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ANIMAL TISSUE CULTURE VIDEO

An Interactive Qualifying Project Report

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by

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Abstract:

Our goal was to produce an instructional Animal Tissue Culture video to be used as an introduction to the tissue culture process. Local area colleges and an advanced level high school then evaluated the video to determine its worth as an educational tool. Their responses to the video indicated that we were successful in developing a video that was of high quality and interest at both the college and advanced high school.

Introduction:

The absence of a demonstration video to aid in teaching instructional lab techniques used in animal cell/tissue cultures has brought about the need to produce a video displaying such techniques. This project has produced a video, which to our knowledge, is the first of its kind. This video is intended for use by instructors of advanced high school and college level students, but is not meant to stand alone. Guidance from the instructor is also needed. The objective of the video is to introduce the animal cell culturing process by demonstrating the proper lab techniques used, while expressing the importance of those techniques. It has been shown that the use of instructional media before executing a new skill can actually improve the viewer's performance of that skill (2). Use of this type of video prior to hands-on work will prove to be particularly beneficial in a laboratory setting where a student's performance of a required technique is critical. The aim of this particular video is to provide a visual introduction to the complete animal cell culturing process, and show the importance of proper lab techniques.

Each of these general topics are executed with proper technique and are clearly shown in this video. Students and faculty from three different area schools, as well as a group of WPI students and professors, participated in evaluation of the video. Their objective was to determine whether it was acceptable on three levels: quality, educational value, and interest.

We attribute the need of this video to the fact that most students are provided with only an instructor's lecture and a lab manual to aid them as they attempt to perform complicated and often difficult procedures for the first time. The need was also

corroborated by the fact that there is a lack of class time for instructors to show students the proper techniques to use throughout each lab. We based this conclusion on our own combined personal experience. The students should be able to recognize procedures and techniques performed from this video. Once they have seen it done properly, they should understand the correct way to accomplish these techniques.

Background:

Animal Tissue Culture:

Significance:

Animal tissue culture (ATC) is concerned with the growth and study of cells, tissues, and organs dissociated from a donor organism. These dissociated cells must be maintained in vitro for more than twenty-four hours in order to be useful (4). Cell cultures can be grow from almost any living tissue, although not all will yield continuous cell lines. Frequently, embryonic cells produce better cultures (5).

"Tissue culture technology has been adopted into many routine applications in medicine and industry" (7). One use is the growth of viable human skin, which is used to treat burn victims. In the United States alone, 11-12 million people have been treated with tissue engineered skin for problems ranging from burns to age related, non-healing dermal wounds (8). Cells cultured after amniocentesis undergo chromosomal analysis to detect genetic disorders in unborn children. Cell cultures are also used to determine the possible effects of pharmaceutical and environmental toxins (7).

The development of animal tissue culture originated mainly for the purpose of cancer research and the development of viral vaccines (5). Protein production is also an important use of animal tissue culture. Many proteins that can be genetically engineered or artificially produced lack certain post-translational elements (7). The ability to perform such processes as enzyme-catalyzed folding, glycosylation, proteolytic processing, and several other covalent alterations makes the use of animal cells indispensable for the production of many pharmaceutically important proteins and polypeptides (6).

A wide variety of medical products, including vaccines, interferons, and hormones, can now be produced in large quantities because of animal tissue culture techniques. Immunological reagents and cellular biochemicals, such as enzymes or materials which have been specifically transformed by cultivated cells, are also frequently produced. The most commonly produced products are viral vaccines. Polio, mumps, measles, rubella and rabies vaccines are all produced with the use of animal tissue culture (9).

Many other areas of research have been affected by the development of tissue culture techniques. "The introduction of cell fusion techniques and genetic manipulation established somatic cell genetics as a major component in the genetic analysis of higher animals including man" (7). Studies into immunological functions are greatly dependent on these techniques, as well as on the cultures themselves (7).

Another beneficial aspect of animal tissue culture application is that the number of animals used in testing can be drastically reduced. "Tissue culture may be used to replace experimentation on live animals ... in many instances" (5). This reduces costs as well as prevents difficult ethical issues. If a product can first be tested using animal tissue cultures, animals would be used only as the final test prior to human use.

The Technology:

To be successful in culturing cells, it is extremely important to provide the best possible conditions for the growth and maintenance of the cells. Although each cell line is distinct in its environmental needs, some general criterion for cultures can be broadly defined. Nutritional requirements also differ greatly, although most media contains water,

amino acids, vitamins, glucose, a buffering agent, and a blood serum, which contains growth factors. Antibiotics are often added to the media to prevent contamination of cultures by other microscopic organisms (7).

Most animal cell cultures grow fastest when the temperature is close to 37 degrees Celsius and the pH of the culture media is between 7.2 and 7.4 (5). Because the byproducts of cellular metabolism are acidic, a buffering system must be set up. Carbon dioxide incubation is therefore required. An equilibrium is formed between carbon dioxide, water, buffering agent, and acidic protons in the excreted cellular wastes (4). As cells continue to grow, the media will become more and more acidic and will eventually kill the culture unless proper maintenance procedures are implemented. This includes subculture of cells, which involves diluting a sample of cells to a much lower concentration, in fresh media (5).

The purpose of culturing cells is to produce a product which can be harvested from the culture. When a specific extracellular protein is produced, the culture medium is removed and the product is purified from it. However, if the product is inside the cells, or is the cells themselves, the cells must be removed, and if located in the cells, lysis must occur to release the product for isolation (5).

