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Invigorating Seventh-day Adventist Science Education with Chemical Knowledge of God's Creation

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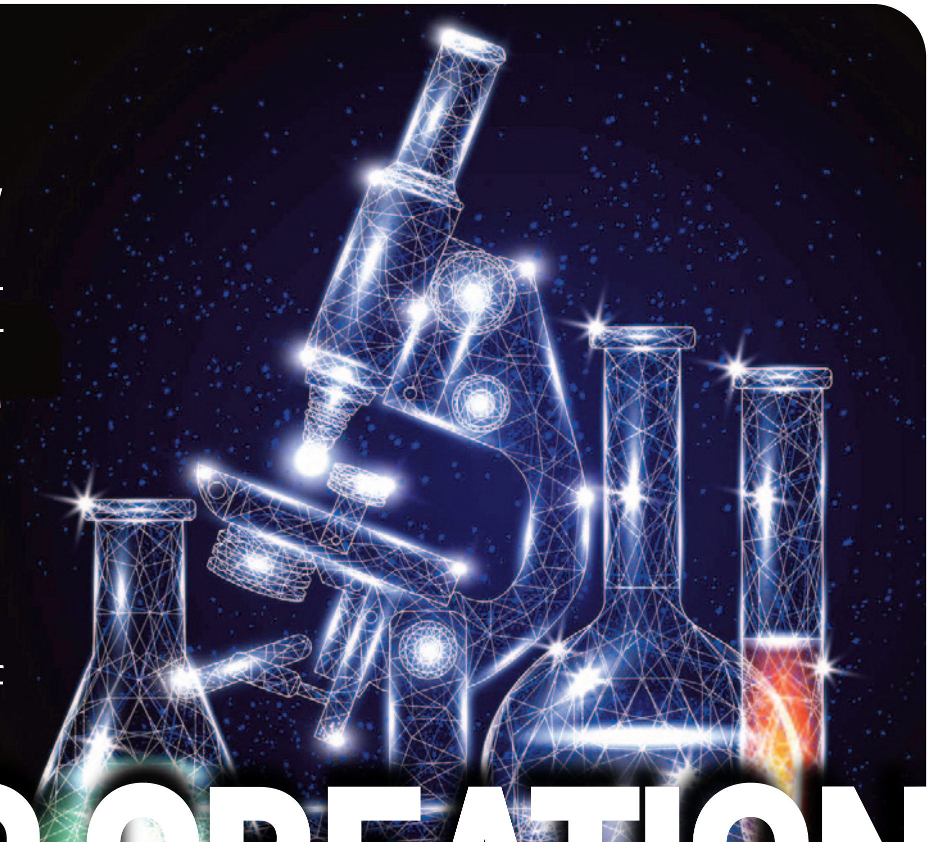

Chemistry is messy. Not only in the sense that chemical reactions easily spill, stain, and explode—like experiments where students learn to make slime for the first time or run an elephant toothpaste reaction (a chemical reaction that creates a giant, toothpaste-like foam)[1]—but also messy from the perspective that chemicals naturally react in ways that create a wide diversity of molecules rather than just the one that was intended.

I (R.H.) learned this lesson repeatedly during the many months I spent in graduate school as I made porphyrin molecules from raw ingredients.[2] Porphyrin ring structures occur naturally in nature, such as chlorophyll and the heme in hemoglobin. I found from personal experience that it was rare to synthesize a pure carbon-based molecule without producing numerous side reactions. To make porphyrin, one needs to mix the proper ingredients, remove impurities from solvents, frequently adjust ingredient ratios, manipulate temperatures and timing, and then allow the chemicals to work spontaneously from that point. Even after I did all that, the desired product was buried in a sea of side products that needed to be extracted or purified in some way.

Surprisingly, this synthesis and purification experience provided me with a background for understanding the progress of science related to origins-of-life research, commonly called "chemical evolution" or "abiogenesis." In essence, a chemical design model can be constructed to determine what can happen naturally or when intelligence is needed to circumvent natural forces that send chemical reactions in the wrong direction (away from life).

