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Cultivating Creative Thinking – Reform on Teaching Biopharmaceutical Process Course

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Abstract The course of Biopharmaceutical Process covers materials such as the biological drug's originations, their properties, structures, applications, manufacturing principles, technological process and production methods. With the rapid development of life science, the amount and types of biological drugs keep increasing. As a result, we added new contents to our courses in order to catch up with industry changes. We created a three-level progressive teaching method where the three levels corroborate each other. We help students gain the ability to understand basic principles, the ability to apply, and the ability to innovate and conduct scientific research. We also reformed the teaching method by adding lab examples and enabling online learning. The multi-faceted approach improves students' comprehensive ability and innovation desires. It also prepares our students to better meet the increasing demand of the biopharmaceutical industry.

Keywords: *biopharmaceutical process, teaching method, comprehensive ability*

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1. Introduction

To accommodate the needs for biochemical pharmaceutical talents, we established the Major of Biopharmaceutical at China Pharmaceutical University in 1979. Biopharmaceutical Process was established to be the core course for undergraduate students. It also set the foundation for cultivating bio-pharmaceutical talents in our country. During the 1980s, with the increasing demand for talents in the biomedical industry in China, we established the first master's and doctorate degree in biochemical pharmacy, and also set up internship programs for undergraduate students through business partnerships with big enterprises. In the 1990s, our school published the first textbooks of "Biopharmaceutical Process" and "The Lectures of Biological Experiments". As a result, we formed a seamless curriculum with a core in "Biopharmaceutical Process" for the Major of Biopharmaceutical. In 2008, the course Biopharmaceutical Process was rewarded as "National Quality Course".

The course of Biopharmaceutical Process covers materials such as biological drug's originations, properties, structures, applications, manufacturing principles, technological process, and production methods [1]. With the rapid development of life science, the amount and types of biological drugs keep increasing. As a result, we added new contents to our courses in order to catch up with industry changes. We created a three-level progressive teaching method where the three levels corroborate each other. We help students gain the ability to understand basic principles, the ability to apply, and the ability to innovate and conduct scientific research. We also reformed the teaching method by adding lab examples and enabling online learning. The multi-faceted approach improves students' comprehensive ability and innovation desires. It also prepares our students to better meet the increasing demand of the biopharmaceutical industry.

2. Apply a Multi-level Teaching Method

We established a three-level progressive teaching method that cultivates students' ability to understand basic principles, ability to apply, and ability to innovate and conduct scientific research (Figure 1). The first level focuses on the understanding of basic theory. We help students build initiative through heuristic teaching and case studies. At the same time, we require students to conduct comprehensive experiments in the labs to learn the basic skills to prepare, identify, and detect biological drugs (Table 1). The second level focuses on the application of theories. We designed various biopharmaceutical processes based on the character of biological drugs, and use examples of biological drugs preparation to guide our students think and apply the theories. In labs, teachers will select a topic and leave it open-ended for students to explore. Students then look up available resources and design their experiments independently with some guidance (Table 2). The third level focuses on innovation and the ability to conduct scientific research. We require students to read comprehensively and complete reading notes and reviews. Additionally, we conduct class verbal presentations and in-class Q&A sections to improve students' capabilities of critical thinking. Last, students

form teams, choose their own research topics, and get trained at local pharmaceutical companies or teacher's research labs to conduct pharmaceutical production cycle or Innovative Practice Projects (Table 3). This teaching method won the second prize of Jiangsu Province in 2009 in China.

