Paying Attention to the Wonder and Skepticism of Science

Charles O. Rutledge
School of Pharmacy and Pharmacy Sciences, Purdue University, West Lafayette IN 47907-1330

Considerable energy in the academy of pharmacy education has been devoted to changing the curriculum so that graduates of our programs are better able to deliver pharmaceutical care to patients. We have assumed that pharmaceutical care is best delivered from a solid foundation in the sciences upon which the profession is based. Therapeutic problem-solving is best done with an in-depth knowledge of how the human body works and how, in the presence of disease, it responds to medications. The content of science in our curricula has spread from a foundation of chemistry, biology, pharmacology, medicinal chemistry and pharmaceutics to include behavioral, social, and economic sciences. Despite this general attention given to the sciences, we have not given as much thought to the essence of science as understood by Michelangelo, Isaac Newton, William Withering, Claude Bernard, Paul Ehrlich, and Alexander Fleming. This is the science of wonder, curiosity, reasoning, hypothesis testing, experimentation, and skepticism.

The science of our professional curriculum is often characterized by short-term memorization, information categorization by discipline, and many descriptive details. Rather we should be focused on extensions of two basic questions: (i) How does the universe work?” and (ii) “What accounts for life?” These questions demand that we have an understanding of mechanisms and that we are constantly analyzing data, searching for the truth. Sometimes, I have tried to gain an appreciation of what students are learning by asking them how they are doing when I see them in the halls. I usually hear about those exams that they have survived and a list of exams which are coming up. Perhaps, instead I should ask them if they have learned anything new about life and about how the universe works.

An indication of the impact that science has had on our students can be seen from a couple of anecdotes. Have you ever discussed the Krebs Cycle with alumni of your pharmacy program. I have had that experience and uniformly they recognize the term but few have a true understanding of the significance of the Krebs cycle. They have missed the idea that this is nature’s way of having the body convert carbohydrates from food into a form of chemical energy that the body can use to regulate cellular function. The way that nature has evolved a series of enzymes and cofactors, including oxygen, in a cyclical pattern to solve this problem should be of great fascination to students. Instead it has been experienced as an exercise in the memorization of a meaningless series of names. It does have a practical side too, for if one knows the function of the Krebs cycle, the action of a variety of poisons can be explained.

Another example indicating that we need to do a better job of focusing on the excitement of science can be seen in continuing education seminars. How many times have you been to a continuing education session in which the speaker shows the structure of a drug and you can hear a groan throughout the audience? The speaker immediately apologizes. Instead, the structure should be welcomed as an excellent clue as to the mechanism of action and the manner of metabolism and distribution of the drug throughout the body.

When I was growing up, I once overheard my father make reference to me. He said that I was basically a good kid. It was just that I didn’t pay attention sometimes. I have thought about that a good deal since then. He was right because I wasn’t paying attention to the same thing that he was at a given moment. In the intervening years, I have considered that paying attention is an important way to have a group of people focus on a particular issue. Thus, I would define paying attention in this context as: bringing together increased energies to focus on a particular topic at the same time that others are also focused on that topic.

This year as President, I would like the Association to pay attention to science and particularly to the “Wonder and Skepticism of Science.” These words were carefully chosen. The wonder of science can be illustrated by considering the origin of museums. The word museum is actually derived from the French word musé or muse, which in an archaic sense means to wonder or ponder dreamily in thought. The first museums were of the fifteenth and sixteenth century and were called wunderkammern or wonder chambers. They were small cabinets that contained oddities of nature often from the new world. These are described in a fascinating book by Lawrence Weschler called Mr. Wilson’s Cabinet of Wonder(1). David Wilson has a small museum in Los Angeles called the Museum of Jurassic Technology that illustrates oddities of nature. These wonders are so strange that they can scarcely be true. The book begins with a quotation from Michael Faraday: “Nothing is too wonderful to be true.” To illustrate the point, is the ant Camponotus floridanus. This ant looks as though he was attacked by a spear to the head. On closer examination, the ant appears to be growing a horn. What is going on? How often have we taken unusual observations of science related to our area of expertise and asked students to wonder about them and offer tentative explanations. How would you explain this spike coming out of the ant. Is it a genetic abnormality? Is it derived from the exoskeleton? Has it been attacked by a microorganism? This is a wonder of nature. The answer is that the ant gets along fine in the forest foraging for food until fungal spores fall from the trees and infect the.
ant. The fungus goes to the brain and soon begins to consume the brain and other soft tissue of the ant. The ant engages in behavior that is odd for an ant and climbs to the top of the forest where it sticks its mandibles in a twig and stays there. The fungus continues to multiply until a spike emerges from the head of the ant and an orange head on the spike explodes and many spores are released to the bottom of the forest and after finding new ants the cycle is repeated.