In 1953, the Miller-Urey experiment (see Figure 1 on page 26) showed the conditions necessary to produce amino acids from a few simple gases and "lightning" sparks.[3] The worldwide scientific community immediately claimed that life's ingredients could be easily made under conditions thought to be present on the early,

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Figure 1. The Miller-Urey experiment setup, which created biotic molecules.

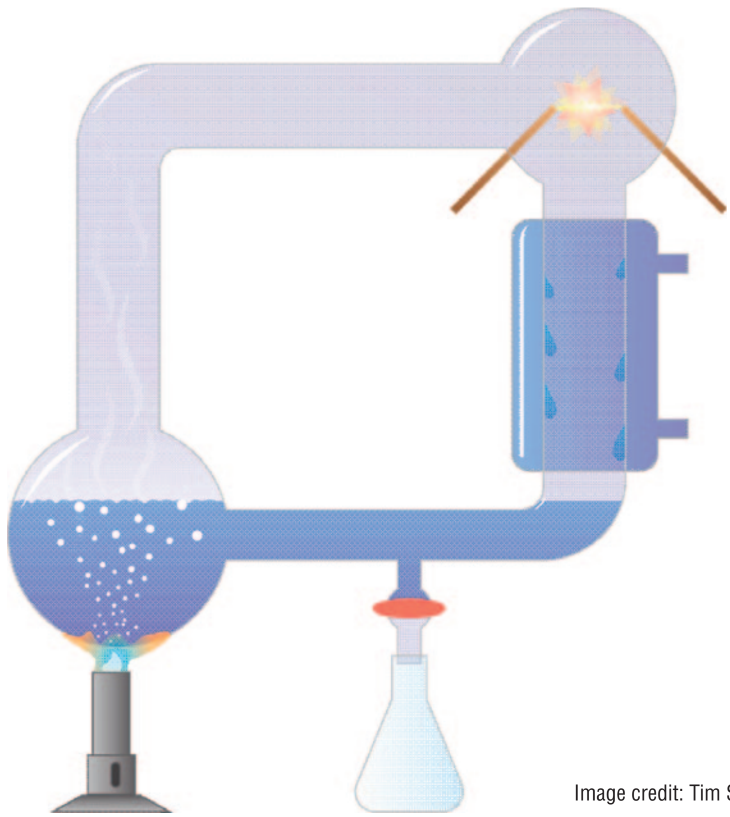


Image credit: Tim Standish.

pre-life Earth, and thus life could easily follow. Further trials confirmed the results of the Miller-Urey experiment and demonstrated that nearly all of the essential amino acids could be made without the need for external intervention.[4] Time, energy, and some simple chemicals appeared to be the "creator" the world of scientific materialism was seeking.

However, Miller-Urey explanations typically leave out the mess that was created by the experiment, which effectively trapped the biotic (molecules needed for life) compounds in a tarry mixture. Amino acids were created in a racemic mixture with a yield of less than one percent, based this article's authors' analysis of the Miller-Urey paper. The gases used in the original experiment were also inappropriate since hydrogen, ammonia, and methane were most likely not available on an "early Earth."[5] It was also recently discovered that the glass of the reactor acted as a necessary catalyst![6]

Regardless of the gases used and catalyst implemented, these experiments have typically produced a messy conflagration of small molecules, most of which are not biotic despite researchers' enthusiasm over generating a few biotic ones.[7] Any oxygen in the experiment blocked amino-acid formation since this creates an oxidizing environment when a reducing environment (one with little or no oxygen) is needed to take the most abundant source of nitrogen, atmospheric dinitrogen, and reduce it to a usable form like ammonia, NH_3.[8] This creates a chemical conundrum since most living systems require oxygen, and there is plenty in our atmosphere, which has likely always been present.[9]

Finally, these reports also fail to mention that critical molecules of life, like ribose, degrade within minutes at high temperatures, which negates the assumed benefits of time and forming life in a hot location like thermal vents.[10] But most important of all, none of these experiments has created anything close to life—just some of the raw ingredients.

