COMMENTARY

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Advances in Science Are Not Linear; They Are Zigzag

> When an old and distinguished person speaks to you, listen to him carefully and with respect—but do not believe him. Never put your trust into anything but your own intellect. Your elder, no matter whether he has gray hair or has lost his hair, no matter whether he is a Nobel laureate may be wrong. The world progresses, year by year, century by century, as the members of the younger generation find out what was wrong among the things that their elders said. So, you must always be skeptical —always think for yourself.
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> —*Linus Pauling (1901–1994)*

In my outpatient clinic sessions over the last 6 months, I start the visit by asking if the patient has been vaccinated against coronavirus disease 2019 (COVID-19). Unfortunately, the answer is often "no, I have not been vaccinated." Because most of these patients have clinically important heart disease, I always spend the next 5 minutes trying to convince them that the vaccine is indeed safe and will protect them from the worst complications of a COVID infection. Patients who are not vaccinated have often been reading internet stories about the rare but nevertheless serious side effects that can occur with the vaccines. At that point in the interview, I do my best to inform the patients that there is only a tiny chance that they will experience an adverse event.

Another comment I often hear is, "Advice from the scientists keeps changing. How can I trust what they are saying since they change their minds all the time?" "Yes," I reply "particularly at the beginning of the pandemic there were many false starts because of our lack of solid information about this virus." I even tell them how our own university hospital initially told us not to wear masks and that the virus was transmitted by touch. Of course, we now know that microscopic droplets in our exhaled breath is the route by which the virus is transmitted from 1 person to another. I readily admit to patients that we did not know this during the early phase of the pandemic, and this ignorance led to the "no mask" order circulated in our and other hospitals throughout the United States. What I then explain is that scientific advances and knowledge do not advance in a "straight line."

Steps forward are invariably preceded by false starts and incorrect assumptions that are eventually shown to be wrong. Each step forward is usually accompanied by a variety of dead-end observations and failed experiments. Thus, scientific advances occur not in a straight line but rather in zigzag fashion with many of the "zigs and zags" shown to be incorrect.

Many of my patients then ask why it is that scientists end up following false leads; why not get it right from the start? That question leads to a brief description of the scientific method, which directs us to develop an idea, a hypothesis, and then do everything in our power to prove it wrong scientifically. If we fail to prove it wrong, then the hypothesis gains strength as well as momentum and may even be tentatively labeled as "true" until, of course, future scientific exploration proves it wrong or amends the initial statement.[1] Just because many experts currently believe that something is true does not prove that it will be true in the future as noted in the quote from dual Nobel Prize winner, Linus Pauling.

There are many examples of widely held beliefs that were subsequently shown to be incorrect. Remember the meeting between the Pope and Galileo where the scientist informed the Pope that the Earth was not at the center of the universe and where the Pope forced Galileo to agree that the Earth was indeed at the center of the universe as stated in the Bible. We now know who was correct in that debate. Another example involves what I was taught as a Harvard medical student: Peptic ulcer disease was caused by life stresses, and ulcerative colitis resulted from a poor childhood relationship with one's mother. An interesting fact is that Nobel Prizes have been awarded to individuals who demonstrated that firmly held ideas were false, an example of zigzag in the process of scientific advance.[2-4]

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What I have personally learned from these disturbing patient interviews is that many individuals would rather believe an opinion expressed on Twitter instead of listening to me. Unfortunately, many of these Twitter statements come from persons with minimal scientific training as well as deep-seated prejudices. I fear that often my efforts to convince patients to take the COVID vaccination are in vain, but I keep trying. There is an occasional bright spot: Some patients do tell me that they are now convinced and that they are going to get "the stick." I hope that they mean what they say, but I do not know for sure that they actually get vaccinated.

As always, I enjoy hearing from readers of the journal at jalpert@email.arizona.edu. I promise to respond.

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References

1. Wilkinson M. Testing the null hypothesis: the forgotten legacy of Karl Popper? *J Sports Sci* 2013;31:919–20. https://doi.org/10.1080/02640414.2012.753636.
2. Nobel Prize in physics: meet the three winners who changed the way we think about the universe. *Science Times*. Available at: https://www.sciencetimes.com/articles/24031/20191011/nobel-prize-in-physics-shared-by-three-scientists.htm. Accessed October 19, 2021.
3. Behind the scenes of the Nobel Prize in physiology or medicine. NobelPrize.org. Available at: https://www.nobelprize.org/behind-the-scenes-of-the-nobel-prize-in-physiology-or-medicine/. Accessed October 19, 2021.
4. Thompson G. *Nobel Prizes that Changed Medicine*. ed London, UK: Imperial College Press; 2012.