Wonder was defined, up to the end of the eighteenth century, as a form of learning—an intermediate, highly particular state akin to a sort of suspension of the mind between ignorance and enlightenment that marks the end of unknowing and the beginning of knowing. Albert Einstein said, “The most beautiful experience we can have is the mysterious. It is the fundamental emotion that stands at the cradle of true art and true science. Whoever does not know it can no longer wonder, no longer marvel, is as good as dead and his eyes are dimmed.” We need to continue to wonder about the universe and about life.

Wonder alone is not enough. Wonder alone can lead to misuse of science and even hysteria. Carl Sagan in a book called “The Demon-Haunted World”(2) illustrates with the phenomena of flying saucers and extraterrestrial life how important it is to combine wonder with skepticism. He refers to Bertrand Russell as saying: “Insight, untested and unsupported, is an insufficient guarantee of truth.” Sagan makes the point that “the heart of science is an essential balance between two seemingly contradictory attitudes—an openness to new ideas, no matter how bizarre or counterintuitive, and the most ruthlessly skeptical scrutiny of all ideas, old and new.” He quotes Rene Descartes who said: “I did not imitate the skeptics who doubt only for doubting’s sake, and pretend to be always undecided; on the contrary, my whole intention was to arrive at a certainty, and to dig away the drift and the sand until I reached the rock or the clay beneath.”

Thus we must use skepticism to inspect the wonder so that we can come closer to the truth about how the universe works and what accounts for life. Most ideas of wonder are wrong, meaning that they are not supported by the data. Many ideas cannot be tested and lead to non-testable hypotheses. These ideas are not useful in discovering the truth. We must come up with ideas that after skeptical scrutiny can be tested to discover the truths of the wonders that we observe.

Our graduate and research programs would be enhanced if we paid more attention to the wonder and skepticism of science. Our graduate training programs are generally designed to educate scientists to perform independent research. As the exciting research questions are found in increasingly narrow fields of research, so too is our training. In many of our programs, there is very little vertical integration from the subcellular-based systems to clinical sciences, psychiatry and even health care and economic systems. What are the social, political, and ethical ramifications of the research that we do? There is a tendency now to have more horizontal integration across disciplines as represented by multidisciplinary and interdisciplinary approaches to research problems, but many of our graduate and research programs are still highly discipline-based and need to have a broader focus. More attention should be paid to the research activities in the social and behavioral sciences as practiced in schools of pharmacy. Smith and Torrey(3), in an article in Science entitled “The future of the behavioral and social sciences,” have made specific recommendations for use of data bases and for incorporation of new methods of analysis that are appropriate for the behavioral and social sciences questions of interest in the analysis and delivery of pharmaceutical care.

Paying attention to the wonder and skepticism of science could be useful as we deliver pharmaceutical care to patients. We attempt to deliver pharmaceutical care to patients in a society that is virtually illiterate when it comes to science. There have been many surveys showing that even our college graduates do not know the most elementary facts related to science (4). In a recent survey of patients in the hospital, it was observed that, in addition to many patients being unable to read adequately, many more had an inadequate health literacy. It was viewed as an important barrier to their understanding of their diagnosis and treatment (5). There is a large literature on science literacy and how it has been addressed both by science educators, scientists and policy-makers. The best treatment of this subject is a book by Morris Shamos entitled “The myth of scientific literacy”(6). He states that there are three levels of science literacy. The first he calls cultural science literacy, in which people recognize science terms usually as used by the media. Most high school graduates reach this level. The second level is functional science literacy, in which people converse, read, and write in a nontechnical way about science-related subjects. The top 25 percent of the high school class achieve this level but they fail to retain this knowledge as they advance into adulthood. The third level of science literacy is called true science literacy, where individuals actually know something about the science enterprise. They are aware of major conceptual schemes that form the foundation of science, and they are familiar with the process of science.

