Scientific Discoveries:
Look What Happened the Year I Was Born!

Detailed example of how my year of birth—1953— was rich with scientific discoveries that changed the world for ever.

Abour H. Cherif, Ph.D
National Associate Dean,
College of Liberal Arts & Sciences
DeVry University, Downers Grove, IL 60515
(630) 353-7014 - acherif@devry.edu

I was born in 1953, a year that I proudly consider the best year for science in general and biology in particular. There were so many profound and breakthrough discoveries that I have a difficult time choosing one. But since most major breakthroughs often follow technological advances, let us first go back to almost 80 years before I was born. In 1869, the Swiss biochemist Friedrick Miescher found the molecule in the nuclei of white blood cells and called it nuclein; better known today as DNA. In 1873, the advances in microscopes and staining techniques enabled scientists to view unusual thread-like structures within the nuclei of animal and plant cells. These structures were dubbed chromosomes (chroma for color and soma for body) for their affinity for colored stains. Although the nature and function of these cell structures were unclear at that time, there were hints that chromosomes played an important role in cell division (Papaneck, 1993).

Thirty years later, American graduate student Walter Sutton and German biologist Theodor Boveri independently proposed that “chromosomes in the cell nucleus contain the vehicles of inheritance.” (Papaneck 1993, p. 129). Soon after the American geneticist Thomas Hunt Morgan empirically confirmed the Mendelian theory of inheritance through work with fruit flies. He discovered the role chromosomes have in the inheritance of traits and definitively linked trait inheritance to a specific chromosome. Through the chromosomal theory of heredity, Morgan proposed that "each chromosome contains a collection of small units called genes (a term he adopted from the Danish physiologist Wilhelm Johannsen), with different genes having specific locations along specific chromosomes. Morgan also was able to infer the process of *chromosome recombination*." (Kandel 2010, pp.18-19) Through his work, he developed the chromosome theory of inheritance and showed how some traits are sex-linked traits. For his work, Morgan was awarded the Nobel Prize in 1933.

In 1953, my birth year, a "fortunate mistake" that led to the discovery of the correct number of the chromosomes in the cells of the human body. When human chromosomes were first studied by Theophilus Painter in 1921, he claimed that there were 24 unpaired chromosomes in the sex cells of human testes and therefore 48 total chromosomes in somatic cells. His findings were not disputed and were even confirmed by other researchers throughout the 1930s and 1940s. But in 1953:

> *A geneticist in Texas accidentally mixed the wrong liquid with HeLa cells [one type of an immortal human cell line grown in culture and used in scientific research] and a few other cells, and it turned out to be a fortunate mistake. The chromosomes inside the cells swelled and spread out, and for the first time, scientists could see each of them clearly. That accidental discovery was the first of several developments that would allow two researchers from Spain and Sweden to discover that normal human cells have forty-six chromosomes." (Skloot, 2010, p. 100)*

In 1955, those two researchers, Joe Hin Tjio and Albert Levan, used better microscopic and staining techniques to clearly count 23 pairs of chromosomes in somatic, disproving the previous thought of humans having 24 pairs of chromosomes. The discovery was noteworthy because changes in the number or structure of chromosomes in new cells may lead to serious health problems.

Once scientists knew how many chromosomes people were supposed to have, they could tell when a person had too many or too few, which made it possible to diagnose genetic diseases. Researchers world-wide would soon begin identifying chromosomal disorders, discovering that patients with Down syndrome had an extra chromosome, number 21; patients with Klinefelter syndrome had an extra sex chromosome; and those with Turner syndrome lacked all or part of one." (Skloot, 2010, p. 100)

But the excitement didn't stop there. By this time scientists knew that chromosomes were made from nucleic acid (DNA) and their attached proteins, but the structure of DNA was still stunningly mysterious, even with famed scientists Edward Chargaff and Rosalind Franklin obtaining necessary information to piece together the DNA structure in 1952. But in 1953, the American biochemist James Dewey Watson and the British physicist Francis Crick delivered the best scientific gift to humanity by demonstrating that DNA consisted of two chains of nucleotides arranged as a double helix, with the purine and pyrimidine bases facing each other and the phosphate links on the outside.