Because an understanding of basic cell culture techniques is vital to the success of animal tissue culture experiments, an instructional video would be an invaluable teaching tool. Although a live demonstration of techniques is often the best way to teach a new concept, most teachers simply do not have enough class time to show their students all that they need to know. Consequently, lectures and handouts are used in lieu of that beneficial demonstration. Some students may have trouble understanding important

concepts without the lab demonstration. Lab handouts are prepared with the assumption that the students performing the experiment fully understand the concepts and procedures. A lack of understanding will result in improper technique as well as a lack of appreciation for the results of the experiment. The purpose for creating a video on animal tissue culture was to reinforce concepts taught in lecture and shown in lab, thus, increasing the students' understanding of laboratory procedure and animal tissue culture techniques.

Video as an Educational Tool:

Use of instructional video in education can be very beneficial to students. New learning technologies are constantly being developed that use live or recorded video to demonstrate a technique or idea. "Any technology which increases the rate of learning would enable the teacher to teach less and the learner to learn more"(3).

The usefulness of video is becoming increasingly apparent. Students and teachers can get more information to their students, and the use of video allows this information to be clearly presented and easily repeated. "In assessing the impacts of technology on today's campuses, we expect students to benefit from it because if offers them greater flexibility and more alternatives in their learning experience"(3). For students, the technology has a major advantage; properly applied, it increases the opportunities for independent methods of instruction. Students will be able to choose between live lecture and recorded video lecture, thus introducing a competition between the two techniques, and potentially raising the quality of instruction of both techniques. Additionally, this technology is infinitely patient towards the slower learner.

The effectiveness of video technology in the classroom has had a centralizing effect. On campuses around the world, the dramatic increase in video use has required upgraded facilities with creation of appropriate viewing equipment, essentially allowing the instructors unlimited, as well as easy access for using the technology. "There is nothing new about the idea of including short motion pictures, slides, live demonstrations, musical segments, or portions of taped interviews in a lecture presentation"(3). However, most facilities were previously not equipped to take advantage of this. The demand for new visual technology has finally been recognized. Subsequently, there has been a rise in the production of such material. It is now common for classrooms to have a multimedia device that can be used on a regular basis. It is not uncommon to find an entire building on campus whose sole purpose is devoted to multimedia and other advancing technologies.

Video can, in some cases, be used constructively for up to two-thirds of the time allotted for instruction, which allows teachers to expose students to a much larger amount of information in the same amount of time. Furthermore, it is possible to expose the students to worlds that previously were not available due to space or financial shortcomings.

Another advantageous aspect of video as a tool in education is very apparent when considering the possibilities of storing videos for repetitive instruction. "It is videotape's ability to provide virtually instantaneous reproduction that gives it a major advantage over film"(3). The instruction on a tape may be replayed back through monitors in classrooms or multimedia rooms. In 1972, it was estimated that "by the year 2000 it now appears that a significant proportion of instruction in higher education on

campus may be carried on through informational technology- perhaps in a range of 10-20 percent"(3). However, information technology has far surpassed this percentage in 1999.

So the question that needs to be asked is "Should video replace a large portion of class time, or simply used as an illustrative tool by the instructor?" The answers are not easy. "Two tests should be applied in deciding whether any technology should be used or not:

- The teaching-learning task to be performed should be essential to the course of instruction to which it is applied.
- The task to be performed could not be performed as well—if at all—for the students served without the technology contemplated" (3).

This raised the question, "Is video more interesting than a lecture?" Again, the answer is not straightforward. It has been found that, "Creative uses of a variety of media will increase the probability that students will learn more, retain better what they learn and improve their performance of the skills they are expected to develop (2)." Students appear to pay better attention to a video, and retain more of what they learn. The most important of these findings, at least for our purposes, is that a student's performance skills will be enhanced.

It is more beneficial for students to see what they are doing, rather than just hearing it through a lecture. "Where the final task performance requires visual knowledge of objects, one would expect pictured representations of these objects to contribute more to learning than printed or lectured stimuli (1)."

Our video is intended to be seen before a laboratory session or can be reviewed as a refresher for the students that will have to execute the techniques they have seen in

the video. A video can also act as a tool for students to be acquainted with unfamiliar instruments and materials.

It seems that, given the importance of animal tissue culture in biology and the proven worth of video in education, there should be a high quality educational video made about animal tissue culture in the laboratory.

Objectives:

The purpose of this project was to produce an instructional video on animal tissue culture. The following objectives had to be completed in order to achieve our goal:

- Develop and rehearse a script.
- Film the essential elements of the video at the cell culture lab at WPI, and on location in a park, and a pet store.
- Edit the raw video at the Instructional Media Center at WPI.
- Create an evaluation tool to use in evaluating the video.
- Analyze and report on the effectiveness of the animal tissue culture (ATC) video as an educational tool.

Methodology:

Video Production:

Our first step in producing a professional quality video on animal tissue culture was to develop a script. Before beginning this process, we had to determine which procedures had to be shown in order for the viewers to better understand how to execute animal tissue culture techniques in the lab. These concepts had to be technically accurate while also piquing the interest of the students. The decision to use fertilized chick eggs to initiate our culture was made early on, and was influenced by such factors as availability and ease of initiating a culture. To be sure the culture would work correctly, we obtained a test batch of eggs to ensure the embryos would develop correctly. Professor Whitefleet-Smith performed the culture process on the test batch and determined the protocol would be successful. Script writing continued as planned. Numerous cartoons and flow charts were created that would later be used to make concepts clearer and more interesting when shown on video. The script was written and re-written until all techniques and equations were completely accurate.

Upon completion of the script, we began working on production of the video at the Instructional Media Center at WPI . All of the laboratory procedures were filmed by a professional video technician. These scenes were filmed on the WPI campus in the cell culture lab. Group members later filmed additional scenes at sites such as: Elm park in Worcester, WPI's Health services office, and at Lisa's pet store in West Boylston. After the filming was completed, editing commenced. This involved recording an audio track of our script and then matching the video to that audio track. Editing took approximately

one hour for each minute of final film. The product was a professional quality twenty-minute video.