In the 70 years since the Miller-Urey experiment, origin-of-life experiments have failed to get much closer to life. "Artificial life" was created in Craig Venter's lab in 2010 by rearranging genes inside bacteria, but the product of this experiment was not made from raw ingredients like air, sand, and water.[11]

Research into the chemical origin of life has shown that conflicting chemical requirements necessary to generate the wide molecular diversity are involved even in the simplest life. Bacteria represent some of the simplest life on our planet, and they require thousands of unique, purified molecules that are made BY the organism from raw materials around it using molecular machines that overcome thermodynamic and kinetic challenges.[12] The biochemical molecules needed by life are created by life and not simply captured from the surrounding environment. Within organisms, what scientists previously regarded as "simple" behavior by atoms has been recognized as an elegantly complex dance coordinated by thousands of molecular machines that were not even imagined 70 years ago.

Clearly, the chemistry in living organisms has not been left to chance but rather is tightly regulated, checked, and rechecked by enzymes, RNA, and biomolecular complexes—all made within living organisms.[13] On its own, chemistry is messy, and that mess is enough to kill cells if not tightly regulated. Even a misfolded protein is extremely dangerous, even though it was formed with the correct sequence.[14]

No set of experiments has been found that demonstrates how the basic ingredients of life such as amino acids, carbohydrates, lipids, and nucleobases can snap together to form the simplest living organism.[15] Despite what people have heard or read in popularized science sources, nothing close to this has been done in the lab nor verified in peer-review journals.[16] The hope is to string together enough "just-so" events that make abiogenesis seem plausible.[17] The simplest genome in a living organism, *mycoplasma genitalium*, contains more than 580,000 nucleobases, but only a 50-mer has been generated in a lab using plausible abiotic conditions.[18]

Millions of dollars have been spent as top scientists have researched whether abiogenesis is possible without some outside influence. Only recently has "chemical evolution research" become organized and funded through the Center for Chemical Evolution under the National Science Foundation and NASA.[19] Scientists are assembling enough chemical details to piece together a just-so story of how thousands of chemicals could come together to form life.

Figure 2 shows the number of articles published between 1980 and the present on "origin of life" using a keyword search on the Web of Science website. There is a major gap in the naturalist model that attempts to explain how life started on a lifeless rock in space from raw ingredients. We (R.T.H. and D.D.N.) are working with a small group of scientists to evaluate the recent chemical literature for plausible information regarding life generated from non-life. What we have found is that the chemical evidence appears to show that chemistry is messy, water breaks apart biopolymers, time and heat destroy life's fragile components, and cells are highly coordinated, regulated, and controlled chemical factories that possess molecular machines to circumvent the thermodynamic and kinetic challenges of assembling raw ingredients into functional biomaterials.

Our analysis is being compiled into a series of short videos (~10 minutes) to articulate this information. The animated videos are insightful and can be enjoyed by nonscientists and scientists of all ages. The first four videos in this "Origin of Life" series are available on YouTube,[20] and we thank the Faith and Science Council for providing some of the funding.[21]

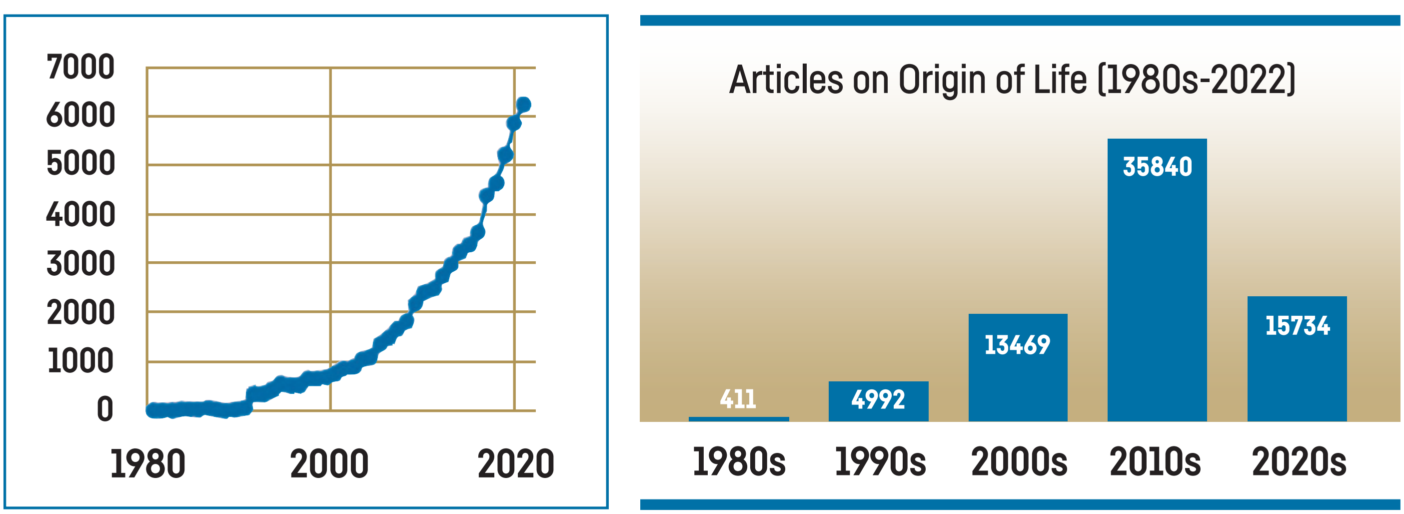
One of the best summaries of this chemical mountain that needs to be climbed is Tan and Stadler's *The Stairway to Life: An Origin-of-Life Reality Check*.[22] This book describes in easy-to-understand language the various chemicals needed to form a living system. As our chemical knowledge increases, our appreciation increases for the intelligence of the supernatural Being that created the chemical engineering that made this world, created life, and keeps it all going!