Purines and Pyrimidines are nitrogen-containing "bases" found in the nucleotides that make up nucleic acids, such as DNA and RNA. Purines have two ring structures while pyrimidines have only one ring structure. Purines also have two nitrogen-containing ring structures (six-membered and a five-membered ring, fused together). Pyrimidines have just only one ring structure of six-membered nitrogen-containing ring. In a DNA strand, adenine and guanine nitrogen bases are purines while cytosine and thymine nitrogen bases are pyrimdines. Because each two-ringed purine faced a one ringed pyrimidine, each adenine and thymine were also faced and paired, as were guanines and cytosines. This structural arrangement makes the space between the two strands is constant.

Of course, in their discovery of the structure of DNA, Watson and Crick relied on the work of others in the field as well, especially those who were like them looking for answers outside the realm of proteins. For example, Watson and Crick made use of the proposed α- helical secondary structure of proteins by Linus in 1951, the disproving of Phoebus Levene's tetranucleotide hypothesis by Chargaff, and the use of a key X-ray diffraction photograph called “Photograph 51" of the "B" form of DNA”, taken by Franklin in 1952 at King's College. Watson and Crick seemed to get hold of this photograph from Franklin’s supervisor, the physicist Maurice Hugh Frederick Wilkins, who made it available to them most likely without Franklin's consent. “Photograph 51'' played a major role in the discovery of the structure of DNA and their proposed molecular structure of the DNA molecule made so much sense that it was accepted at once. The importance of DNA within living cells was no longer a point of dispute. Indeed, Watson and Crick's unveiled molecular structure of DNA “set off a firestorm of discovery and innovation that has continued for over 50 years.” Because of this breakthrough, in 1962, Watson, Crick, and Wilkins received the Nobel Prize for physiology and medicine as a result of their work modeling the DNA molecule (Franklin has passed away, and the prize is not awarded to the deceased) (Bryson 2003).

The discovery of DNA was voted the greatest UK scientific breakthrough of all time by a more than 400 UK academics but this writer feels it is the most significant discovery ever made in genetic and molecular biology. The discovery stil has implications for experiments today. For example, synthetic biologists have started to learn how to engineer genomes that could enable them to go from information to reproducing organisms (Biello and Harmon 2010.)

As Tom Siegfried, the editor in chief of Science News wrote, "Among the molecules of life, DNA is the MVP. It provides the mechanism for hereditary, the blueprints for proteins and the recipe for reproduction. ... It helps explains the secrets of many dark diseases. And it gives scientists one of the best tools and toys available for playing around in nanoworld. ... No doubt DNA's nanotechnological ability will also be applied to making tiny electronic parts for a computer that could fit inside an eyelash." (p. 2) The Discovery of DNA structure has excited scientists and science fiction writers, inspired artists, captivated Hollywood and the general public, and challenged society with emerging ethical issues (Allison 2007)

The Pursuit of the Origin of Life.

While all these exciting activities related to DNA were taking place, researchers started trying to understand of the origin of life at a more rapid pace. All around the globe, individuals, as well groups of graduate students and scientists were in a race to examine what kind of environment would be needed to allow life to begin. In 1953 an American graduate student, Stanley L. Miller, worked with the Nobel laureate Harold C. Urey at the University of Chicago and conducted an experiment that changed the approach of scientific investigation into the origin of life. In the Miller/Urey Experiment, Miller created an instrument of a closed system which consisted of two flasks connected with rubber tubes which were supplied by a source of electrical sparks. Miller conducted the experiment by placing water in one flask to present the conditions on the primeval ocean and a mixture of gases in the other flask to present Earth's early atmosphere. Then he connected the flasks with rubber tubes, and introduced electrical sparks, standing in for lightning. Through this experiment, he demonstrated how organic compounds can be generated from inorganic substances by fairly simple physical processes. Specifically:

The gases they used were methane (CH_4), ammonia (NH_3), hydrogen (H_2), and water (H_2O). Next, he ran a continuous electric current through the system, to simulate lightning storms believed to be common on the early earth. Analysis of the experiment was done by chromotography. At the end of one week, Miller observed that as much as 10-15% of the carbon was now in the form of organic compounds. Two percent of the carbon had formed some of the amino acids which are used to make proteins. Perhaps most importantly, Miller's experiment showed that organic compounds such as amino acids, which are essential to cellular life, could be made easily under the conditions that scientists believed to be present on the early earth. This enormous finding inspired a multitude of further experiments.

www.chem.duke.edu/~jds/cruise_chem/Exobiology/miller.html)

Many of the compounds made in the Miller/Urey experiment are known to exist in outer space. On September 28, 1969, a meteorite fell over Murchison, Australia. While only 100 kilograms were recovered, analysis of the meteorite has shown that it is rich with amino acids. Over 90 amino acids have been identified by researchers to date. Nineteen of these amino acids are found on Earth. The early Earth is believed to be similar to many of the asteroids and comets still roaming the galaxy. If amino acids are able to survive in outer space under extreme conditions, then this might suggest that amino acids were present when the Earth was formed.

