attributed these spurious deflections as being due to some unobserved collision or perhaps a proton and dismissed them. Anderson looked further and the positron was discovered. A positron is a particle with the same mass as an electron but having opposite charge. It is called the anti-particle of the electron. Other nuclear particles also have anti-particles. For his discovery, Anderson received the Nobel Prize in Physics in 1936.

Einstein's theory of relativity indicates that by moving faster than the speed of light, a particle could move backward in time. Also, an anti-particle can be viewed as the same particle going backward in time. Richard Feynman used this fact to developed the theory that only one electron would be needed to populate the whole of space. That is, the electron can be at one point in space at a given time. Then by going faster than light it can move to a new location before re-appearing at a different location at the same time for the previous location. Thus, only one electron is needed to populate the whole universe. We may have more in common than we know.

While on the subject of Einstein, I might say a little about his work. Natural Philosophers of the 19th century believed that all space was occupied by a fluid having very unusual properties. This was the aether. They believed it necessary for the propagation of light and for other physical actions at a distance. No one had been able to detect the presence of this aether however. Michelson and Morley devised an ingenious experiment to measure the velocity of the earth through the aether. They got a null result. They improved their apparatus, still a null result. Lorentz and Fitzgerald both explained their null result by saying that the arm of the apparatus pointing in the direction of the earth's motion was contracted by just enough to cause the result obtained. Einstein looked and decided that, if one assumed that the speed of light in vacuum was the same in all reference frames, one would get the result obtained by Michelson and Morley without having to contract the arm. This is the basic premise of his special theory of relativity. Without going into the theory, I would like to use a couple of limericks to point to consequences of it.

There once was a lady named Bright
Who traveled much faster that light.
She set out one day in a relativistic way
And returned the preceding night.

Said the Bright one to her friends in chatter,
I learned something new about matter.
My speed was so great,
Much increased was my weight
But I did not get any fatter.

Einstein did not get the Nobel Prize for his theory of relativity but for the discovery of the photoelectric effect.

The development of electrostatic theory has had some very interesting contributors. Luigi Galvani was one such individual. In 1780, he was the Professor of Anatomy at the University of Bologna. While studying the nervous system of frogs, he had accidentally discovered that touching the inner crural nerve caused the muscles of the frog's legs to contract violently. To determine if the frog would also respond to lightening and other atmospheric conditions, he began dissecting frog and inserting brass pins into their spinal columns. He found that the muscles would convulse even in clear weather when the frogs were hung on an iron fence in his garden. Upon further investigation, he found that whenever the pins were touched to a conducting surface, the muscle spasms would occur, but when touched to a non-conducting surface, nothing happened. He had discovered the contact potential that exists between all dissimilar conductors. He later commented that he had almost come to the conclusion that the contractions were due to atmospheric electricity and discontinued the experiments at the conclusion of the iron fence trials. As he said: "For it is easy to in experimenting deceive ourselves, and imagine we see the things we wish to see."

Speaking of seeing the things we wish to see, Aristotle objected to experimentation on just that point. He believed that pure logic was the way to truth. He did, however, mix observation with thought. As an example: heavy objects fall toward the earth and light objects float or rise. Consider; a rock falls, a feather floats and smoke rises. Thus, according to Aristotle, heavy things fall and light things rise. A big rock, twice as big as a smaller rock, would fall twice as fast as the smaller rock. Galileo tried this in his famous experiment from the tower of Pisa and found that both rocks hit the Ground at almost the same time. His contemporaries observed the experiment, scratched their heads, said that every one knew that Aristotle was right and went back to their ivory towers. Galileo knew better and eventually prevailed.

An interesting footnote: Galileo Galilei is one of the few people we refer to by first name.

Galileo is given credit by some for inventing the microscope, but most people now give credit for this to Hans Lippershey or Hans Janssen of the Netherlands. Lippershey is also given credit for inventing the telescope. Galileo made improvements to both of these instruments and was the first to point the telescope toward the night sky. Before that, the telescope was an instrument of commerce. Using it, underwriters could look out to sea for approaching ships and sell shares on a sure bet. Galileo discovered the moons of Jupiter and the phases of Venus. These discoveries led him to the conclusion that Copernicus was right; the sun, not the earth was the center of our universe. This was at odds with the teachings of the church and he was forced to recant in order to save his head. He spent the last part of his life under house arrest.

The king of the Netherlands was criticized for giving financial support to Lippershaey during the development of the microscope. After all, the plague was rampant in Europe and the money could be better spent helping people who were dying. The cause of the plague was found using; you guessed it, the microscope. Today we still look at money spent on research and ask couldn't that money be better spent elsewhere.