Evaluation:

After completion of the video, the next step involved determining whether the objectives were successfully completed. Hopefully, students would learn the important aspects of animal tissue culture while being interested by the video, and instructors would believe the video is appropriate to introduce students to animal tissue culture in the lab. Evaluation forms were created for both instructors (Figure 1) and students (Figure 2) of animal tissue culture, to determine if our video was of high quality and interest as an introduction to animal tissue culture.

We contacted two area schools, Worcester State College in Worcester, MA and Minuteman Science-Technology High School in Lexington, MA to evaluate our video. Worcester State College is a four year public college, while Minuteman is a public high school, that also has an advanced school within a school, the Biotechnology Academy. A group of students from WPI's Cell Culture Theory class also evaluated the video to ensure the audience was diverse. Professors who taught these students in each respective institute were also used to evaluate the video. The student and teacher evaluations were used to give us an idea of our video's strengths and weaknesses. Each evaluation form was statistically analyzed using a variety of different groupings to determine the effectiveness of our video with different groups of people. For example one such grouping included an analysis of responses by college students versus the responses to the same questions by high school students.

Figure 1: Instructor Evaluation Form

Animal Tissue Culture (General Questions)	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
1. The Animal Tissue Culture video was clear and easy to understand.	4	3	2	1
2. I found this video interesting.	4	3	2	1
3. I would use this video in my classes if it were available.	4	3	2	1
4. I have access to the materials and equipment in this video.	4	3	2	1
5. This video is as good as, if not better than other instructional videos I have seen.	4	3	2	1
6. I feel that my students would enjoy this video.	4	3	2	1
7. I feel that this video would hold the interest of my students.	4	3	2	1
8. The concepts in this video would be understood by my students	4	3	2	1
Animal Tissue Culture (Introduction)	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
1. The introduction was clearly presented.	4	3	2	1
2. The introduction was a good background to the video.	4	3	2	1
3. I found the introduction to be interesting.	4	3	2	1
4. The images and photographs presented in the video helped to reinforce the concepts explained.	4	3	2	1
Animal Tissue Culture (Laboratory Demonstration Questions)	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
1. The video demonstrated proper Animal Tissue Culture techniques adequately.	4	3	2	1
2. I have prior experience with Animal Tissue Culture techniques.	4	3	2	1
3. I feel that I would be able to conduct an Animal Tissue Culture experiment after seeing this video.	4	3	2	1
4. I would run these experiments in my classes if this video were made available to me.	4	3	2	1
5. The Animal Tissue Culture video was of adequate length.	4	3	2	1
6. I feel that this video is a good introduction to Animal Tissue Culture.	4	3	2	1
7. This video would become part of my curriculum if it were available to me.	4	3	2	1
8. My students would have no problems with the concepts and vocabulary in this video.	4	3	2	1
9. I would recommend this video to others to illustrate the techniques of Animal Tissue Culture.	4	3	2	1

Written comments:

Figure 2: Student Evaluation Form

Animal Tissue Culture (General Questions)	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
1. I found this video clear and easy to understand.	4	3	2	1
2. I feel that I would be able to perform the following procedures as shown in this video: a) media preparation	4	3	2	1
b) cell counting	4	3	2	1
c) subculture	4	3	2	1
d) harvesting cells.	4	3	2	1
3. I learned a lot about animal tissue culture by watching this video.	4	3	2	1
4. I found this video to be interesting.	4	3	2	1
5. I found this video to be entertaining.	4	3	2	1
6. This video is better than other lab videos I have watched.	4	3	2	1
7. I understand the following topics from this video: a) cell counting	4	3	2	1
b) assay of cell viability	4	3	2	1
c) cell growth and CO_2 incubation	4	3	2	1
d) subculturing	4	3	2	1
e) harvesting	4	3	2	1
8. I would like to perform the experiments presented in this video.	4	3	2	1
9. I enjoy science.	4	3	2	1
10. I would like to perform more labs in my science classes.	4	3	2	1
11. I consider myself a good student.	4	3	2	1
12. I have had exposure to the following topics in the biology classes I have taken: a) cell biology	4	3	2	1
b) tissue culture	4	3	2	1
c) sterile technique	4	3	2	1
13. I have prior experience with Animal Tissue Culture techniques.	4	3	2	1
Animal Tissue Culture (General Questions)	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
1. I understand the importance of Animal Tissue Culture in research and industry.	4	3	2	1
2. I understand the importance of each of the animal culture procedures demonstrated in the video.	4	3	2	1
3. I understand the concept of logarithmic growth of cells.	4	3	2	1
4. I understand the importance of cell counting.	4	3	2	1
5. I understand the definition of confluence.	4	3	2	1
6. I understand why trypsinization of adherent cultures is important.	4	3	2	1
7. I understand the concept of CO_2 incubation.	4	3	2	1

Written comments:

