

Experiment and Experience

JENNIFER B. NIELSON

I have to tell you how much I love working and living in a college town, where I get to know so many wonderful students. When our youngest, Rob, was about five, we were out shopping, and I bumped into a bunch of students, as frequently happens. It was great because he looked up at me kind of wide-eyed and said, “Mom, every place we go people know you. Are you famous?”

Of course I said, “Yes.”

I may not be famous, but I am blessed to work with so many fantastic colleagues and friends and to have so many great students; they inspire me in many ways. Many of my students are here today. My Chemistry 285 class actually meets every day at noon, so today they get a short, one-day reprieve from amino acids and proteins, but they should be suspicious that I am going to work in something from today’s devotional in tomorrow’s quiz. So pay attention.

As a brand-new chemistry graduate student at the University of California, San Diego, my faculty advisor, Dr. Charlie Perrin, gave me the relatively easy task of replicating the experiments of a student who was leaving our lab. The results from that project were going to be published in the *Journal of the American Chemical Society*, which is a top journal in my field.

When I finished the experiments, my results were the opposite of the original findings. I repeated the experiments several times, but each time the results didn’t match. I began to panic. My failure to replicate felt like evidence that I was terrible in the lab. I took my results to my advisor, and he was surprised. He suggested a series of modified molecules on which I could repeat similar experiments.

I worked hard. I purified materials. I read literature techniques. I did a mountain of experiments. I talked about ideas with my favorite friend in chemistry, Julie, and at the end of a long day I would come home and worry out loud to my husband, Dan. In the end, what we learned is that the original results were inaccurate. Eventually we published a paper in the same journal, retracting the first claims and proposing a new conclusion. In fact, the title changed from the original “Symmetries of Hydrogen Bonds” to “Asymmetry of Hydrogen Bonds.”

Charlie Perrin became one of my heroes. He valued learning truth over protecting his reputation. Every time I entered his office with new

Jennifer B. Nielson was a BYU professor of chemistry and biochemistry when she gave this devotional address on 3 March 2015.

ideas or new results, he welcomed them. He felt that even an unexpected or “wrong” result taught us something.

I learned so much from this experience—including that ice cream soothes my soul after a long day—that has shaped me over the years. I learned that experiments help us gain truth, that we can become stronger from struggles, that meaningful results require a lot of time and effort, and that working with others is essential. I believe that life experiences, which we might also call experiments, are *meant* to enable us to grow and become Christlike.

Gain Truth

Theory is not enough. Experimenting is where theory meets reality. Doctrine remains theory in our minds until we show our belief in the doctrine by acting. Amulek taught this principle to the poor among the Zoramites in Alma 34:

*Yea, even that ye would have so much faith as even to plant the **word** in your hearts, that ye may try the **experiment** of its goodness.¹*

The word they should plant is the doctrine of the Atonement:

I do know that Christ shall come among the children of men, to take upon him the transgressions of his people, and that he shall atone for the sins of the world; for the Lord God hath spoken it.²

The experiment Alma exhorts them to try is found in verses 17–29: to exercise faith unto repentance, to pray always and everywhere, to take care of the needy and the naked, to visit the sick and afflicted, and to share their substance.

Experiments can also teach us whether a theory explains reality or needs to be revised or discarded. When our son Rob graduated from diapers at age two, he got his first pair of briefs, emblazoned with the Spiderman logo.

Excited, he asked, “Does this mean I can climb up walls now?” He tested his theory, and he learned he could not climb walls, but he confirmed a number of times that he could bounce off of them. Good experiments make learning concrete and teach us truth.

I am seeing firsthand the value of experiments in my chemistry education research in Uganda. Last year Makerere University—which at 40,000 students is the largest university in East Africa and considered the most prestigious university in Uganda—had only two students declare chemistry as their major. The year before there was only one. What could be the reason for this? Here’s a clue: students in Uganda are required to study four to six years of chemistry before they finish secondary school, yet few of them have opportunities to learn chemistry principles through hands-on experience—*through experimentation*. Many secondary schools lack the adequate equipment and supplies for chemistry labs and the facilities to handle the resulting lab waste. So for most students, chemistry is pure theory and rote memorization. Consequently, many of the students come to see it as too difficult and pointless.

As I have worked at Makerere University the past few summers I have seen the need for students to experience science hands-on to make the chemistry concepts come alive and become meaningful. My research team facilitates workshops designed to help secondary school teachers incorporate simple water-based experiments into their classes and labs. The team emphasizes exploration and experience, discovery and development.

