Bring a Molecular and Cell Biology Laboratory into the Classroom of HKUST

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1. INTRODUCTION

Biological sciences are fundamental for both life science and medicine. Although they are moving into more systematic and information based directions, this is still an experimental science where knowledge is primarily obtained through conducting experiments in the laboratory. Thus, the most effective way to teach biological courses is to combine the classroom teaching with laboratory practice, so that students can gain a deeper understanding of how experiments are conducted and biological discoveries made.

For many reasons, however, many biological courses offered at HKUST do not have a lab course and the contents of the course syllabus usually do not contain information on laboratory or practical aspects. To solve this problem, we recorded the experimental process of major experiments in Molecular and Cell Biology on videos with detailed demonstrations and instructions. These allow students to visualize how experiments are conducted in the laboratory, increasing their understanding and learning efficiency in the fundamental concepts of Molecular and Cell Biology.

2. MATERIALS GENERATED AND METHOD OF USING THEM TO ENHANCE TEACHING EFFICIENCY

We have produced 13 videos demonstrating essential recombinant DNA techniques including culturing bacterial cells, isolating plasmid DNA, analyzing digested DNA using agarose gel electrophoresis, introducing cloned DNA molecules into bacterial cells by transformation and analyzing the recombinant clones (Table 1). We also prepared lecture slides with colorful drawings and good animations to further enhance the visual effects (Table 1).

Table 1. Lecture contents and videos developed in this project

Lecture contents for DNA Cloning Part I	**Videos**
• Introduction	
• Basic features of plasmid	

• Basic components of a cloning vector	
• Aseptic techniques	1. Autoclave 2. Filtration 3. Biosafety Cabinet
• Bacterial culture	4. Liquid Medium 5. Agar Plate 6. Streaking a Plate 7. Bacterial Inoculation
Lecture contents for DNA Cloning Part II	
• Isolation of plasmid DNA	8. Isolating of Plasmid DNA
• Quantification of nucleotides using a spectrophotometer	9. Quantification of Nucleotides
• Restriction analysis	10. Restriction Analysis
• Agarose gel electrophoresis of DNA	11. Agarose Gel Electrophoresis
Lecture contents for DNA Cloning Part III	
• Ligation	12. Ligation
• Transformation of bacteria using calcium chloride/heat shock and electroporation	13. Transformation and Electroporation
• Antibiotic selection	
• Detailed procedures of DNA cloning and important factors for designing a cloning strategy	

These teaching materials helped me greatly when describing and explaining some important features of DNA recombinant technology. For example, when talking about restriction analysis, I first explained that "restriction endonucleases are enzymes which can recognize specific sequences of four or six nucleotides on double-stranded DNA and cleave the DNA molecules." I told them that "these target sequences are often palindromic (that is, the nucleotide sequence is symmetrical around a central point)." It is quite hard for students to understand my point without using a drawing. With the help of CELT staff, we can now use a newly generated animation to do this.

Another example involving the isolation of plasmid DNA from bacterial cells, performing restriction digestion and finally analyzing the digested DNA using agarose gel electrophoresis. These three experiments are essential parts of DNA cloning which involve many steps and it is almost impossible for students who never enter a biology laboratory to imagine how these experiments were conducted there. In the lecture, I first used lecture slides to explain the concept behind conducting these experiments, the purpose in using each chemical reagent, and the principle and application of each piece of equipment. I then went through the following experimental procedures step by step:

Procedure of Isolation of Plasmid DNA using Miniprep DNA Kit:

1) Obtain two 3 ml of overnight bacterial cultures.
2) Centrifuge for 10 min at 4,000 rpm.
3) Discard the supernatant and dry the pellet by gently tapping on a piece of paper towel.