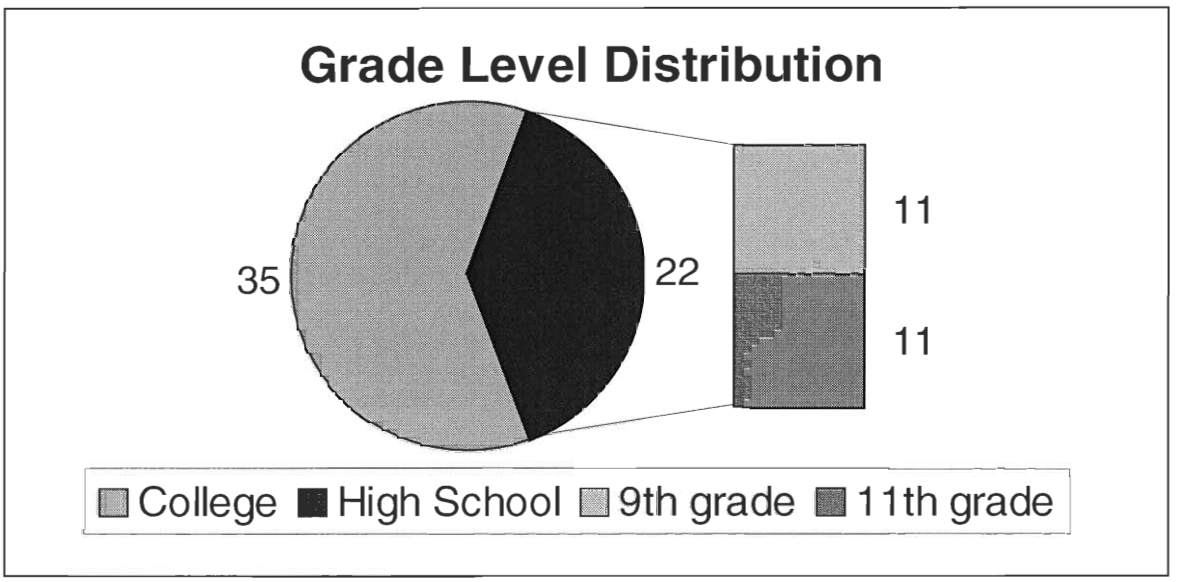
Results and Discussion:

Students and professors from three different area schools (Worcester State College, Minuteman Technical High School, and Worcester Polytechnic Institute) viewed the ATC video. They were then asked to complete a survey, which was designed to evaluate the effectiveness of the video as an educational tool. Their responses comprise the data, which was analyzed to determine if our objectives were achieved.

Demographics:

The combined demographics for this group consisted of 57 students and seven professors. In all, 35 college level students, 11 junior level high school students, and 11 freshman level high school students participated in the survey, as shown in Figure 3.

Figure 3: Distribution of grade level of the students surveyed.



Twenty-two of these students were male, 31 were female, while four students failed to specify a sex (Figure 4).

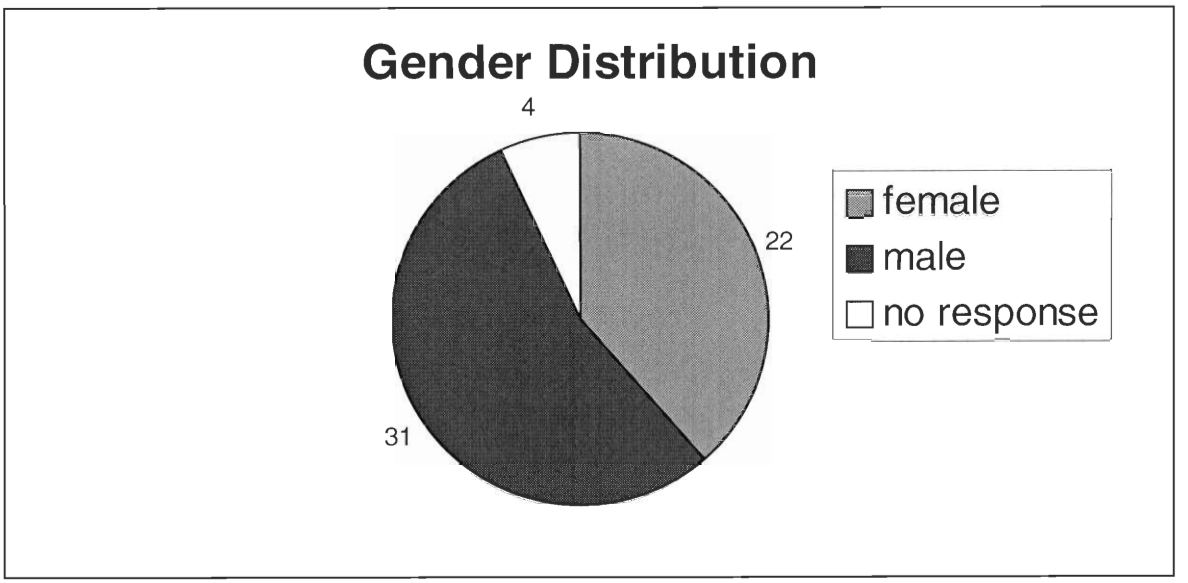


Figure 4: Gender distribution of students surveyed.

Six of the 22 males and 14 of the 31 females specified that they did not have experience with animal tissue culture. These percentages indicate that only about 55% of the females surveyed had experience with animal tissue culture, while about 73% of the males surveyed had experience.

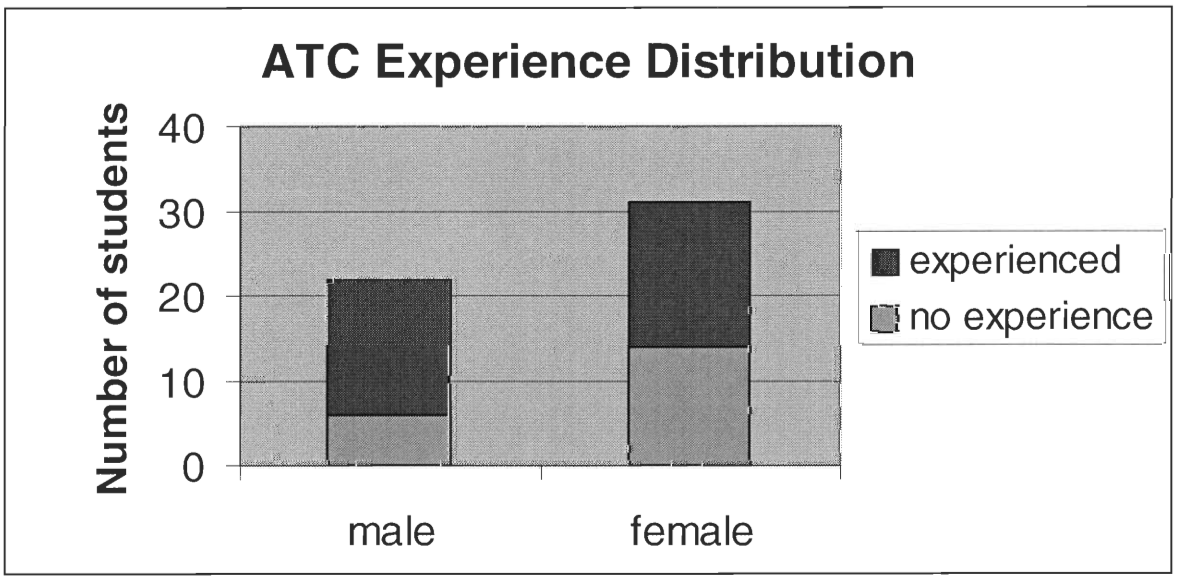


Figure 5: ATC experience distribution. The majority of students have experience with ATC.