The words *experiment* and *experience* have the same Latin root: they both come from the word *experior*, which means to gain knowledge through repeated trials. Let us think about the word *trial* for a minute, because for most of us, this word represents the difficult, even horrendous, experiences we have in life. But in the scientific world, the word *trial* has positive

connotations. It refers to experiments repeated in order to learn something valuable. For example, a clinical trial can be used to study the effects of a new drug or medical procedure. In science, then, the word *trial* is not associated with the difficult parts of the experiment; it is the experiment.³

Interestingly, the same Latin root is in the word *peritus*, or “tested,” which is related to the word *peril*, reminding us that there are risks in experiments. We often don’t find the results we would like, or there are sometimes unintended consequences, like an explosion in the lab. Yet it is through experimental trials that scientists collect enough data points to see patterns in their work and reveal truths about the world.

A sufficient number of trials actually lend *power* to an experiment. *Power* in this context is not talking about how important or valuable a clinical trial or its results are; it is referring to statistical power. This kind of power is derived from the number of observations and is one of the factors that gives confidence to an experiment’s results. Francis Collins, who is the current director of the National Institute of Health, said:

*When we fund a clinical trial, are we making sure that it has sufficient power—that it will enroll enough participants—to produce a meaningful result? Small trials with uncertain endpoints may cost less than larger, well-designed trials, but may not teach us what we need to know.*⁴

Curiously, a range of experimental trials can increase the probability of more successful results. In the book *Make It Stick: The Science of Successful Learning*, the authors Peter Brown, Henry Roediger III, and Mark McDaniel describe an experiment in which eight- and twelve-year-olds were randomly assigned to one of two groups. In the control group, after the children were blindfolded, they practiced throwing beanbags at a target that was three feet away. In the treatment group, after the

children were blindfolded, they practiced tossing beanbags at targets two feet and four feet away. Then both groups were given repeated feedback on their attempts. The students practiced for a couple of weeks, and then they were all tested on how well they could throw a beanbag three feet. And surprisingly, the treatment group that had worked on the two-foot and four-foot ranges but never on the three-foot range were much more likely to hit the bull’s-eye accurately than the control group, which had only practiced the one perfect distance.⁵ This experiment suggests that practicing a range of distances prepared the children to better hit the mark at testing time.

The Lord’s plan—the plan of salvation—provides opportunities for learning in our temporal and spiritual lives, not simply for the sake of knowing but for the ability to do and become through a multitude of experiences. You might even describe what the adversary put forth—that we would always be forced to obey—as only one impoverished experience. Satan’s version of the plan had neither power nor range.

I am grateful for the opportunity to practice and continually improve and to learn truths about what I am capable of and where I need to change. Honestly, I don’t want the last time I cut someone off in traffic to be the single piece of evidence of who I am. Power comes when we see all our experiences—which are often trials in both senses of the word—simply as more opportunities to practice faith, patience, resilience, love, service, and forgiveness. Sure, I can forgive when it is my sister, but can I forgive when it is my brother? (I have six.) Or when I am tired, when I am angry, when I am busy, when I am wronged? Every experience in life would become another trial run, giving us power to discover the truth about our lives and how we can change to become more like our Savior.

One of my favorite missionary companions in Brazil was a convert who had joined

the Church at age sixteen. Sister Adriana had grown up in a family that owned a bar, and she had started drinking at an early age. She told me she was addicted and that giving up alcohol was the hardest thing she had ever done. When we taught investigators the Word of Wisdom, I could certainly share my witness of its truth, but she would share about craving alcohol and then testify that she would rather feel the Spirit, and she couldn't do both. She had felt redemption from the Savior's Atonement in this part of her life, and she could testify with power.

That is not to say that you have to have every experience in order to find truth and fulfill your potential. You don't have to experiment with things that draw you away from God. Thankfully, our own experiences are not the only ones we have to rely on. This is one of the reasons we have family and gospel stories and pass down wisdom from generation to generation. "If I have seen farther, it is by standing on the shoulders of giants," was the acknowledgment of Sir Isaac Newton.⁶

In fact, when we designed our experiments in Uganda, we didn't have to test everything. We were able to structure the workshops using literature on science education in teacher development workshops in the United States. Likewise, when I listened to my companion's testimony of the Word of Wisdom, it confirmed my own beliefs without me having to experience what she went through.

