

# Thoughts on Chemistry and the Curriculum of a Catholic University

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The discussion of curriculum at a Catholic university raises difficult questions for the inclusion of Catholic/Christian values in the teaching of chemistry at the undergraduate level. Certainly the curriculum is a very important part of the undergraduate experience. While faith in God may be the heart of the Catholic university, the curriculum is its lifeblood, supplying the university with an ever-refreshing flow of wisdom, sense of purpose and spiritual life. It is through the curriculum that the perspective of Catholicism is presented, argued, witnessed, and lived by the university. Chemistry, and the sciences in general, are not immune to the need for the presentation of Catholic/Christian values in the curriculum.

It should be pointed out that, while Catholic/Christian perspectives are an important part of the undergraduate curriculum, there is an equally, if not more, important part of the curriculum that the chemistry discipline addresses. That is in the skill of critical thinking. Throughout all of the reading materials for the seminar, critical thinking was at the top of the educational goals. In *Ex Corde Ecclesiae*, the first educational goal is the development of critical thought by students, before those critically trained minds are focused on the theology, science, literature, etc.

Beyond critical thinking, and in areas more traditionally assigned to the Catholic/Christian perspective, there are two basic areas of instruction in chemistry where Catholic/Christian perspectives find inclusion in the curriculum. The most obvious area is in the discussion of moral and ethical decisions made by chemists during their activities as chemists. The carry-over of strong Catholic/Christian values from the classroom to the laboratory to the work place and, finally, into the homes is the responsibility of all chemistry instructors. The second area where the Catholic/Christian perspective is important to the undergraduate chemistry curriculum is in presenting to the students the knowledge that high quality chemistry is not antithetical to Catholic/Christian beliefs. A slightly stronger statement would be that the belief in any religion supporting a sincere theology does not prevent full participation in chemistry, nor does the belief in a scientific theory or model prevent full participation in religion.

However, the insertion of Catholic/Christian perspective in the chemistry curriculum is not simple. The artificial insertion of moral and ethical questions in courses where pedagogy and factual content are the major curricular goals is not only difficult but also can be interpreted as arbitrary and disruptive by students. There are problems dealing with religious content, appropriate reading materials and appropriate chemical and religious models. The difficulties cover the spectrum from the specific, i.e., what are you going to use for a book? to the general, i.e., what does chemistry have to say about the significance and meaning of human life? to the sublime, i.e., what is God's role in the

formation of chemical bonds? These are questions that need be contemplated and answers attempted. I hope to begin here with a discussion that will provide a source of initial discussion and criticism. In the last section, I will propose the development of a course that could help students generate meaningful discussion of a Catholic/Christian perspective in chemistry.

### *University-wide Educational Goals in Chemistry*

Instruction in chemistry in the undergraduate curriculum carries many of the same educational goals that are present in the other university disciplines. Critical thinking is widely recognized as one of the primary educational goals at the university level. Chemistry, since its regular inclusion in the undergraduate curriculum in the 19th century, has played a key educational role in the education of science and engineering students. Chemistry is one of the first disciplines where students are forced to conceptualize heavily and think critically in the abstract.

Chemistry is a very abstract subject. It requires conceptualization and visual imagination of the existence and action of truly microscopic particles that behave in highly predictable manners. Chemists have yet to see an atom or molecule directly. We have only detected electrical signals that signify the presence of an atom, yet the effect of billions of billions of atoms can be directly observed. On a macroscopic level, the rearrangement of individual atoms to make new compounds returns the students from abstract conceptualization of a chemical reaction to the observable reality of the student's test tube. This affirmation of the atomic model by their own observations as a demonstration of a testable abstract theory has resulted in the study of chemistry early in the curriculum of university students. Abstract thinking followed by rigorous critical thinking is a very important intellectual tool. Once students can readily move between the abstract world of their ideas and the physical reality of their own experiments, they are ready to come to grips with increasingly more abstract concepts and models within chemistry and in other disciplines.

Suffice it to state again that the critical thinking goals of the Catholic/Christian perspective in the university curriculum are readily met in the chemistry discipline. I will argue in the third and fourth sections that the ability to critically review abstract theories and models is one of the most important, yet difficult, skills needed by a student at a Catholic university.