When asked about their scientific interests, 55 of the 57 students said that they had biology or biology related interests; two students did not respond to this question. It was expected nearly all of the students would have biology interests, because all students surveyed are enrolled in programs where biology is the major subject taught.

For evaluation purposes, the average of the responses of the students and the instructors was calculated. Average responses between 2.5 to 4.0 were considered to be in agreement with the survey question, while responses averaging between 1.0 to 2.5 were considered to be disagreement.

Instructor Evaluations:

The results of analyzing the evaluation forms indicated a general consensus between students and instructors that the video is better than other instructional videos that they have viewed (Table 1, question A5; Table 2, question A6). From these results, we come to the conclusion that our objectives of quality and interest were maintained while preserving the importance of demonstrating proper lab techniques.

The majority of instructors indicated that they would include the video in their curriculum if it were available (Table 1, questions A3 and C7). They would also recommend it to others for illustration of the proper techniques of animal tissue culture (Table 1, question C9). All of the instructors felt that the video was a good introduction to the topic of animal tissue culture (Table 1, question C6).

Results from the instructor's survey, questions C1 through C4, which dealt with the introduction of the video, showed that the introduction was clearly presented, offered

Table 1: Instructor Evaluation Form

Animal Tissue Culture (General Questions)	**Average Response**
A1. The Animal Tissue Culture video was clear and easy to understand.	3.43
A2. I found this video interesting.	3.86
A3. I would use this video in my classes if it were available.	3.57
A4. I have access to the materials and equipment in this video.	4.00
A5. This video is as good as, if not better than other instructional videos I have seen.	3.29
A6. I feel that my students would enjoy this video.	3.29
A7. I feel that this video would hold the interest of my students.	3.29
A8. The concepts in this video would be understood by my students	3.43
Animal Tissue Culture (Introduction)	**Average Response**
B1. The introduction was clearly presented.	3.43
B2. The introduction was a good background to the video.	3.29
B3. I found the introduction to be interesting.	3.14
B4. The images and photographs presented in the video helped to reinforce the Concepts explained.	3.72
Animal Tissue Culture (Laboratory Demonstration Questions)	**Average Response**
C1. The video demonstrated proper Animal Tissue Culture techniques adequately.	3.57
C2. I have prior experience with Animal Tissue Culture techniques.	4.00
C3. I feel that I would be able to conduct an Animal Tissue Culture experiment after Seeing this video.	3.14
C4. I would run these experiments in my classes if this video were made available to me.	3.72
C5. The Animal Tissue Culture video was of adequate length.	3.43
C6. I feel that this video is a good introduction to Animal Tissue Culture.	4.00
C7. This video would become part of my curriculum if it were available to me.	3.57
C8. My students would have no problems with the concepts and vocabulary in this video.	3.57
C9. I would recommend this video to others to illustrate the techniques of Animal Tissue Culture.	3.72

a good background, and maintained interest while presenting a visual representation that reinforced the concepts explained. Six out of seven of the instructors felt that the video was interesting (Table 1, question A2), indicating that our goal of maintaining interest without sacrificing content was completed.

The video demonstrated clear and proper animal tissue culture techniques and was easy to understand. This is shown by the results of question A1 where six out of seven instructors indicated that they agreed with the statement "The animal tissue culture video was clear and easy to understand;" and question C1 where all of the instructors agreed with the statement "The video demonstrated proper animal tissue culture techniques adequately."

Student Evaluations:

The student evaluations showed that students also thought that the video was clear and easy to understand (Table 2, question B1). It was important to achieve this objective because the video is of no use unless it can be clearly understood by the students it is intended to teach. Results from Table 2, question B2, which states, "I understand the importance of each of the animal tissue culture procedures demonstrated in the video" indicate that the students obtained an understanding of the importance of proper procedures and techniques in animal tissue culture.

Another objective of the video was to hold the interest of the viewers. This was apparently successful according to evaluations indicating an agreement with Table 2, question A4, which states, "I found this video to be interesting." However, when individually analyzed, the WPI and Worcester State College students both showed