Other Chemical and Biochemical Support for the Existence of a Creator

In the following paragraphs, we will present a few chemical and biochemical details that lend additional support to our perspective on the existence of a Creator. Using these details as the foundation, we suggest that more chemical-design-related information be integrated into the chemical-education curriculum of Adventist schools. There are five aspects to chemical design: the proper ingredients, how these ingredients get selected (selection/purification), what happens with too much/too little of certain ingredients (fine-tuning), how the ingredients are combined into a product (process), and what can happen spontaneously (naturally).

It is important to understand what the chemical forces of nature and time can and cannot do, and whether nature can do anything without an outside intelligence, an outcome that is referred to as "spontaneous" or "natural." Nature can do certain things, such as make *some* biotic small molecules, so this is *natural*. But we be-

Figure 2. Total articles by year and by decade concerning "origin of life."



(Web of Science search, August 15, 2022).

lieve, based on the latest research and firsthand chemical-synthesis knowledge, that nature cannot bring these ingredients together and form life *spontaneously*, which makes many aspects of the natural world *nonspontaneous*. Therefore, we observe things in nature that are both natural and unnatural. To appreciate these chemical design parameters, cooking is a great place to start.

Cooking: Teaching students how to make food from recipes will equip them to appreciate how ingredients transform into final products. Using planned cooking experiences, teachers can equip students with knowledge about amounts, concentrations, heat, freshness, mixing, solids-liquids-gases, timing, and procedures to bring everything together. Through these experiences, they begin to understand when intelligence (external manipulation), is needed or not needed. After explaining the recipe, the teacher can go through the "too much/too little" fine-tuning discussion so that students understand the purpose of each ingredient or process. Advance discussions could center on the role of each ingredient and whether nature can make cookies without human/intelligent intervention. Can freshly baked cookies spontaneously form, given enough time, temperature, and chance interactions? Cookies need only nine or 10 chemical ingredients, but the simplest living system is based on thousands of chemical ingredients!

Earth's Finely Tuned Air: For carbon-based life to exist, a planet is needed that can hold onto its water. It is not easy for a planet to hold onto water, as evidenced by Venus and Mars. Doing so requires the proper gravity, distance from the Sun, air pressure, a protective magnetic field, lack of an electric field, ozone at the correct altitude, and cold-enough temperatures to freeze water at high elevations. This is effectively called the "water trap."[23] If any one of these conditions (as well as many more not listed) is not met, planets lose their water and turn into dry, inhospitable places.