Galileo died in the same year Isaac Newton was born. Some have said that Newton was the reincarnation of Galileo. Newton was born on Christmas Day, 1642, three months after his father died. His father had been a very successful farmer but had not been well educated. His mother married a wealthy clergyman from a nearby village two years later and had three more children. Eight years later, the clergyman died and the family moved back to the family estate. Young Isaac was sent away to school where he did not do too well. In fact his teachers said: "He was slow and inattentive."

He returned to manage the farm at age 17 but found that he no interest in doing so. After a short period, his mother declared him a miserable failure and relieved him of his duties. An uncle suggested that he be sent to Cambridge, so in 1661 he went to Trinity College. Evidently his mother did not think he would do much better there than he had done at managing the farm; so Isaac worked as a sizar, or student worker, waiting tables and cleaning rooms for other students and faculty members. In 1664 he was elected a scholar, guaranteeing four years of financial support. During the summer of 1665 the school was closed and the students were sent home to avoid the plague that was then sweeping Europe. It was during this period that the apple incident happened.

The apple story is a myth not attributed to Newton. It is said to have been started by people of his hometown, Lincolnshire. He is said to have had a revelation as he sat musing in the orchard when an apple fell. "Aha! I now know what keeps the moon and planets in their orbit."

Newton was aware, prior to his return home, of gravitational attraction between physical bodies and of Keplers laws of planetary motion. He did not use an apple to explain what kept the moon in its orbit, he used a canon ball. In fact, in his treatise Philosophiae Naturalis Principia Mathematica , commonly referred to Principia, he describes his theory by use of an outsized mountain with its peak above the atmosphere from which a canon is fired parallel to the earth's surface. A ball fired from such a canon at normal speed will eventually strike the ground, but if the ball has sufficient speed it will fall to earth at a rate that will cause it maintain a path on a circle concentric with the earth. Or as he said, the motion of the moon in orbit could be understood by natural extension of Galileo's theory of projectile motion.

During the two-year period that the university was closed, Newton made revolutionary advances in: mathematics, optics, physics and astronomy. He began his development of differential and integral calculus. He invented the reflecting telescope, which reduced or eliminated the problems spherical and chromatic aberration. In doing this, he ground and polished his own mirrors and lens and he made all the metal parts. Newton was an excellent modeler and machinist. Using a prism he made and a slit in his window shade, he showed that white light, or sunlight, was made up of the colors of the rainbow.

Newton was one of those people who craved recognition but feared criticism and rejection. He would not publish his findings in many cases until forced to do so by someone publishing similar results. This led to disagreements with Leibnitz over the development of calculus and the postponing of his book on optics until Hooke had died. He and Hooke had disagreed about the nature of light. His mentor Isaac Barrow brought his work to the attention of a London mathematician but Newton would not acknowledge it until he learned that the work had been widely accepted.

During the 1670s, Newton became interested in theology. He studied Hebrew scholarship and ancient and contemporary theologians. He became convinced that Christianity and the Church of England had departed from the original teachings of

Christ. His friend Barrow resigned the Lucasian Professorship at Trinity College and recommended Newton as his replacement saying Newton was more worthy of the Chair. All professor of Trinity were required to take holy orders, which Newton was not willing to do. King Charles II issued a royal decree excusing Newton from this requirement. Actually, to prevent this being a wide precedent, the decree specified that, in perpetuity, the Lucasian professor need not take holy orders. Stephen Hawkins currently holds the Lucasian Chair. Even though he was not ordained, he is buried in Westminster Abby, but it is said that he was buried standing because of his views concerning the church.

Newton is said to be the founder of a mechanistic view of theology. That is, the universe he felt was like a big machine created and put in motion by God. God then withdrew to watch it run. The poet William Blake differed publicly with Newton and Newton supposedly responded: "We both read the Bible day and night. He reads black while I read white."

A final comment on Newton; he spent the last half of his life in London as Master of the Mint. When praised for his accomplishments he said: If I have seen further than others it is because I stood on the shoulders of giants. He was one of those giants.

Another giant who followed after Newton was Benjamin Franklin. Franklin's father was a candle maker in Boston. He tried to get Ben interested in Candles to no avail. Thus, Ben was sent as an apprentice to his older brother James, a printer. He learned the trade and became a better printer than his brother in a very short time. Feeling that he was being held back he ran away before his apprenticeship was completed. He went first to New York and then on to Philadelphia. There after working for a while, he found some one who would finance his starting his own shop, if he would take on the benefactor's son as a partner. Before long, Ben was the sole owner of the shop. Later he took on another partner who ran the business with Ben getting half the profits. This freed him to pursue his scientific interest.