Table 2: Student Evaluation Form

Animal Tissue Culture (General Questions)	**WPI Students**	**Worcester State**	**Minuteman High School**	**Average Response**
A1. I found this video clear and easy to understand.	3.43	4.00	3.30	3.46
A2. I feel that I would be able to perform the following procedures as shown in this video: a) media preparation	3.48	3.75	3.15	3.40
b) cell counting	3.59	3.88	3.30	3.53
c) subculture	3.43	3.75	3.20	3.39
d) harvesting cells.	3.37	3.50	3.35	3.38
A3. I learned a lot about animal tissue culture by watching this video.	3.14	3.75	3.00	3.18
A4. I found this video to be interesting.	3.21	3.88	2.65	3.12
A5. I found this video to be entertaining.	2.66	3.25	2.30	2.62
A6. This video is better than other lab videos I have watched.	2.98	3.63	2.85	3.03
A7. I understand the following topics from this video: a) cell counting	3.52	4.00	3.20	3.47
b) assay of cell viability	3.48	4.00	3.08	3.41
c) cell growth and CO_2 incubation	3.45	3.50	3.08	3.32
d) subculturing	3.38	3.50	3.10	3.30
e) harvesting	3.43	3.38	3.15	3.32
A8. I would like to perform the experiments presented in this video.	3.21	3.63	3.10	3.23
A9. I enjoy science.	3.86	4.00	3.53	3.76
A10. I would like to perform more labs in my science classes.	3.34	3.88	3.30	3.40
A11. I consider myself a good student.	3.45	3.75	3.58	3.54
A12. I have had exposure to the following topics in the biology classes I have taken: a) cell biology	3.76	3.88	3.75	3.77
b) tissue culture	3.62	4.00	3.40	3.60
c) sterile technique	3.72	4.00	3.80	3.79
A13. I have prior experience with Animal Tissue Culture techniques.	3.17	3.00	2.60	2.95
Animal Tissue Culture (General Questions)	**WPI Students**	**Worcester State**	**Minuteman High School**	**Average Response**
B1. I understand the importance of Animal Tissue Culture in research and industry.	3.72	3.88	3.50	3.67
B2. I understand the importance of each of the animal culture procedures demonstrated in the video.	3.41	3.88	3.15	3.39
B3. I understand the concept of logarithmic growth of cells.	3.66	3.75	2.80	3.37
B4. I understand the importance of cell counting.	3.72	4.00	3.00	3.51
B5. I understand the definition of confluence.	3.59	3.88	2.70	3.32
B6. I understand why trypsinization of adherent cultures is important.	3.52	3.88	2.85	3.33
B7. I understand the concept of CO_2 incubation.	3.69	3.75	2.85	3.40

responses that were significantly greater, 3.21 and 3.88 respectively, than the average of all the students, which was 3.12. The average response of the Minuteman High School students, which was 2.65, was well under the average response of all three schools. The video was not found to be entertaining; however, this was not one of our main objectives (Table 2, question A5). This question was asked to determine whether entertainment was incorporated into an interesting video. Entertainment is not a necessary aspect in an instructional laboratory video, it would only add to the appeal of the video.

Student results indicated that they learned more information about animal tissue culture through watching the video and developed a meaningful understanding of the importance of animal tissue culture in research and industry (Table 2, question A3 and question B1).

The student survey results showed that from viewing the video, an understanding of all the major topics covered was gained. Specific procedures were shown in the video, and the students agreed they could now perform those procedures (Table 2, questions A2a through d).

Several questions were used to determine an individual's exposure to given topics relating to animal tissue culture. The results indicated all of the groups generally agreed about their understanding of the topics of cell counting, assaying cell viability, cell growth and carbon dioxide incubation, subculture, and harvesting cells. Very little difference in response was shown resulting from grade level, which ranged from ninth grade to college level (Table 2, questions A7 a through e). Table 2, questions B3 through 7 asked specific questions targeted at the understanding by the student of each major topic that was covered. Again, the responses were all favorable.

From this aforementioned set of questions, the survey results show the quality of the video to be high. After watching the video, students indicated that they felt they obtained the basic knowledge needed to perform procedures needed in cell culture. Table 2, questions A12 a through c specifically asked about exposure to topics relating to cell culture on a more general level, such as cell biology and sterile technique. Here, responses were very favorable, indicating that students have covered these topics in their biology classes. However, when student's were asked about their prior experience with animal tissue culture, the response was not as favorable, indicating students had not performed any or all of the techniques shown in the video. The Minuteman High School students returned the lowest responses to this question, which could be expected due to their grade level.

Conclusions:

Overall, the results indicate that we did achieve our goals of quality and interest while maintaining clarity, proper technique, and ease of understanding. Overall, there was a positive response to the video. This indicates that the production was of the intended quality and level of education. An overwhelming majority of both instructors and students believed the video to be useful for future classes and for students interested in performing animal tissue culture techniques.

The results of our IQP support the research information that we found regarding video as an educational tool. We found that students appear to pay attention to a video, and retain what they learn. The evaluation forms from our project indicate that the students learned a lot about animal tissue culture by watching this video (Table 2, question A3). Possibly the most important finding, at least for our purposes, is that a student's performance skills will be enhanced. This is supported by responses to question A2 in table 2. If students can learn about animal tissue culture and improve their laboratory results by watching this video then we have accomplished our goals as an IQP team.

Acknowledgements:

Special Thanks to:

- Dr. Peter Bradley and the students of Worcester State College, for evaluations.
- Dr. Ronald Midgett and the students of Minuteman Science-Technology High School, for evaluations.
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- Tara Smith, for laboratory assistance.
- Professor Pamela Weathers, Project Advisor.

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References:

1. Allan, W.H. (1969) "Audiovisual Instruction: The State of the Art." *The Schools and the Challenge of Innovation.* MacGraw Hill: New York. p 219.
2. Brown, J.W., Lewis, R.B., and Harcleroad, F.F. (1973) *AV Instruction: Technology Media and Methods.* MacGraw Hill: New York. p 2.
3. The Carnegie Commision on Higher Education. (1972) *The Fourth Revolution: Instructional Technology in Higher Education.* MacGraw Hill: New York. pp III, IV, 1-21.
4. Freshney, I.R. (1987) *Culture of Animal Cells: A Manual of Basic Technique.* A.R.Liss Publishing: New York. pp 1-6.
5. Freshney. I.R. (1992) *Animal Cell Culture: A Practical Approach.* Oxford University Press: Oxford, England. pp 1-20.
6. Grampp, G., Sambanis, A., and Stephanopoulos, G. (1992) "Use of Regulated Secretion in Protein Production From Animal Cells: An Overview." *Advances in Biochemical Engineering/Biotechnology.* 46:36-37.
7. Harrison, M.A., Rae, I.F. (1997) *General techniques of cell culture.* Cambridge University Press: New York. pp 65-73.
8. MDL. (1995) "MDL- Tissue Engineered Skin." *http//www.leahcim.demon.co.uk/tisseng/skinrev.htm*
9. Spier, R. (1980) "Recent Developments in the Large Scale Cultivation of Animal Cells in Monolayers." *Advances in Biochemical Engineering.* 14: 120-125.