Become Stronger from Struggles

There is a saying that "the truth will set you free, but first it will make you miserable." These words sure feel true sometimes, but we have a superior way of looking at life's experiences so that they turn from trials in the purely hardship sense to trials in the cumulative knowledge sense. Christ doesn't just give us options, He gives us the power to make good choices, the power to repent and begin again after making bad choices, and

the power to identify truths from our experiences. President Howard W. Hunter taught, "If our lives and our faith are centered upon Jesus Christ and his restored gospel, nothing can ever go permanently wrong."⁷ With the Atonement my mistakes do not become permanent but instead are another trial run as I am learning how to become like Him.

When we find ourselves in a horrible experience, because of either our own bad choices or the decisions of others, we can learn to turn tragedy into victory by using the Atonement. Remember in Doctrine and Covenants 122 when Joseph Smith was in Liberty Jail? The Lord described all the ways in which the world could—and would—turn against Joseph and then counseled: "Know thou, my son, that *all* these things shall give thee experience, and shall be for thy good."⁸ We certainly can learn important skills and strengthen our faith by coming out of a trial even stronger than when we entered. Even if it is a hard experience, we can choose to see it as an opportunity to live and experiment.

Christ Himself showed us the importance of obtaining a body and experiencing life. Why couldn't Christ just study the plan of salvation and learn what His role was in the Atonement? Why couldn't He just know all things? He came to earth. He experienced the rough waves in a ship and the calming power of the priesthood during a storm. He experienced the love and kindness of His mother and father, the gentleness of the woman who washed His feet with her tears, the gratitude of a leper He had healed, and the grief of friends when Lazarus died. He experienced the tenderness of Mary weeping for Him when she did not find Him in the tomb. He experienced Gethsemane, the cross, and cruelty. It wasn't enough to theoretically know; He experienced the reality of mortality that He might know and understand what we experience. He suffered and died for us that we might experiment and live. I share my witness of Jesus

Christ and His Atonement. We will be resurrected with our bodies after this life. With Christ's help we can repent; we can change and become the person God wants us to be.

Develop a Growth Mind-Set

So how do we truly learn from our experiments—the kind of learning that brings us closer to Christ?

Reverend Thomas Bayes, the patron saint of statisticians, proposed a method for updating prior knowledge with newer experimental results.⁹ If my daily focus is to be a good driver and a kind person, a single incident of distractedly cutting someone off shouldn't have sufficient weight to convince me that I am a bad driver. But it is a valuable data point that challenges me to renew my efforts to be more conscientious in my driving *and* to react charitably when others cut me off. However, if in my search for truth I find patterns in my behavior that do not fit with my view of myself, that evidence needs to be given more weight as I look to make necessary changes.

Professor Carol Dweck at Stanford University has spent twenty-five years researching how people's self-concept matters in how they react to disappointment and failure. What do they do with results they don't like? In one of her seminal studies she gave visual IQ tests to fifth graders and then randomly assigned what type of feedback each was given. In one treatment group the students were told they had performed well and were *praised for their intelligence*. In the other treatment group the students were told they had performed well and were *praised for their hard work*.

Next the children were given opportunities to practice different types of questions, and the students praised for their effort overwhelmingly picked harder problems than the students praised for being smart. Then Dweck's team gave the fifth graders a seventh-grade IQ test, which they all bombed, but the kids

praised for effort performed better than those praised for their intelligence. This makes sense in retrospect, I suppose, given how the different groups had practiced. But then Dweck's team did something especially clever: they readministered the same fifth-grade test the children had all aced earlier. Again the effort-praised children outperformed the intelligence-praised ones. But here is the surprising thing: the kids praised for being smart actually did worse than they had in the first round of testing. It was almost as if they had grown dumber. Once they no longer believed they were smart, they weren't.¹⁰

Dweck has proposed that there are two basic mind-sets: a growth mind-set and a fixed mind-set.¹¹ The assumption of those with a growth mind-set is that intelligence, creativity, artistic ability, or other traits are flexible, not frozen, and that they can increase with continual practice. The assumption of those with a fixed mind-set is that traits are inherent and cannot be changed. The problem with the fixed mind-set is the belief that an outcome is somehow a comment on a person's very nature. If I cut someone off in traffic, it not only says that I am a bad driver but that I am a bad person. If I fail an exam it means that I am not intelligent. In contrast, a person with the growth mind-set sees mistakes and failures as data points that can be used as Reverend Bayes proposed: to update prior knowledge in order to improve.

