Nanotechnology in Pharmaceutical Education in USA

Yashwant V. Pathak* and Ajoy Koomer**
Department of Pharmaceutical Sciences
Sullivan University College of Pharmacy
2100 Gardiner Lane, Louisville, KY 40205, USA
*ypathak@sullivan.edu , **akoomer@sullivan.edu

ABSTRACT

Nanotechnology is on its way to make a big impact in Biotech, Pharmaceutical and Medical diagnostics sciences. Pharmaceutical education in USA is also taking significant steps in incorporating courses as well as offering specialization in nanotechnology and its applications in Pharmaceutical scenario. This paper discusses status of nanotechnology and its application in educational curriculum in US pharmacy schools. We surveyed the curriculum offered at various levels in Pharmacy schools which covers the nanotechnology and its application in pharmacy, using two methods. It was observed that none of the pharmacy colleges have a separate course at the Pharm.D. level on nanotechnology, though good numbers of them have incorporated chapters in some of the courses with different titles. On graduate level many colleges have reported to have courses addressing nanotechnology in their curriculum.

Keywords: nanotechnology, pharmacy curriculum, education

1 INTRODUCTION

The nanotechnology and related development in sciences is leading to technological revolution in many fields of sciences. Even though the nano particles have been in nature since time immemorial, the importance of utilizing this technology is growing significantly in last two decades and making strides in different fields. It has enormous potential to influence our lives and has been employed in many areas including electronics, defense, pharmaceuticals, consumer products, environment, medicine and many more. In United States, Japan, India, Europe and many countries several initiatives have been undertaken and members of the private as well as public sectors are intensifying their researches in this field. It is also a novel way to create intellectual properties for the private sectors [1]. Hundreds and millions of dollars are committed to the research and development in this field. This is going to change our traditional practices of design, synthesis, and analysis and manufacture different products in various fields. This impact is very well felt by the pharmaceutical industry as well as field of medicine. Several new techniques are being introduced in the field of drug delivery systems, targeting the drug, prosthetics, using these techniques to overcome the blood brain barriers in drug treatments, and many other fields including the diagnostics and analytical techniques. The area of Nanomedicine is developing very fast. Nanomedicine is an emerging field of medicine with novel applications. Nanomedicine is a subset of nanotechnology, which uses tiny particles that are less than one-millionth of an inch in size. In nano medicine, these particles are much smaller than the living cell. Because of this, nano medicine presents many revolutionary opportunities in the fight against all types of cancer, neurodegenerative disorders and other diseases. This change is creating a challenge to the academic community in the field of sciences to educate the students with necessary knowledge, understanding and skills to interact and provide leadership in the emerging nanotechnology [2].

Pharmaceutical education throughout the Americas is responsible for preparing students to begin the practice of pharmacy as vital members of the health care team or to assume other roles where pharmacists' knowledge and skills are required. Pharmaceutical education prepares students to become informed citizens in a changing health care environment. It is responsible for generating and disseminating new knowledge about Pharmaceuticals and pharmaceutical services, and about the role of the pharmacist in the unique health care system. Pharmaceutical education provides students with the values necessary to serve society as caring, ethical, learning professionals and enlightened citizens. It provides students with scientific fundamentals and fosters attitudes necessary to adapt their careers to changes in health care needs over a lifetime. It also encourages students prior to and after graduation to take active leadership roles in shaping policies, practices and future directions of the Profession and national health priorities. Pharmaceutical education both at the undergraduate and graduate level is responsible to the profession and society for generating knowledge about pharmaceuticals, pharmaceutical products, therapeutic actions and rational

NSTI-Nanotech 2008, www.nsti.org, ISBN 978-1-4200-8503-7 Vol. 1

drug use through basic and applied research. It promotes the pharmaceutical sciences by fostering graduate education and research. Pharmaceutical education continually evaluates its mission, goals, objectives and outcomes throughout the Americas and relative to specific, unique conditions in individual countries. Based on the advances in pharmaceutical education and research, the necessary changes will be implemented.