Each gas in Earth's atmosphere plays a key role in sustaining life. When we consider ingredients, selection, process, and fine-tuning of each atmospheric ingredient, the purposes of nitrogen, oxygen, carbon dioxide, water, and ozone for life are revealed. Too much oxygen and the hydrocarbons of life (i.e., trees and plants) will be highly combustible. Adding more greenhouse gases such as water, methane, or carbon dioxide, causes Earth to overheat, resulting in conditions that affect its ability to sustain life, as has been noted in many articles.[24] However, with too few greenhouse gases, Earth would turn into an ice ball! Each chemical ingredient in Earth's air has a purpose that becomes clearer when considering the "too much/too little" scenario. In-depth discussions can center around the chemical cycles for each atmospheric ingredient.

> Water's ability to hold onto heat (i.e., high heat capacity), lack of conductivity, low viscosity, high surface tension, high salt solubility, nonflammability, and other properties make it the ideal chemical to support and sustain life. No other chemical has these combinations of properties.

Water's Unusual Properties for Sustaining Life: The chemical properties of water are astounding when compared with those of other chemicals. We live on a privileged planet with an abundance of liquid water on its surface. Most people are very familiar with water's properties, but unfamiliar with the other potential options. The fact that "ice floats" is a chemical abnormality, as only a few elements have this property (e.g., gallium, bismuth, germanium, and silicon). Even though a few other compounds possess this characteristic, water is the only known compound with a combination of life-sustaining properties, which makes it rare. If ice sank to the bottom of a lake or pond, then the fish and other life in the water would have to migrate to the top or be crushed and frozen by the falling ice. If ice sank, then warm liquid water would be brought to the surface and the freezing process accelerated. Since ice floats, it can act as a thermal barrier and slow the cooling of the air and water above it, while maintaining a livable aquatic environment beneath it.

Water's ability to hold onto heat (i.e., high heat capacity), lack of conductivity, low viscosity, high surface tension, high salt solubility, nonflammability, and other properties make it the ideal chemical to support and sustain life. No other chemical has these combinations of properties. There is plenty of water to support life on this planet, although some areas do not have adequate access to potable water. In-depth discussions can take place on the properties of water.[25]

Genetically Coded Information: Just because a researcher *might* possess many of the correct chemicals to make life, he or she would still need to ensure that they are programmed and arranged into the correct sequences. This is referred to as chemical--encoded information, and this code is found in DNA. There are trillions of ways to arrange the nucleobases of DNA, but only a limited set of sequences encode functional information. Scientists and authors such as Stephen Meyer (*Signature in the Cell: DNA and the Evidence for Intelligent Design*) and Douglas Axe (*Undeniable: How Biology Confirms Our Intuition That Life Is Designed*) have helped make this argument.[26]

Figure 3. YouTube series on understanding that chemicals cannot come together to form life on their own.

Visit https://www.youtube.com/ playlist?list=PLR8eQzfCOiS0AfFPsMAUYr_VVkpU13uv9.

Without the information, the chemical system to convey the information, and a chemical correction system that maintains that code, life does not have a chance to start or survive. This is called the "Information Problem." We know that capable scientists are excellent producers of useful and specific code, but natural forces, time, and chance are feeble generators of this type of code. Our Creator had the foresight to write the chemical program inside of cells and to incorporate maintenance systems to repair the coded information when it becomes corrupted.

Thousands of defects spontaneously occur each day in human DNA.[27] One unchecked defect can lead to mutations that can cause disease, dysfunction, and death in any living system, although the genetic code and associated systems commonly do an amazing job of preventing these negative outcomes.[28] Inside each living organism is a series of systems that seek out damage, remove the damage, and perfectly repair it.[29] Without this repair, living systems would crumble into a lifeless pile of inert cells. The discovery of these essential systems inside living things is so astounding that three scientists were awarded the 2015 Nobel Prize in chemistry for their work in this area.[30]

Ways Schools Can Convey This Information

How can schools incorporate and implement this information when many students already find chemistry so hard to understand? Here are a few suggestions to help organize the chemical information into a comprehensive K-16 program that points to the Creator:

Primary Institutions: Students can analyze basic properties like density, boiling points, and melting points along with the three phases of matter: solid, liquid, and gas, and apply them to aspects of Earth that are needed for life. In our unofficial surveys of many elementary and high school students, most of them did not know which chemicals are generally found in high amounts in Earth's atmosphere. If students learn the names, formulas, and chemical structures of water, carbon dioxide, dinitrogen, dioxygen, ozone, and a few other basic elements, then a foundation can be laid for an understanding of Earth's atmosphere. Comparing Earth's atmosphere with that of the other planets in our Solar System can help students appreciate the uniqueness of our atmosphere.