4) Resuspend pellet completely in 250 µl of Cell Resuspension Solution by pipetting up and down.
5) Add 250 µl of Cell Lysis Solution, mix by inversion.
6) Add 10 µl of RNase Solution and mix by inverting the tube 4 times.
7) Incubate the tube for 5 min at room temperature. Do NOT EXCEED 5 min. Longer incubation time may result in contamination from bacterial genomic DNA.
8) Add 350 µl of Neutralization Solution and mix by inverting the tube 4 times. DO NOT VORTEX!
9) Leave the tube at room temperature for 5 min.
10) Centrifuge the bacterial lysate at 14,000 rpm in a microcentrifuge for 8 min at room temperature to precipitate the pellet.
11) Insert a Wizard spin column into a 2 ml collection tube.
12) Transfer clear bacterial lysate into Wizard spin column (Avoid disturbing or transferring any of the white precipitate with the supernatant)
13) Stand for 1 min, centrifuge at maximum speed in a microcentrifuge for 1 min at room temperature.
14) Remove the spin column from the tube and discard the flow through from the collection tube. Reinsert the spin column into the collection tube.
15) Add 750 µl of Column Wash Solution to the spin column, stand the column for 2-5 min and centrifuge for 1 min.
16) Discard the flow through and repeat the wash procedure using 250 µl of Column Wash Solution.
17) Centrifuge for 2 min to completely remove the Column Wash Solution.
18) Transfer the spin column to a clean 1.5 ml microcentrifuge tube. This time, the supernatant is collected.
19) Add 50 µl of Nuclease free autoclaved ddH_2O to the spin column and let stand for 2 min.
20) Centrifuge at 14,000 g for 1 min at room temperature.
21) Collect the plasmid DNA eluted from the column.

Finally, I used an eight-minute video to demonstrate how to isolate plasmid DNA from two tubes of bacterial culture. Students showed a great interest and all liked it very much. I also uploaded all the videos and course materials to the course website under the Learning Management and Evaluation System (LMES). In addition, a lab manual covering both theory and experimental procedures for recombinant DNA technology was created. These materials were used to teach a PG course, BIEN503: Molecular Biology for Bioengineering in the fall semester of 2006 and 2007.

3. EVALUATION RESULTS

CELT conducted an evaluation at the end of the fall semester of 2006. Results showed that the teaching materials developed from this project received very positive comments from the students.

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Result of the usability test for 'Bring a Molecular Cell Biology Laboratory into the Classroom of HKUST' conducted by the CELT staff.

Total number of responses: 23

Table 2. Summary of the evaluation results

	Questions		**Frequency**	**Percent**
1	Have you had any laboratory experience in molecular cloning?	Yes	10	43.5
		No	13	56.5
2	Do you think the videos of the following topics help enhance your understanding?			
	2a. Aseptic techniques	Yes	23	100.0
	2b. Bacterial culture	Yes	23	100.0
	2c. Isolation and quantification of DNA	Yes	23	100.0
	2d. Restriction analysis	Yes	22	95.7
		No	1	4.3
3	Do you think the animations of the following topics help enhance your understanding?			
	3a. Aseptic techniques	Yes	23	100.0
	3b. Bacterial culture	Yes	23	100.0
	3c. Restriction analysis	Yes	21	91.3
		No	2	8.7
4	Overall, to what extend did the multimedia elements, including videos and animation in the PowerPoint presentation, facilitates your study?	Yes	12	52.2
		No	11	47.8
5	Other comments from the students: · Done very well · Greatly helps the student to understand lab practical. Very good · I think the videos are very helpful. I hope to see more videos on topics such as legation, transformation and electroporation · It is a very good tool to help us learn · More videos/animations demonstrating the bioinformatics part would be helpful · More wonderful videos should be developed. They really helped me a lot because of my lacking of a molecular biology background · The video shows techniques needed in biology labs in a detailed & clear way · The videos give clear explanation and instruction in experimental skills, which text and pictures cannot accomplish · Very good and detailed, instructor. Dr. Luo is very nice · Very helpful			