Our daughter Abi is a talented runner. When she was a freshman in high school she became very focused on her performance—in showing how fast she was—and she feared failing because that would mean she wasn't talented. One particularly hot fall afternoon she chose not to run in a meet because it just seemed too hard for her to run well. In contrast, by her senior year she used each meet, regardless of circumstances, to learn how she could improve. She scored in every race. She ended up as her team's most consistent runner, placing better at nearly every meet, and

she ran in the state championship. She demonstrated a shift from a fixed mind-set to a growth mind-set.

The good news, which Dweck's subsequent research showed, is that you can learn to have a growth mind-set and see yourself more as a work in progress who will improve with time and effort. I have seen many of you in my classes develop more of a growth mind-set while learning chemistry. The really "good news"—*god spiel*, or *gospel*, in Old English—is that Christ's Atonement is very real and that we are not fixed but can always flex and grow.

Do Hard Things with Help from Others

My own life experiments have been possible because of the people with whom I collaborate. For years our family motto has been "Nielsons do hard things." (You can imagine that our kids have not always been fond of the family motto.) However, we were rescued so many times our first summer in Africa that we actually changed our motto to "Nielsons do hard things with help from God and others."

At one point I was traveling in rural Uganda to meet the organizer of a women's co-op. It was raining hard and the streets were not paved. By the time we arrived at the house, my friend Kristyn and I were muddy. I really hesitated though to take off my shoes to enter the house. They were fairly expensive walking sandals; I had bought them specifically because I knew I would be walking a lot in Africa that summer. With some anxiety I left them on the front porch.

When I stepped in the house I was astonished to see a paper on the refrigerator that read "As Sisters in Zion." Kristyn and I actually starting singing, and then a lilting voice joined us from the other room. I then noticed a picture of the First Presidency of the Church on the wall. We were in this little slice of heaven. Our new friend greeted us with a very traditional and gracious Ugandan greeting: "You are welcome." And we responded by

saying "thank you," which is the opposite of what we do in the United States. This woman was in the Mukono Ward, and her husband was the bishop. She told us her story and we met her kids. It was a glorious hour.

When we exited the house, my shoes were gone. I will admit that my soul sank. All those lovely feelings fled. Then from around the corner of the house came a neighbor holding my clean shoes. It must have taken her the whole hour to remove the caked-on mud. She simply said, "You are welcome." I felt the love of God and the goodness of people. Those shoes mattered to me right then only because they had given me the experience of seeing the kindness of strangers and realizing again that *any* hard thing I have done really has come through the help of God and others.

I love the ways that you serve and connect to each other. I see you doing this all the time. Earlier this semester one of my students came to me distraught over failing a midterm. We discussed several ways she might improve: taking the practice exam as if it were real, forming a study group, teaching the principles to others, and trying more problems. She listened, she adjusted, and she aced the next midterm. Last week during office hours a different student expressed dismay at her performance on the midterm. The first student overheard her and immediately invited the discouraged classmate to join her study group and learn from the group's collective experience. Love from others is essential when we are not having the experience we want.

Embrace Experience Without Fear

There will be many times that we have an experience we don't want. So what else can we do? May I suggest, with apologies to Stephen Stills: If you can't be with the experience you love, honey, love the experience you're with.¹²

Rabbi Ronnie Cahana had a stroke affecting his brain stem in 2011. The effect of the stroke was slow enough that he was aware as

his body gradually became paralyzed, starting from his legs and traveling up to just below his eyes. The condition is known as locked-in syndrome. Family and friends learned to communicate by saying the alphabet and then having him blink when they got to the right letter, thereby spelling out any message.

Rabbi Cahana's reaction to this experience was incredible. He spent hours pondering the beauty of God and life, wondering that he could experience such an exceptional state. He said that at night his mind would soar and he would be in motion, "swirling and twirling" above the ground. By blinking his eyes he wrote letters and sermons sharing his experience. He declared, "I want you to know that this too, is healige (holy in Yiddish). I am in a broken place, but there is holy work to be done."¹³ His willingness to search for truths in this trial helped him to transcend his misery.