Partnerships with local companies or other educational institutions can help create excitement and helpful connections. Andrews University is partnering with the Village Adventist Elementary School's outdoor-school program for 7th and 8th grades to provide the concentrations of various elements in the local creek near Berrien Springs, Michigan.

Secondary Institutions: At the secondary level, in addition to instruction about chemicals, chemical structures, and chemical bonding, students can be taught the percentage composition of our atmosphere (78% N_2, 21% O_2, 0.94% Ar, and 0.041% CO_2),[31] along with an understanding of the density and location of ozone (O_3) in our atmosphere and the dangers of too much or too little of each atmospheric ingredient. This could be compared with the gaseous components of other planets in our Solar System, followed by a discussion of why each component is important for life on Earth. More properties of water should be explained and related to sustaining life.

Tertiary Institutions: In chemistry courses, teachers can continue building a foundation for chemical design: the proper ingredients, source of ingredients, fine-tuning, process, and understanding spontaneity. Chemicals can only do certain things, even when given lots of time and energy. When students see how chemicals work and behave "on their own" within the fundamental forces, they will comprehend that nature is full of "unnatural" chemical reactions knitted together and sustained in intelligent ways beyond the reach of blind chance. We believe that students will thus receive a more purposeful foundation for their future careers in any discipline. One of the authors of this article (R.T.H.) currently provides a 10-part series during the Andrews University co-curricular educational program that helps students to appreciate the chemical design of Earth.

The foundation for our beliefs continues to be solidified by recent findings in science and Scripture. Some

Adventist scientists are working on ways to supplement our primary, secondary, and tertiary curricula with this information, which points to a loving, protective Creator who supplies all our needs. Every breath we take is a reminder that God chemically provides for our every need without us asking and without us having to earn this blessing.

Conclusion

Seventh-day Adventist education must be on the forefront of taking scientific information and partnering it with the creation story. We, as Adventist scientists and teachers, must learn how to define and defend intelligently designed systems to show they are beyond the reach of chance and time while logically pointing to the benevolent and wise Creator revealed in Scripture. Many of us are collaborating as individuals or through the Faith and Science Council of the General Conference to do just that. Excellent work in geology, archaeology, paleontology, chemistry, math, physics, and biology is being performed that scientifically supports the concept of a Creator. Biological-design information is nicely integrated into the 5th- to 8th-grade *By Design: Journey to Excellence Through Science* textbooks, but more is needed from the other disciplines, especially chemistry.[32]

A new high school biology textbook was recently released that incorporates design thinking throughout the curriculum.[33] Integrating this material is hard work and requires much inspiration and funding to carry out, as well as appropriate training and in-service for teachers. We are grateful for our churches, schools, leadership, and businesses who are partnering and coordinating resources to do the job of integration.

Scientists are not exempt from the duty to proclaim the three angels' messages but rather have additional responsibilities to proclaim that our God is the Creator and Sustainer of all life, since we know "all things were created through Him and for Him."[34] We need to be missionaries in our disciplines and train our students to do the same. It is time for more chemistry missionaries to step up and show the hand of God at work. ✐

Sidebar 1. Additional Resources

Teachers in our elementary and secondary schools do not generally have the tools and information for teaching chemical design, but we are working to solve this problem. It is important to know that our tertiary institutions are doing more to provide this critical information and resources. Please refer to the following:

- GRI (Geoscience Research Institute) webpage (https://www.grisda.org/);
- Adventist Learning Community webpage (https://www.adventistlearningcommunity.com/);
- Southern Adventist University's Faith and Science webpage (https://www.southern.edu/academics/faithandscience/);
- Southwestern Adventist University's Dino Dig page (https://www. swau.edu/dinosaurs/project); and
- Andrews University's summer STEM Boost class webpage (https://www.andrews.edu/cas/stem/boost/index.html).

This article has been peer reviewed.

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34. Colossians 1:16, 17. Scripture is taken from the *New King James Version* (NKJV)®. Copyright © 1982 by Thomas Nelson. Used by permission. All rights reserved.