The 2004 CAPE Educational Outcomes are intended to be the target toward which the evolving pharmacy curriculum should be aimed [3]. Many schools have used the 1998 CAPE Educational Outcomes as the template for curricular mapping endeavors. To facilitate these endeavors and to stimulate communication between schools, AACP held annual assessment institutes (from 1998-2003) in exchange for feedback regarding how faculty members were using the document. Hence, many schools adopted the 1998 Educational Outcomes as the definitive set of abilities that each student would conceivably possess upon graduation. Before publication of the 2004 CAPE Educational Outcomes, schools were using the 1998 document to reevaluate their curricula and implement outcome assessment strategies as a means of continuous quality improvement. Even with the adoption of the 2004 CAPE Educational Outcomes, some schools may elect to refer to the more comprehensive 1998 version for more detailed direction in determining student abilities.

Because of the increasing knowledge regarding disease and drug therapy, it is impossible for didactic and experiential pharmacy education to adequately cover all aspects of disease management and pharmaceutical care [4]. It is imperative that the pharmacy curricula be dynamic and able to quickly respond to the expected advancement of patient- and population-centered pharmacy practice. The 2004 CAPE Educational Outcomes addresses these expected changes and allows individual schools to maximize their local resources while ensuring that basic principles of pharmaceutical care are learned. However, these outcomes must also be attainable. For example, the outcomes listed in the Systems Management and Public Health sections may be beyond what can be attained in a PharmD program.

In addition to the 1998 and 2004 CAPE documents, several additional pharmacy educational and competency statements either have been published recently or are in the midst of completion. The National Association of Boards of Pharmacy (NABP) recently revised the Competency Statements for the North American Pharmacist Licensure Examination (NAPLEX) [5]. The 3 competency areas described in the NAPLEX Blueprint correlate with the 2004 CAPE Educational Outcomes:

- Area 1: Assure safe and effective pharmacotherapy and optimize therapeutic outcomes
- Area 2: Assure safe and accurate preparation and dispensing of medications
- Area 3: Provide health care information and promote public health

According to the CAPE outcomes the focus of Pharmaceutical education has changed from product oriented to patient oriented teaching [6] and more stress has been given in clinical pharmacy practices and its training so that the pharmacist becomes an integral part of the patient care team in health sciences. Hence, it is interesting to see how the present day pharmaceutical education incorporates the recent advances in the field of nanotechnology in their curriculum and courses.

2 METHODS

We used two techniques to get the information. We have developed a small questionnaire and were sent to all the Deans of the Colleges of Pharmacy (106) using survey monkey. We received 20 responses while more than 25 e mails were bounced back as the dean's e-mail accounts were not receiving the unsolicited e mails. The second method was to visit the website of each college and look at their course and curriculum and look for the nanotechnology courses being offered or incorporated in any of the courses being taught at Pharm. D. level.

3 OBSERVATION AND RESULTS

3.1 Current status of Nanotechnology in Pharmaceutical Education in USA

Some of the observation we had seen from the results are:

1. The academic community in Pharmaceutical education in USA is reacting slowly to prepare the work force for the emerging opportunities for the students.
2. None of the 106 colleges have separate course on nanotechnology or related topics in their Pharm.D. Curriculum.
3. Majority of the colleges have incorporated one chapter on few courses, interestingly the courses are taught with different titles such as Compounding and manufacturing II, Novel drug delivery systems, Pharmaceutics I or II, Dosage form technology, but none of the courses were exclusively dedicated to nanotechnology.
4. At a graduate level the scenario was different many graduate programs have been offering courses in nanotechnology. The titles of the courses which were taught at masters or Ph.D. levels were application of

nanotechnology in drug delivery systems, protein and peptide drug delivery systems with reference to nanotechnology and its application in this field, controlled release , introduction to nanotechnology, nano crystal technology and polymeric nano particle synthesis, biotechnology based drug dosage forms, advanced drug delivery systems.
5. Graduate level courses also offered elective projects in nanotechnology, elements of nano science and nano technology, seminars in nano science and seminars in antibody mediated drug delivery systems based on nanotechnology.
6. A good number of universities were offering research opportunities at master's and Ph.D level in nanotechnology and its applications in Pharmaceutical sciences. But there were no structured courses in the curriculum per say.