Appendix A:

Video Script

Audio:	Video:
Scene 1: introduction	"Animal Tissue Culture"
Start music. Have you ever wondered how burn victims are able to recover and produce new skin?	Show a person in bandages
Sometimes they get a little help from scientists who are able to produce large amounts of skin after starting with only a small sample. This process involves what is known as tissue culture.	Show scientists in a lab
Tissue culture is the growth and study of animal cells, tissue, or organs that are maintained in vitro for more than twenty-four hours.	Show definition on screen
Another use of animal tissue culture in the medical profession is in producing medications. Vaccines, interferon's, and therapeutic proteins can all be produced in large quantities using animal tissue culture.	Show doctors office someone getting a shot
For example, vaccines produced using animal tissue culture have saved countless lives from such diseases as polio, mumps, measles, rubella, and rabies.	Children running around happy people
A final, and very important effect of animal tissue culture is that it saves the lives of animals. Using tissue cultures, an experimental product can be tested thousands of times without killing a single animal. For example, cultured breast cancer cells have been used by Pfizer to test the effectiveness of the drugs Tamoxifen and Raloxifene for treatment of breast cancer. In this way, animal use is minimized to only the final tests before use on humans.	Show animals in the park (dogs, ferrets)
Now that we know how important animal tissue culture is, we need to understand the process of starting and maintaining animal tissue cultures. In this video you will see, how to prepare media, how to initiate a primary cell culture, how to count cells and determine their viability, how to subculture and maintain a cell culture and how to harvest cells.	Starting and Maintaining Animal Tissue Cultures Then show the goals on the screen one at a time

Audio	Video
Scene 2: Preparing Media.	Preparing Media
To be successful in culturing cells, it is extremely important to provide the best conditions for the growth and maintenance of the cells. Here we describe the general approach for making cell culture media.	Lab culture shots
There are many different kinds of culture media out on the market. Each is different in some way, but there are many similarities between them. Examples of some are Dulbecco's minimal essential media and Dulbecco's modified eagle's media. Most media are made by measuring individual salts and organic compounds according to a tested recipe. The more commonly used media are also available in a premixed form.	Show the different kinds of media and catalogs(wide shot)
No matter what kind of culture media you are using, some key ingredients remain the same. There is always water, a buffering agent like sodium bicarbonate, amino acids, vitamins, glucose, and a blood serum, which is usually fetal calf serum. Antibiotics are also added to prevent microbial contamination.	Media and packet overlay list of the ingredients
To make the media, the appropriate amounts of all the dry materials are dissolved in deionized, distilled water. Because many of the components in animal tissue culture media are unstable when heated, the mixture is usually sterilized by filter sterilization into a sterile container. The sterile media is then dispensed into pre-sterilized culture vessels.	Show filter sterilizing of media
There are two basic types of culture vessels, there is the T-flask and the petri dish. These vessels are usually purchased pre-sterilized. We will use both in the following lab procedure.	Show petri dish and T-flask

Audio	Video
Scene 3 Initiating a Primary Cell Culture	Initiating a Primary Cell Culture
All animal tissue culture requires good sterile technique and use of a sterile hood. These topics will NOT be covered here. It is assumed that you already know these skills. Please see the two relevant videos in this series for a review.	Sterile Technique Use of a Sterile Hood
Both adult and embryonic tissue can be used to establish animal cells in culture. Cells can be released from these tissues by mechanical and enzymatic means.	Show pictures of embryonic chick
Primary embryonic cells will yield cells that have the ability to undergo logarithmic growth.	Show a cartoon of one cell undergoing logarithmic growth.
Any tissue can be used to establish cell cultures, including mouse embryos or human tumors. The tissue we will be using is obtained from fertilized chick eggs, which have the advantage of providing their own sterile packaging. The shell effectively preserves the egg until it is needed. Use of embryonic chicks allows for specific isolation of cell types from 12 to 24 day old embryos.	Can then show other animals whose embryos can be used, examples like a live mouse or rabbit etc. Show a chick embryo and its packaging opened up for easy viewing
Basic materials needed to initiate the culture include: Three 8-day old fertilized eggs, Petri dishes, Forceps, 100 ml of Hank's Balanced Salt Solution, or Hank's BSS, a scalpel, sterile pipettes, sterile centrifuge tubes, T-flasks for culture, 100 ml of Eagles culture media, 10 % of which is fetal calf serum, 0.25% Trypsin, a sterile container with stirring bar, a sterile funnel with gauze filter	Show all the equipment at once then one at a time
First the egg shell is disinfected with 70% ethanol. The blunt end of the egg is then placed uppermost in a small sterile beaker.	Show swabbing of egg and placing into beaker