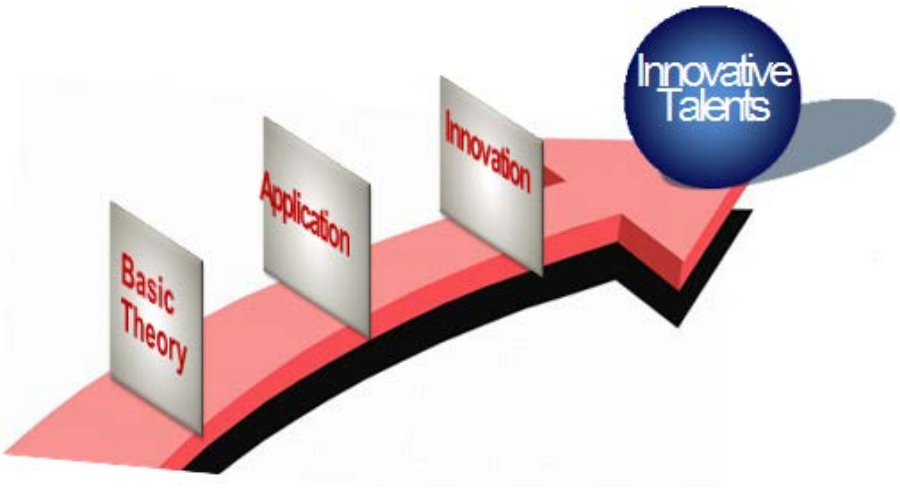

Figure 1. A multi-level teaching system

Table 1. Part of comprehensive experimental examples

Experiment Item	Periods (hours)
Preparation and Analysis of Tremella Polysaccharide.	18
Extraction and Electrophoresis of Plasmid DNA	12
Preparation and analysis of Elastase	18
Preparation and Analysis of The Hemin	12
Expression and Identification of Recombinant protein	24
Production of L - Aspartate by Immobilized Cell	24
Discovery and Research of Natural Bioactive Substances	24