It is important when delivering pharmaceutical care to determine not only general literacy in terms of the ability to read and write but also science literacy in terms of the ability to understand what is happening to patients’ bodies during the treatment of disease. The premise is that the better the patient understands the science of the disease and its treatment, the better will be compliance and the therapeutic outcomes. Pharmacists could work with patients to make observations and collect data in therapeutic problem-solving. When does the pain occur in relation to meals, exercise, and the use of over-the-counter products? Pharmacists could help patients collect and interpret the data.

How should AACP and our schools pay attention to the wonder and skepticism of science? I would like to charge the three standing committees of the Association to pay attention to the wonder and skepticism of science as related to their specific sphere of influence.

 Academic Affairs Committee

The academic affairs committee will be asked to study the educational outcomes developed by the Center for Advancement of Pharmaceutical Education (CAPE) from the point of view of the principles of science, emphasizing abilities of scientific thinking, observation, experimentation, analysis of data, and problem-solving. They should recommend modifications of these outcomes and add other outcomes, if necessary. Secondly they should provide suggestions for how the faculty might examine the curriculum’s ability to convey the wonder and skepticism of science. A third charge will be to investigate the availability and use of
instruments to assess student attitudes about science. Finally, I will ask the committee to recommend that AACP sponsor programs that will help the faculty in the development of approaches and processes to instruction that will instill a spirit of experimentation in teaching and learning, and that will facilitate student development of an appreciation for the wonder and skepticism of science.

Research and Graduate Affairs Committee

I am asking the research and graduate affairs committee to examine the extent to which the principles of scientific investigation are incorporated into graduate training programs in the pharmaceutical sciences. These are well developed in The Art of Scientific Investigation by W.I.B. Beveridge(7). Here are some of the important concepts that should be reviewed:

- Critical review of the literature
- The use of the controlled experiment to test hypotheses
- The role of chance in important discoveries
- The use of the hypothesis to devise new experiments
- Productive thinking consists of both imagination and curiosity—don’t be trapped by the hypothesis
- Intuition is often helpful in bringing fresh ideas but it may be wrong
- Reasoning consists of verifying, interpreting and developing data
- Accurate observation of complex phenomena is essential but difficult
- Expect extreme resistance to new ideas that must displace established knowledge

Many of these concepts may be encountered while conducting a thesis project but it would be an enhanced learning experience if specific attention were given to these concepts, which are central to the science enterprise. The case method of study would be an excellent way to teach these concepts.

I don’t know how many of you have been following the scientific integrity case involving David Baltimore, Thereza Imenishi-Kari and Margot O’Toole. It has been going on now for over ten years and in some ways this case highlights the difficulty science is having in the eighties and nineties. There is a good review of this case in the May 27, 1996 issue of New Yorker magazine. The societal issues involve character attacks by members of the press and an extremely aggressive interrogation by a Congressional committee, but the essence of the case is the use of scientific judgment and intuition in deciding the validity of experiments and data. On the one side, there are those who say that there should be rigid adherence to a protocol and no data should be excluded. There are others who say that judgment needs to be used to establish the validity of the data to discover the truth. The truth is often hidden in a morass of irrelevant data points. I would like the research and graduate affairs committee to investigate whether the art and principles of science are appropriately represented in our graduate training programs. In addition, there are those in the pharmaceutical industry who are calling for more scientists trained at the level of the MS degree. I would like for this committee to evaluate the role of the MS degree in the pharmaceutical sciences and decide whether their roles should be expanded or perhaps be diminished.

Professional Affairs Committee

The Professional Affairs Committee will be asked to examine the “wonder and skepticism” of science in relationship to professional practice, identifying ways to enrich the practice experience through better understanding and application of the sciences basic to the profession. They will also be asked to identify ways in which pharmacists can enhance patients’ understanding and use of science to improve their own health and well-being. Finally, this committee will identify ways in which pharmacists can better engage patients as partners in both the scientific and clinical aspects of their care. For example, pharmacists may become involved in teaching enhanced observational and measurement skills, fostering collaboration with patients in interpreting data, and helping them form conclusions about their health and clinical outcomes from treatment.

Commission on Graduate Education

Considerable attention has been paid to both the quantity and outcome abilities of scientists that have been trained in this country in the past few years. The Committee on Science, Engineering and Public Policy (COSEPUP) of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine published a report entitled Reshaping Graduate Education of Scientists and Engineers. This report raised questions about whether we are producing too many scientists and whether their training has adequately prepared them for the positions that they eventually fill in the scientific community. Most of the training programs are designed to develop independent research investigators and yet it has been estimated that less than 15 percent of biomedical scientists actually assume positions as independent research investigators.