### *Ethical Issues in Chemistry*

In a world of ever-quickenning development of new chemical technologies, critical review of the chemistry which generates these new technologies requires a well-educated populace. Chemists are finding themselves more involved in making ethical judgments on their own and their colleagues' endeavors. It is in the question of ethical judgments that chemists need to discuss Catholic/Christian perspectives within their instruction in chemistry.

The inclusion of ethical judgments in the performance of chemistry begins with the mundane imperative to correctly and accurately record experimental procedures and results. It is very easy to approximate or incompletely record in spite of very careful measurement and thereby generate inaccurate data. Further along in the scientific method, it is far too tempting to observe only those data that support the hypothesis.

At higher levels of critical review, chemists must evaluate the purpose of their scientific activities. Most chemical research is performed with the intent of furthering chemical knowledge or creating materials with more useful properties. Chemists now know that they must be more vigilant in their design and testing of new chemicals before allowing them to leave the realm of their laboratory. The inappropriate use of chemicals has led to a highly suspicious public. Chemists need to show that they are acting in an ethical manner and are making sound scientific and ethical judgments in their chemical activities.

Within the chemical curriculum, there is a justifiable emphasis on covering the basic course material and instruction in problem solving with little discussion of the ethical issues. Practically speaking, it requires considerable thought to include extended discussion of ethical issues in the chemical curriculum. The first four semesters of the chemistry curriculum are nearly entirely devoted to basic instruction in the principles and facts of chemistry. Discussion of ethical issues generally focuses on the mundane aspects of ethical behavior. The discussion of the ethical actions of other chemists as models can only be barely mentioned due to the students' still nascent concepts of chemical models. A meaningful discussion of ethical choices and decisions often requires a deeper understanding of the sources of the original inquiry, identification of the subtle errors in the decision process or historical relevance.

In order to discuss complex controversial issues in the ethical practice of chemistry, it is important to have had personal experiences in the discipline. This is where the "apprenticeship" of laboratory and the actual practice of chemistry are important. By sharing experiences, the conceptualization of new or other problems becomes much more possible. In addition, it is very important that the students be able to critically review the information of the case studies. Critically reviewing unfamiliar situations and documents can be a very difficult intellectual process for students. Often it is necessary to be able to not only understand what is written, but also be able to identify what has not been included. The process requires conceptualization of the circumstances of the situation chemists may find themselves, and then require extension beyond the described situation. Throughout the discussion of ethical issues, it is imperative that the students reason critically.

### *Antithetical Issues in Chemistry*

It is important for the student at a Catholic/Christian university to recognize that chemistry is not antithetical to the Catholic/Christian perspective. The development of modern experimental science since the mid-19th century has been regarded by many people as an overt methodical attack on religion. In *Ex Corde Ecclesiae*, the pope makes

clear that modern science and theology are both working on understanding and improving the human condition. These fields of study are not in competition with each other, but rather are working on separate, yet important, aspects of the human condition.

Several authors (Barbour, Peacocke, and Polkinghorne) have detailed the commonalities and differences between scientific and theological study; all agree that the sources for conflict between the sciences and theology arise from within our own failings as humans and our limited human minds. The human mind is capable of transcending only very little of our world. As mankind has delved toward a potentially deeper understanding of the world and our relationship with God, mankind has built models. It is the contention of many authors that the conflicts between our limited models give rise to conflicts between science and theology.

There are many models within chemistry. The basic atomic model is fraught with misconceptions, poorly diagrammed pictures and rationalizations. For example, very few scientists actually believe that electrons spin. In our macroscopically limited view of electrons, we simply find it easier to conceptualize a spinning electron, rather than assign a physically vague quantum number. In yet another model, we cannot conceptualize how an electron in a particular atomic orbital has zero probability of moving between two sides of an atom, yet has equal probability of being present on both sides.