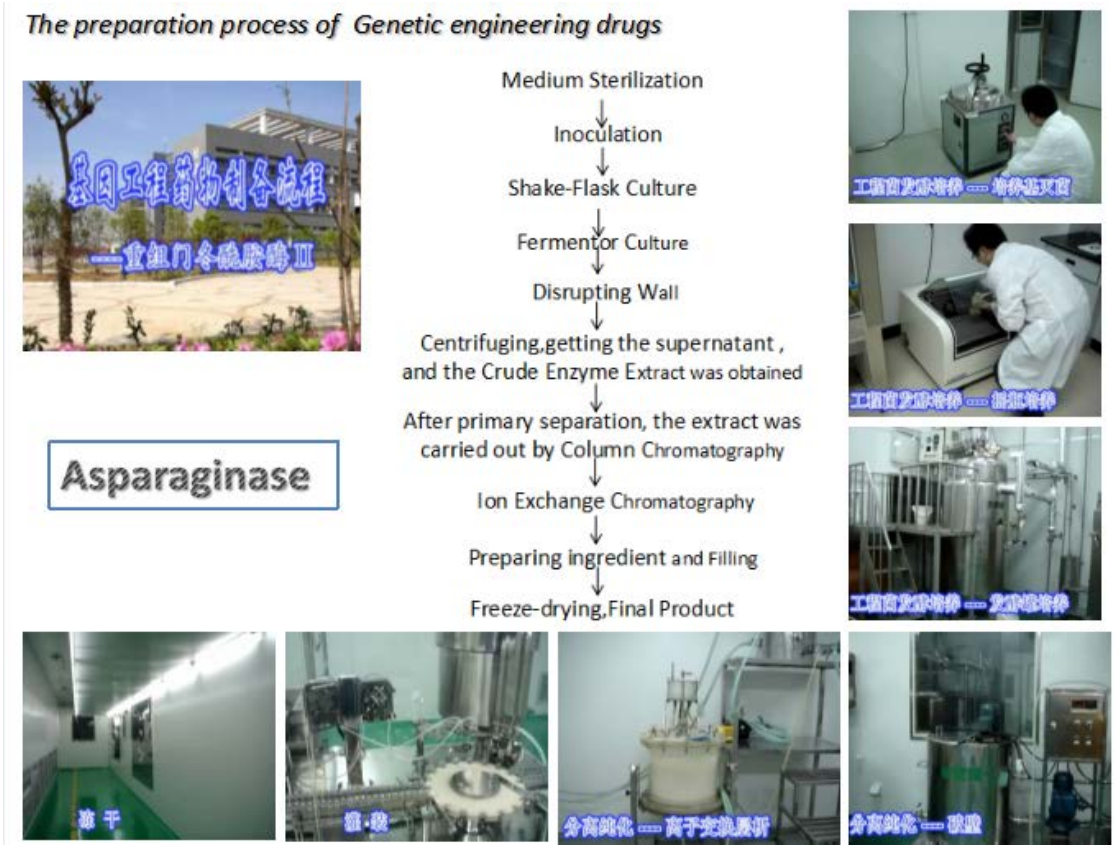

Figure 2. The production process of Asparaginase in company

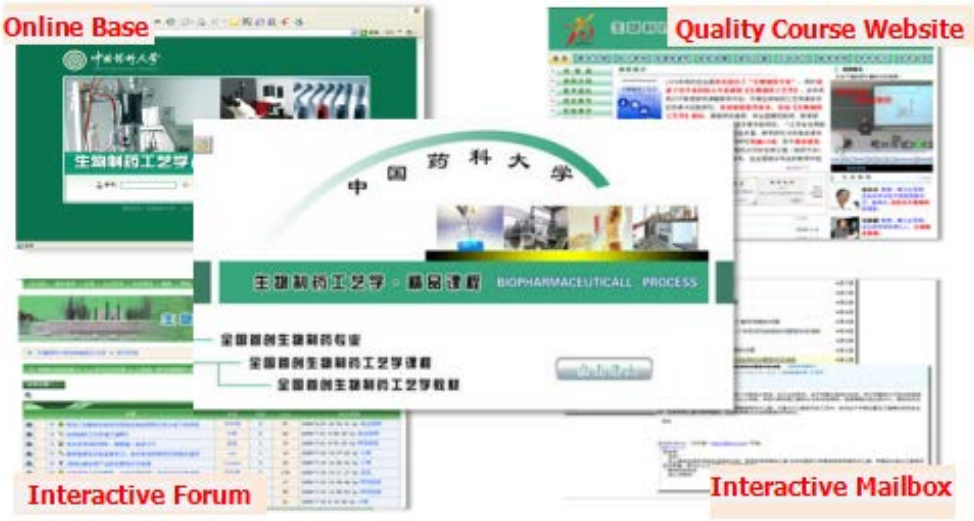

Figure 3. The curriculum resources of the Biopharmaceutical Process

Table 2. Open experimental examples

Open Experiment Item	Student	Advisor
Purification and Extraction of Fucoidan	Lu Meiling, Luo Yongquan, Huang Jie	He Shuying
Purification and Activity Study of Agaricus Blazei Murill Polysaccharides	Guo Shentao, Liang Zhuangyan, Jiang Fuman	Kong Yi
Study on the extraction process of Lycopene	Chen Liping, Zhao Hui, Zang Chengxiao	He Shuying
Preparation Technology of Superoxide Dismutase	Chen Yanzhi, Li Zhengyang, Chen Hai	Gao Xiangdong
Separation and Purification of Lycopene by Column chromatography	Yuan Gang, Zhang Fan, Han Jing, Xing Yun	He Shuying
Preparation of Glutathione by Enzymatic Conversion Method	Fang Yongliang, Wang Wei, Yan Yan, Lu Yingfei, Ting Ting	Zheng Heng
Preparation and Analysis of Congo Red Elastin	Li Yingying, Lu Junjie, Mao Meifen, Lv Li	Li Qian