If these compounds were not created in a reducing atmosphere here on Earth as Miller suggested, then where did they come from? New theories have recently been offered as alternative sites for the origin of life.

www.chem.duke.edu/~jds/cruise_chem/Exobiology/miller.html

It is worth mentioning as Bryson (2003) stated: “Scientists are now pretty certain that the early atmosphere was nothing like as primed for development as miller and Urey’s gaseous stew, but rather was a much less reactive blend of nitrogen and carbon dioxide. Repeating Miller's experiments with these more challenging inputs has so far produced only one fairly primitive amino acid." (p. 287-288)

Therefore, despite a century of further study, "we are no near to synthesizing life today than we were in 1953." (Bryson (2003, p. 288) Even though what Craig Venter and his team work did not result in a synthetic organism, scientists think that the result is an important step toward synthesizing life in the laboratory. (Palca 2010). Although we may not have found complete success in synthesizing life, scientists should continue to study how to properly synthesize life until we find an answer.. What Venter and his team did accomplish was taking "the genome from a simple cell, a small bacterium called Mycoplasma mycoides, and spent several years trying to transfer its genome into a related species, Mycoplasma capricolum. He finally succeeded.So it was the capricolum cell, with the mycoides genome in it." (Palca 2010)

Piltdown Man! It is Only a Hoax

A fossil is any remains, impression, cast, or trace of a once-living organism of a past geological period preserved in the rock strata. In order to become a fossil, several things must happen including dying in the right place, being buried in sediment, and decomposing without exposure to oxygen allowing permitting the molecule to be replaced. In 1912, a group of workers discovered a fossil in the shape of skull in Sussex, England. It was named the "Piltdown Man." The skull was an important find that generated a lot of interest simply because of the process it takes to be fossilized. Also, it was unusual because

> "It (the skull) had an ape-like lower jaw attached to a much more human-looking skull, and was heralded as the long sought-after 'missing link' between humans and the great apes. Only in 1953 was it revealed to be a hoax when radiocarbon analysis, the same technique that was later used to date the Iceman, proved beyond any doubt that the Piltdown skull was modern. The perpetrator, who has

> never been identified, had combined the lower jaw of an orangutan with a human braincase and chemically stained them both to look much older than they really were. The long shadow cast by the Piltdown Man fraud lingers even to this day."(Sykes 2001, p. 60)

In 1973, "geneticists spliced together DNA segments from a toad cell and a bacterial cell. They implanted the hybrid in another bacterial cell, causing a mass production of the toad's DNA and its proteins. Their success gave rise to the science of genetic engineering." (Papaneck 1993, p. 130).

Ten years later, Barbara McClintock was awarded the 1983 Nobel Prize in biology for her insight in jumping genes (migrating genes) which she proposed in 1940s. McClintock's contribution to genetics was recognized and ranked by the Nobel Prize committee as "second in importance only to the discovery of DNA's double-helix structure." (Papaneck 1993, p. 75).

In 1993, "the Human Genome Project sequenced 120 million of the three billion nucleotide pairs in the human genome." (Papaneck 1993, p. 131). Also that year, Kary Mullis received a Nobel Prize for developing the Polymearase Chain Reaction (PCR); a simple, yet a powerful tool and technique that helps to amplify a sequence from an arbitrarily small amount of material. This technique helped to solve the huge practical hurdle of not having enough DNA to analyze for a given purpose such as from crime scenes, old bones, hairs, etc. Because you can start with a very small amount of material PCR is enormously powerful with hundreds of thousands of applications. (Shuster et al. 2011; King 1994)

> Without some way to increase the amount of DNA in a saliva stain for example, DNA would be useless as evidence. Mullis solved that problem in mid-1980s when he developed a ground breaking technique called the polymerase chain Reaction (PCR) – a chemical reaction that can vastly increase the amount of

DNA in a sample."(Shuster et al. 2011, p. 7-8). "From a starting of just a few molecules of DNA, PCR can make billions of copies."