3.2 Current status of Nanotechnology Education world wide

1. Currently there are very few universities world wide imparting specialized education in nanotechnology. The web search provided following countries with courses and degrees offered in nanotechnology. The number in bracket shows the number of universities offering the nanotechnology education programs leading to full degrees. Brazil(2), Mexico(2), Czech Republic(2), Denmark(40), France(10), Germany(4), Israel(1), Italy(1), Netherlands(2), Norway(1), Spain(1), Sweden(20), Switzerland(1), United Kingdom(8), Turkey(1), United States(30), Australia/New Zealand(13), Canada(4), India (17), Singapore(1) and Thailand (2).
2. The primary mission of these universities is to conduct research and develop in the area of nanotechnology and nano science, even today there is less focus on nanotechnology education.
3. Some research centers are supporting associate and certificate programs as part of their activities in conjunction with other degrees they are offering.
4. Most interesting part all over the world is the faculty members in this area are supporting their laboratories and researches though their grant funding and encouraging the graduate student s to get involved in this type of research.

3.3 Some of the suggested courses for the Colleges of Pharmacy in USA as well as world wide for Nanotechnology can be:

1. Generic methodologies for the nanotechnologies
2. Nanoscale magnetic materials and their applications in medicines and devices
3. Processing and properties and characterization of inorganic nano materials
4. Macromolecules delivery using nanotechnology
5. Bio nanotechnology
6. Nanotoxicology
7. Bionanomaterials
8. Nano Polymeric Products for pharmaceutical applications
9. Techniques to manipulate interfaces and surfaces at nano level.
10. Self assembling nanostructures and its applications in Pharmacy
11. Nanostructures for pharmaceutical applications like aerogels, carbon nano tubes, dendrimers, magnetic molecules, metallic nano particles, nano clays, nano crystals, quantum corrals, nano wires
12. Fabrication of nanostructures
13. Characterization techniques for nano structures
14. Nanoapplications in Biosciences
15. Nanoparticulate drug delivery systems

These can be offered as:
1. Certificate course for the Pharm.D.B.S students with at least 15 credit hours which can be taken while studying for their professional degree there can be four courses to be taken to complete the certificate course as follows
2. Masters level as specialization in nanotechnology
3. PhD level graduate programs in Nanotechnology in Pharmaceutical sciences.

3.4 Major constraints for implementing nanotechnology in pharmaceutical education:

1. Lack of resources and materials especially in teaching nanotechnology at undergraduate and professional level
2. Applied aspect needs to be well documented and resources need to be developed to incorporate the recent advances in the field
3. As the focus of the total pharmaceutical education is pharmacy practice based, we need to develop courses with application in practice and understanding the importance of these techniques in practice settings
4. Majority of the universities do not have facilities for the research as the equipments involved in manufacturing and characterizing are very expensive, hence need to develop courses where these need not be used.
5. There is a need for educating the educators at various levels about nanotechnology and also creates interests in students about nanotechnology.

4 CONCLUSIONS

Nanotechnology has great future in pharmaceutical education, as the science behind will be more and more applied; the courses will appear in the curriculum. The pharmaceutical education will have to gear up for the growing needs of the society in this area by incorporating topics appropriately.

REFERENCES

[1] National Science Foundation's national nanotechnology initiative http://www.nsf.gov/home/crssprgm/nano 2001.
[2] M Uddin and AR Chowdhary, Nanotechnology education, http:/www.action bioscience.org/education, Paper presented at the International conference on Engineering education, in Oslo, Norway, 2001.
[3] Susan P Bruce, Amy Bower, Emily Hak, and Amy H Schwartz, American Journal of Pharm. Education, 15, 70-74,2006.
[4] T. Schwinghammer, American Journal of Pharm. Education, 13, 68-71, 2004.
[5] J Cerulli and M Malone, American Journal of Pharm. Education, 12, 67-69, 2003
[6] LL Maine, American Journal of Pharm. Education, 13, 68-71, 2004.