Franklin's interests were diverse, but I will confine my comments to his contributions to the field of electricity. His interest was whetted when attend an electrical demonstration presented by a Dr. Spence from England. He felt that he could do better than the good doctor. He began by repeating and extending the work of others. In the process, he noted that one got stronger discharge from sharp points. Thus, he reasoned the opposite might be true and sharp points should attract electricity. The lightning rod was born. Many of his inventions were born out of necessity. Lightning was a problem in Philadelphia where most of the houses had roofs of wooden shingles that were easily set ablaze by a strike.

During the time of Franklin, static electrical charge was generated by rubbing certain objects. Amber when rubbed with fur produced one type called resinous electricity and glass when rubbed by silk produced a different type called vitreous. Most researchers thought of these two as different kinds of electrical fluids. Since objects charged with like types repelled each other and objects charged with unlike charges attract, Franklin felt that one type represented an excess of a single fluid and the other type represented a deficiency of the same fluid. He associated the term "positive" with vitreous charge and "negative" to resinous charge. Those terms have stuck. We now know that the negative charge is associatede with the electron and the positive charge with the proton. It would have been better had he reversed his designations; since by his convention, current flows from positive to negative; but in fact, the negative electron that carries the current moves from negative to positive.

All have seen pictures of Franklin standing on a hillside, coattail flapping, flying a kite in a rainstorm. It never happened. That was Walt Disney's version. The real Ben had a shed built from which the kite was flown and he did not hold the string, his assistant did. Some think his assistant may have been his son William. A silk leader was attached to the kite's string to avoid the holder getting shocked, but once the assistant was knocked to the ground when the silk leader got wet.

We think that "nuking" food with electrical energy is something new. Not so. Due to the high humidity in Philadelphia, Ben had a limited season each year in which his experiments could be performed. In a letter to a friend in England, he described the party he was going to throw to mark the end of a season. He was going to run a wire from one side of the river to the other and through it, kill a turkey. He relayed to his friend that six jars were required to cook a chicken but eight were required to cook a turkey. The jar he referred to was the Leyden jar. A device used to store electrical charge. He was also going to serve "bumpers" at his party. A "bumper" was a glass tumbler filled with water into which he had inserted a charge. When brought to the lip one got a jolt similar to that one would get by sliding across the seat of one's car and reaching for the door handle. I had considered serving "bumpers" tonight but was afraid I might over charge them and end with several lawsuits on my plate.

One final comment before leaving Ben, in today's society he might not fair so well or perhaps Bill Clinton will be redeemed by history. You see, Ben was quite the lady's man. He had at least one woman in each of his ports of call. His oldest child was born to a woman lost to history just before he married and he brought the lad into his home for his new wife to raise.

I have several more stories but I do not wish to tire you. I will end with a story taken from the internet. It is called "Thermodynamics of Hell" and it goes like this:

"The following is an actual question given on a University of Washington chemistry mid term. The answer by one student was so 'profound' that the professor shared it ......"

"Bonus Question: Is Hell exothermic (gives off heat) or endothermic (absorbs heat)?

Most of the students wrote proofs of their beliefs using Boyle's Law, (gas cools off when it expands and heats up when it is compressed)." I want to interject into the story that this is not so according to Boyle's Law. This fact puts the authenticity of the story in question, but it is still a good story.

"One student, however, wrote the following:

'First, we need to know how the mass of Hell is changing over time. So we need to know the rate that souls are moving into Hell and the rate they are leaving. I think that we can safely assume that once a soul gets to Hell, it will not leave. Therefore, no souls are leaving. As for how many souls are entering Hell, let's look at the different religions that exist in the world today. Most of these religions state that if you are not a member of their religion, you will go to Hell. Since there are more than one of these religions and since people do not belong to more than one religion, we can project that all souls go to Hell. With birth and death rates as they are, we can expect the number of souls in Hell to increase exponentially. Now, we look at the rate of change of the volume in Hell because Boyle's Law states that in order for the temperature and pressure to stay the same, the volume of Hell has to expand proportionately as souls are added. This gives two possibilities:

1. If Hell is expanding at a slower rate than the rate at which souls enter Hell, then the temperature and pressure in Hell will increase until all Hell breaks loose.

2. Of course, if Hell is expanding at a rate faster than the increase of souls in Hell, then the temperature and pressure will drop until Hell freezes over.

So which is it?

If we accept the postulation given to me by Karen during my freshman year, '.... it will be a cold day in Hell before I sleep with you,' and taking into account the fact that I still have not succeeded in having relations with her, then #2 cannot be true, and thus I am sure that Hell is exothermic and will not freeze."

It is said that the student got an "A". Should he have gotten that "A" and how sharp was the professor?