(Shuster et al. 2011, p. 9)

Isotactic Polymers:

Understanding polymers and polymerization processes not only has helped to bring biology and chemistry together but also helped to excrete the revolution in our understanding of modern biology and chemistry. Today, many people cannot even imagine our world without these synthetic polymers, even if they're unaware of them, because of the essential and ubiquitous roles they play in everyday life. Polymer materials are long-chain molecules built up of simple repeating units typically connected by covalent chemical bonds. However, for many years, the usefulness and the use of polymer products was very limited because of the lack of sophistication of techniques and technology in controlling and perfecting how these simple units combine instead of their random combinations during polymerization. But in 1953, German chemist Karl Ziegler discovered a better way to control the polymerization process and increase the usefulness of polymers. Ziegler invented a way to use a resin, to which ions of metals such as aluminum or titanium were attached, as a catalyst in the production of polyethylene. "Chains without branching were then formed. As a result, the new polyethylene was tougher and higher-melting than the old."

Specifically, while trying to obtain a high-molecular-weight polyethylene using metallic catalysts,

Ziegler and Heinz Martin, ended up with a dimer--a short-chain polymer composed of two molecules of the same chemical composition--of ethylene. After some investigation they surmised that the reaction vessel they had used had contained a small amount of nickel. Realizing that other metals could also affect *the reaction and inhibit polymerization, they began to investigate. To their surprise they found that while some metals were found to inhibit polymerization, others enhanced it. They also found that a metal chloride used with organ aluminum compounds caused the rapid low-temperature polymerization of ethylene into a very high molecular weight linear chain. The discovery of catalysts that made possible low-temperature polymerization revolutionized the chemical industry* ("Ziegler Biography" 2012).

Today because of the extraordinary range of properties and accessibilities, the list of synthetic polymers materials is quite long and includes synthetic rubber, nylon, PVC, polyethylene, silicone, and many more. Also careers can be built through the study of polymers, specifically polymer chemistry, polymer physics, and/or polymer science.

Bubble Chambers:

For many years, physicists were using a cloud chamber tool invented by Scottish physicist Charles Thomas Wilson to investigate the path of subatomic particles. This device was used for detecting particles of ionizing radiation, and using humid air on the point of forming droplets of liquid in the cloud chamber. "The speeding of the charged particles would encourage the formation of droplets, and a line of droplets would mark out its path. (P.)

In 1952, at the age of 25, the American physicist Donald Arthur Glaser started to wonder what would happen if he started with a liquid that was on the point of boiling and forming small bubbles of vapor. Would the speeding of charged particles encourage the formation of trail bubbles, and would the line of those tiny bubbles mark out a path that could be photographed? This was the beginning of a journey to revise and reverse the principles of Wilson's invention. By 1953, Glaser had succeeded in making his bubble chamber a practical reality, and it since has become an indispensable tool of subatomic investigations.

In Glaser's bubble chamber:

> The first bubble chamber, no bigger than its inventor's thumb, contained a clear, super-heated liquid in the path of charged atomic particles accelerated by an atom smasher. As the particles pushed through the liquid, they created a trail of tiny bubbles that could be photographed through the window of the chamber. Analyzing the bubbles provides physicists with insight about the particles and related forces. ... (2010 p. 2)

Since then, Glaser's invention has become second in importance only to the cyclotron for atomic physicists. For his work, he was awarded the Nobel Prize for physics in 1960.

Appendix 2

In the area of social and political affairs, 1953 was also a significant year. For example:

1. The Korean War came to an unofficial end through a truce that still holds today.
2. Soviet dictator Stalin died, and the Soviet Union exploded its first fusion bomb.
3. A full-scale revolt against Great Britain began in Kenya and started to spread cross Africa.
4. Ibn Saud, the founder of modern Saudi Arabia died.
5. The first 3-D movie, *Man in the Dark,* was released at the Globe Theater in New York City by a major Hollywood studio, beating *The House of Wax* to the screen by only two days.
6. Edwin Powell Hubble, who overwhelmingly altered our understanding of the universe by demonstrating the existence of galaxies other than the Milky Way, died on September 28.
7. The novel Casino Royale which introduced the literature's most famous spy, James Bond, 007 was published by Ian Fleming.

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Communcation Information:

Abour H. Cherif, Ph.D
National Associate Dean,
College of Liberal Arts & Sciences

DeVry University
3005 Highland Parkway
Downers Grove, IL 60515-5799
(630) 353-7014 (W)
(630) 353-9903 Fax

acherif@devry.edu