Although the issue is important for science in general, training in the pharmaceutical sciences has some unique characteristics. The training programs represent many disciplines from chemistry and biology to sociology and economics. They have in common the study, discovery and appropriate use of drugs used in the prophylaxis and treatment of disease. Our PhD graduates find positions not only in academia and the pharmaceutical industry but in several government agencies, research institutes, and in the health care industry.

In addition, the Council on Competitiveness has published a report entitled Endless Frontier, Limited Resources: U.S. R&D Policy for Competitiveness in which it is emphasized that research and development partnerships hold the key to making and exploiting discoveries and innovations in areas critical to the nation’s future. It defines partnerships as cooperative arrangements engaging companies, universities, and government agencies in varying combinations, pooling resources in pursuit of shared research and development objectives. They have identified Pharmaceuticals as one of the six industrial sectors in which these partnerships should be fostered. Are our schools and colleges prepared to enter these partnerships and to participate as full participants? Are our training programs suitable for educating scientists who will have careers within these partnerships?

The members of AACP have been concerned about issues of graduate education for many years. Several groups have studied various aspects of graduate education, but little has changed in the way in which we educate and train scientists in schools and colleges of pharmacy. As we approach the twenty-first century, we have had many changes...
not only in the sciences related to pharmacy but in the policies regulating science and the funding of science. It is now time for an in-depth, scholarly analysis of training in the pharmaceutical sciences with specific recommendations for implementation of changes in our PhD training programs.

Several background documents will be useful to begin this analysis. Besides those previously mentioned, the quality of graduate education was address by the Study Commission on Graduate Education (The Lemberger Commission) in 1979. The Commission to Implement Change in Pharmaceutical Education’s Background Paper IV, entitled The Responsibility of Pharmaceutical Education for Scholarship, Graduate Education, Fellowships and Postgraduate Education and Training, identified many issues that colleges and schools of pharmacy should address in evaluating their graduate programs. The AACP Research and Graduate Affairs Committee has addressed many of the quality and quantity issues related to graduate programs over the years. In 1995-96, it recommended that a commission be established to examine two questions over a longer period of time. The Committee also recommended that the perspective not be limited to those representing academic pharmacy. The Commission should have representation from the pharmaceutical industry, government, and the broader scientific community. Therefore, a Commission on the Future of Graduate Education in Schools of Pharmacy will be established to address the following questions:

• What are the numbers and abilities of PhD graduates needed in the pharmaceutical sciences now and in the future? In particular, what factors should be used to monitor the supply and demand of pharmaceutical scientists? How can programs adjust the supply to meet current and projected demand for scientists?

• What should be the nature of the education and training of PhD students in the pharmaceutical sciences? Additionally, what is the appropriate range of skills needed by PhD students to maintain productivity in a rapidly changing, multidisciplinary scientific environment which is practiced on a global scale?

The expectation is that these questions will be addressed in a scholarly manner using the documents previously developed by AACP as well as other documentation deemed appropriate by the Commission. The Commission will analyze the current training in the pharmaceutical sciences (defined broadly to include the social, behavioral, and economic sciences), make specific recommendations for implementation that would apply both to AACP and individual schools and colleges, and provide for an evaluation mechanism to assess whether progress has been made in the implementation of the recommendations. It is hoped that, after many years of discussion of issues related to graduate education in the pharmaceutical sciences, action will be taken. Faculty in our schools need to make changes that will better enable our PhD graduates to address questions related to the pharmaceutical sciences in the twenty-first century.

In addition to these new initiatives, I will be working with the Board of Directors to continue the unfinished business begun by President Mary Anne Koda-Kimble, including the Janus Commission, the strategic plan, and analysis of the organizational structure of AACP. We have made great strides in curricular reform, adjusting our degree programs so that our graduates are better able to deliver pharmaceutical care. Through CAPE we are addressing the needs of current practitioners who want additional education to provide better pharmaceutical care to their patients. The Janus Commission is analyzing important changes in our environment. We need to continue to examine whether AACP should undergo organizational change to better achieve our vision of pharmaceutical education in the future. We should continue the stepped-up pace set by David Knapp and we should implement what we learned off the trail with Mary Anne Koda-Kimble. In addition, I hope that we will pay attention to the wonder and skepticism of science in our professional programs, our graduate and research programs, and in professional practice.


References