Likewise, we have God, who is a trinity and imagined as father, mother, son, king, lord, ruler, law giver, giver of free will, judge of free will, shepherd, gardener, fisherman, creator, omniscient, compassionate, forgiving, active and a combination of all the above. This is certainly not a complete list, but represents some of the major symbolism we use in the discussion of God. We are further handicapped by our own interpretation of God's action as viewed by our own models.

Since both chemistry and theology are striving to enhance the human condition through understanding the range and meaning of human existence, it is not surprising that chemical and theological models collide. The unfortunate part of these collisions is that they could be avoided. It is the extension of a model beyond its usefulness that causes the collision with another model. A God who only creates and doesn't act in the present is certainly a model that some physicists espouse, yet this model is clearly contradicted by the regular belief of God's action in the world.

A very important model in the scientific field is the theory of reductionism. Briefly, reductionism is the idea that study toward greater and greater detail, in an ever-decreasing level of complexity, ultimately will reveal the causality of phenomena. Reductionism has been, and continues to be, an essential guiding principle in modern science. A great amount of scientific knowledge has been gained by finely dividing the question to dissect out the essential causality. However, with the limitations of knowledge at the quantum level and the unraveled morass of many higher-level questions, reductionism is unable to make significant headway in questions at both levels. It is the extension of reductionism beyond its useful boundaries, or unsupported extrapolation, which has led to the greatest levels of conflicts between science and religion.

Such extrapolation of reductionism to extremely complicated systems has, in general, drawn displeasure from theologians. This is mainly due to the fact that religion is their particular area of study and religion is a study which attempts to transcend and find meaning in the human condition. Attempts to trivialize humanity, deny transcendence and reduce the search for religious meaning to wholly physical causes is generally considered hostile. While scientists need to recognize that mankind in the Catholic/Christian perspective is more than a collection of cells, organs and systems, theologians need to recognize the physical reality as well as the spiritual reality.

It should be of little surprise that mankind has such problems with attempts to understand God. Our models are woefully inadequate and require constant and critical review. Any serious discussion of religious or scientific models requires the application of critical thinking to very abstract models. The Catholic/Christian view is that someday we may understand God and that God, in knowing how inadequate our minds are, has given us assistance and assurance in the path of knowledge that leads to understanding God. This certainly gives hope and comfort to those who believe.

#### A Course in Ethics and the Catholic/Christian Perspective in Chemistry

The development of a course in the senior year of the undergraduate program appears to have great potential for the consideration of a Catholic/Christian perspective. By the time the students have reached their senior year, they have covered in detail the basic principles of chemistry and know a great deal of factual information in the discipline. They truly have come to terms with theoretical models and have developed the capacity to understand ideas of assumptions, approximation, and extrapolation.

At this point, discussion of Catholic/Christian perspectives would be a much less threatening experience. Being well grounded in the discipline allows the shock of a new, or different, value system to be absorbed, contemplated and discussed in an intelligent and useful manner. Similarly, at a Catholic university such as the University of St. Thomas, the students have experienced theological discussions previously and will welcome the opportunity to discuss and debate theories, approximations, assumptions and models in their own discipline.

For such a course to be successful, a collaborative effort between the chemistry and theology departments would be needed. In practical terms, it might be necessary to encompass a wider student body by offering the course as a science and theology course, possibly with an extra emphasis on ethical and moral issues. By encouraging and incorporating critical thinking from both disciplines on questions covering ethical and moral issues and mankind's condition, reasoned and rational discussion could flourish.

My view is that this essay is an attempt to identify, organize and bring a first discussion of the concerns, questions and difficulties in expanding the Catholic/Christian perspective into the chemistry curriculum. In general, I find the Catholic/Christian perspective to add little to the study of chemistry except in the ethical and moral aspects. It is certainly mind-expanding to discuss chemical theory with the view that atoms, electrons and

molecules have a religious significance and behave in a religious manner. However, as viewed from the discipline, these thoughts are mere flights of fantasy. Nonetheless, I have, for a long time, been amused by the idea, that the sharing of pairs of electrons to lower the atomic interaction energies resulting in the formation of chemical bonds is the physical basis for altruism. Both atoms reduce their energies, each getting what they need by the simple act of sharing.

## Notes

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