Table 3. Part of Innovative Practice Projects

Innovative Practice Projects Items	Student	Advisor
A preliminary study on the targeting mechanism of Antitumor Marine Fungus Polysaccharide-YCP	Zhang Yiran, Qiao Shuxi, Zhang Yi, Xu Yanbin, Chen Longrui	Gao Xiangdong
Production of Lycopene by Microbial fermentation	Qiang Xiaoyan, Cui ran, Wang Haiqin, Yang Xue, Zheng Jiaojie	Zheng Heng
Preparation of Heparin Oligosaccharides and its effects on the proliferation of vascular smooth muscle cells	GaoYu, Chu Yanan, Huang Qing, Wang Jianping	He Shuying
Preparation and Study on antidiabetic activity of a novel recombinant extend-4	Tang Qingqing, Wu Yanfeng, Zhang Xiuhua	Li Taiming
Optimization of fermentation conditions of recombinant strains of hepatic stellate cell activity related protein	Zheng Minjia, Hu Lei, Lu Chuanwen	Liu Yu

3. Facilitate Teaching with Real-life Examples

While teaching, we have a focus on students' awareness of innovation and their comprehensive capabilities [2]. For example, when we were teaching the chapter of Biological Products, we associated that chapter with the 2009 outbreak of H1N1 influenza, and inspired the students to raise questions and think about the solutions. We guided them to think through the preparation methods of influenza virus vaccine. With the discussion of real life examples, we can effectively stimulate students' enthusiasm.

Biopharmaceutical Process is a highly practical course. It's important for the students to understand and master the theories through labs in order to strengthen the students' problem solving skills [3].

4. Combine In-class Teaching with Practice

Because of the practical nature of the course of Biopharmaceutical Process and the students' lack of exposure to production, it's hard for the students to picture production process. Therefore, we show the production process video to students when we introduce the biological drugs, in order to make students understand the process of biological drugs operation and purification methods better.

Using thymosin and asparaginase as examples of biochemical and biotech drugs, we first introduce the process through PowerPoint presentations, and then show the video in order to combine theory learning with practice (Figure 2). We avoid simply reading the slides,

and add more practical experience and authenticity into our teaching.

Eighty percent of the contents in the course materials and experimental guidance come from our real research and production practice. One good case is the National Key Project (the immobilized cells product aspartate, alanine) that won the second technology advancement prize of Ministry of Pharmaceutical Admin in 1993 [4]. Many teachers have previously collaborated with companies on scientific research. Therefore, the teachers can speak from their experiences when teaching, and students truly welcome those real-life experiences [5]. Among the 5,700+ students we have taught, over thirty percent have become the main force and taken leadership roles in big enterprise and scientific research institutions.

5. Carry out the Construction of Network Resource and Internet Teaching

We carry out constructions of network resources and internet teaching by sharing the curriculum resources of the Biopharmaceutical Process. On the online platform, you can find course introduction, powerpoints, videos, exercises, mock exam questions, lab courses, references, outlines, lesson plans, and the most recent progress of the biopharmaceutical industry. These resources allow interchange of information freely among teachers [6]. At the same time, we provide students opportunities for online learning through "Sky Classroom". We also built an online forum for the course, set up a blog and a public mailbox to facilitate communications between teachers and students. As a result, student can communicate real-time with the teachers regarding the difficulties they encounter (Figure 3).

6. Conclusion

In conclusion, we promptly introduced new contents to the course based on the most recent technology in the world. We established a teaching method that combines three levels of learning that corroborate each other: the ability to understand basic principles, the ability to apply, and the ability to innovate and conduct scientific research. We also reformed the course in terms of contents, methods, and introduced lab teaching and internet learning. We have seen tremendous results from the reforms. "Methods and Practices in Cultivating Bio-Pharmaceutical Talents" won the first prize of Excellent Teaching Achievement of Jiangsu Province in 2007. "Multi-Layer Stereoscopic Teaching – Reform and Practice of Biopharmaceutical Process" won the second prize of Excellent Teaching Achievement of Jiangsu Province in 2009. What's most important, we helped, are helping, and will continue to help develop capable and innovative talents for the biopharmaceutical industry.

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