In a TEDMED talk his daughter said that the family cocooned him in love.¹⁴ He imagined moving his fingers while his loving family physically moved them in therapy. And then his body rekindled. Slowly he began to feel electrical sensations in his arms. He eventually regained enough feeling to be able to breathe on his own and then to talk with his own voice. Every day he witnessed another miracle. His body developed like a baby's, but he observed it with all the experience of a fifty-seven-year-old mind and felt wonder and gratitude. He used his new understanding of truth to grow and was, remarkably, not afraid. The truth had set him free.

If we are not afraid, our life experiments can be tools to learn truth and to make changes. The pioneer chemist Marie Curie believed that "nothing in life is to be feared—it is only to be understood."¹⁵ My daughter Catie is in a class this semester studying Mormon women, and she shared with me the story of another pioneer, Jean Rio Griffiths Baker, who, like many new converts from England, had to face an ocean of unknowns to travel to the United

States to be with the Saints. In 1851, before she set out to cross the plains to Utah, she wrote in her journal, "The future will most likely be an account of trials, difficulties, and privations such as at present I have no idea of, so as to be able to provide against them. But as you are aware I am not one to go through the world with my eyes shut."¹⁶

Paul taught us how to approach life experiences using the Savior's Atonement. One of my favorite scriptures is 2 Timothy 1:7 because of the three gifts from God that are specifically mentioned: "For God hath not given us the spirit of fear; but of power, and of love, and of a sound mind."

Our earth life—and for us, this university life—is a unique place for exploration, experience, and discovery. Let us use our life experiments to turn theory into reality with Christ's help. In the name of Jesus Christ, amen.

Notes

1. Alma 34:4; emphasis added.
2. Alma 34:8.
3. There is even a laboratory procedure that plays on the double meaning of the word. It is known as Job's method because it has so many trials.
4. Francis S. Collins, "From the NIH Director: The Importance of Clinical Trials," *NIH Medline Plus* 6, no. 2 (summer 2011): 2, nlm.nih.gov/medlineplus/magazine/issues/summer11/articles/summer11pg2-3.html.
5. See Peter C. Brown, Henry L. Roediger III, and Mark A. McDaniel, *Make It Stick: The Science of Successful Learning* (Cambridge, Massachusetts: Belknap Press of Harvard University Press, 2014), 46.
6. Sir Isaac Newton, in David Brewster, *Memoirs of the Life, Writings, and Discoveries of Sir Isaac Newton*, vol. 1, (Edinburgh: Thomas Constable and Company, 1855), 142; see also bbc.co.uk/worldservice/learningenglish/movingwords/shortlist/newton.shtml.

7. Howard W. Hunter, “Fear Not, Little Flock,” BYU devotional address, 14 March 1989.

8. D&C 122:7; emphasis added; see also verses 1–6.

9. See Thomas Bayes, “An Essay Towards Solving a Problem in the Doctrine of Chances,” *Philosophical Transactions of the Royal Society of London* 53 (1763): 370–418, rstl.royalsocietypublishing.org/content/53/370.full.pdf; also, stat.ucla.edu/history/essay.pdf.

10. See Claudia M. Mueller and Carol S. Dweck, “Praise for Intelligence Can Undermine Children’s Motivation and Performance,” *Journal of Personality and Social Psychology* 75, no. 1 (1998): 33–52.

11. See Carol Dweck, *Mindset: The New Psychology of Success* (New York: Random House, 2006).

12. See Stephen Stills, “Love the One You’re With,” *Stephen Stills* (Atlantic, 1970); see also

Crosby, Stills, Nash, and Young, *4 Way Street* (Atlantic, 1971).

13. Ronnie Cahana, quoted in Shayne Vitumb, “Rabbi Ronnie Cahana, Broken, but with Holy Work to Do,” *Jewish Herald-Voice*, 31 May 2012, jhvonline.com/rabbi-ronnie-cahana-broken-but-with-holy-work-to-do-p13146-96.htm.

14. See Kitra Cahana, “My Father, Locked in His Body but Soaring Free,” talk given at TEMED 2014, San Francisco, <http://tedmed.com/talks/show?id=292955>.

15. Marie Curie, quoted in Barbara Goldsmith, *Obsessive Genius: The Inner World of Marie Curie* (W. W. Norton, 2005), 15.

16. Kenneth W. Godfrey, Audrey M. Godfrey, and Jill Mulvay Derr, *Women’s Voices: An Untold History of the Latter-day Saints, 1830–1900* (Salt Lake City: Deseret Book, 1982), 221; see also pages 203–21.