Audio:	Video:
Crack the top of the shell and peel off the edge of the air sac with sterile forceps. Resterilize the forceps by dipping in 70% ethanol and flaming. Then peel off the white shell membrane to reveal the embryo.	Show process being performed on egg. Show forceps being sterilized in between
Being careful not to sever the neck, lift the embryo out of the inside of the egg with sterile forceps and place it in a sterile petri dish.	Show placing of embryo in dish
Transfer the embryo to a beaker of previously prepared PBS, gently rinse the embryo, then remove it from the PBS and place into another sterile petri dish. Now dissect the sample using sterile forceps and scalpel, removing all unwanted tissue. In this case we are excising all internal organs, leaving behind the embryonic skin, muscle, and bone for culture of fibroblasts. Rinse the sample again with PBS.	Show tissue being transferred and then being dissected Show microscope picture of fibroblasts on screen
The tissue sample should now contain only the embryonic skin, muscle, and bone. Finely chop these tissues and again rinse with PBS. The PBS will be removed by centrifugation. Centrifuge and then remove the media solution off with a sterile aspirator. Resuspend the cells in fresh trypsin solution and place in a sterile stir flask to which 15 ml of a 0.25% trypsin solution in PBS is added. The trypsin will help separate adherent cells from each other.	Show sample being finely chopped up and then put into the stir flask. Show centrifuge and resuspension.
Stir at 200 rpm for 20 minutes at 37 degrees Celsius. Then allow pieces to settle.	Show stirring and a picture of the settling pieces
Strain out remaining un-dissociated tissue by filtering through sterile gauze.	Show filtration process.
Centrifuge for 5 minutes at 500 x gravity. Aspirate the trypsin solution off. Then resuspend the cells in 10 ml of fresh Eagles growth media containing 10% fetal calf serum	Show pieces being removed then show centrifuge and resuspension of cells in the media

Audio:	Video:
Once the culture has been initiated, it needs to be incubated in order to grow. Most cell types need to be incubated at 37 degrees Celcius, in media that is between pH 7.0 – 7.2. The byproducts of cell metabolism can make the media too acidic and ultimately may kill your culture. Therefore, a buffering system must be used.	Show cartoons of cells being incubated Show cartoons of cells in acidic media
A common buffering system uses the bicarbonate in the medium and a CO2 supply from the air, which is why it is important to use a CO2 incubator to grow the cells.	Show a picture of a CO2 incubator
A normal setting for the incubator is 5% CO2, and 95% air at 37 degrees Celcius. There is also a water reservior to maintain a high humidity level within the incubator.	Overlay a table of the correct settings for CO2 incubation on same picture above, 5% CO2, 95% air, 37 degrees Celcius
The bicarbonate in the media will react with the acidic hydrogen ions to make carbonic acid, which is in equilibrium with water and dissolved CO2. This maintains the pH at a constant level. The high humidity helps prevent evaporation of the media.	Overlay the balanced chemical formula and pH level: $CO2 + H2O \Leftrightarrow H2CO3 \Leftrightarrow H^+ + HCO3^-$ $PH \approx 7.0$
Scene 4	
We are now ready to learn how to count cells and determine their viability.	"Cell Count and Viabilty" written on the screen
The growth of cells in vitro is extremely important to the biotechnology industry. The more cells that are present in the culture, the more product can be obtained. A method of counting cells and determining their viability will be shown here.	Show lab shots of people using a hemocytometer, other procedures
For this exercise, you will need: a hemocytometer Phosphate Buffered Saline (PBS) a tube of cells suspended in media a tally counter a pipette with sterile tips a microscope 20-200ul of 0.4% Trypan blue dye Ethanol And kimwipes	Pan across materials as they are read. Show 1ml pipetteman and sterile tips in a box.

Audio:	Video:
First, clean the hemocytometer using 70% ethanol and a kimwipe. Hemocytometers, which look very much like a glass slide, were first used to count blood cells. The surface has been machined so that there is a grid containing nine large squares, each with a volume of 10^-4 mL on the surface. Be sure not to use a paper towel because it might scratch the grid.	show cleaning of the slide. Graphic of hemocytometer as seen through microscope
Next place a clean cover slip on the hemocytometer, making sure it covers the grooved areas along the central grid. You can moisten it slightly to keep it in place.	Show correct method for putting on cover slide.
Resuspend cells, trying not to make bubbles.	Show pipetting the cells up and down.
Add 0.1 ml of the cell suspension to 1.9ml of the Trypan blue solution giving a 1:20 dilution.	Show adding the dye
Use a pipetteman to place your sample on a hemocytometer.	Briefly show placing sample onto a hemocytometer.
Place the hemocytometer on the microscope stage.	Show transfering of hemocytometer to microscope stage
Select the 10x objective and focus on the grid lines. If the cells are not visible or not in focus, you may have to adjust the light intensity. Viable, or living cells appear clear, with a refractile ring surrounding them. Dead cells will appear stained blue-black	Show picture through microscope Point out viable cell, then dead cell with arrows
Place the slide so that the center of the grid is visible. There should be 25 smaller squares visible in the center.	Point out grid, and the appropriate square
Count all cells present in the central grid, including the ones that appear blue-black. For cells along the large square, only count cells along the top edge and the left side. This will ensure that cells are not counted twice if additional squares are counted.	Arrow along top and left side

Audio:	Video:
For this procedure, you should count at least 100 cells. You can count more or all of the squares until that number is reached. If there are still not enough cells, you will have to recentrifuge the sample, and resuspend the pellet in a smaller volume of PBS and repeat the counting process.	Show a sample with not enough cells.
Recount the cells which appear blue-black in the grid. These are cells which are not viable. The percentage of viable cells now can be calculated, using this formula.	Show formula for %viable cells % Viable cells = [(Total cells – dead cells)/ total cells]x100
Another useful calculation is the number of cells per unit volume of the sample, which uses this formula based on counting the number of cells in the large squares	Show formula for # cells/volume Cells/mL = (Total # of cells counted / total # of large squares counted) x dilution factor x 10^4
Scene 5 Once a cell culture has been initiated and grown, the cells must be subcultured and maintained so they do not die.	"Subculture and Maintenance"
Subculture is the process of removing cells from their old media and putting them into fresh media.	Show definition
Cultured cells grow in either one of two ways. They can be free-floating in a suspension of media, or they can adher to the bottom of the culture flask. Here we will show subculture of adherent cells because these cells must first be released from the surface to which they are stuck. They are then treated the same way you treat a suspension culture.	Cartoon of suspension vs. adherent culture and then suspension and adherent cells.

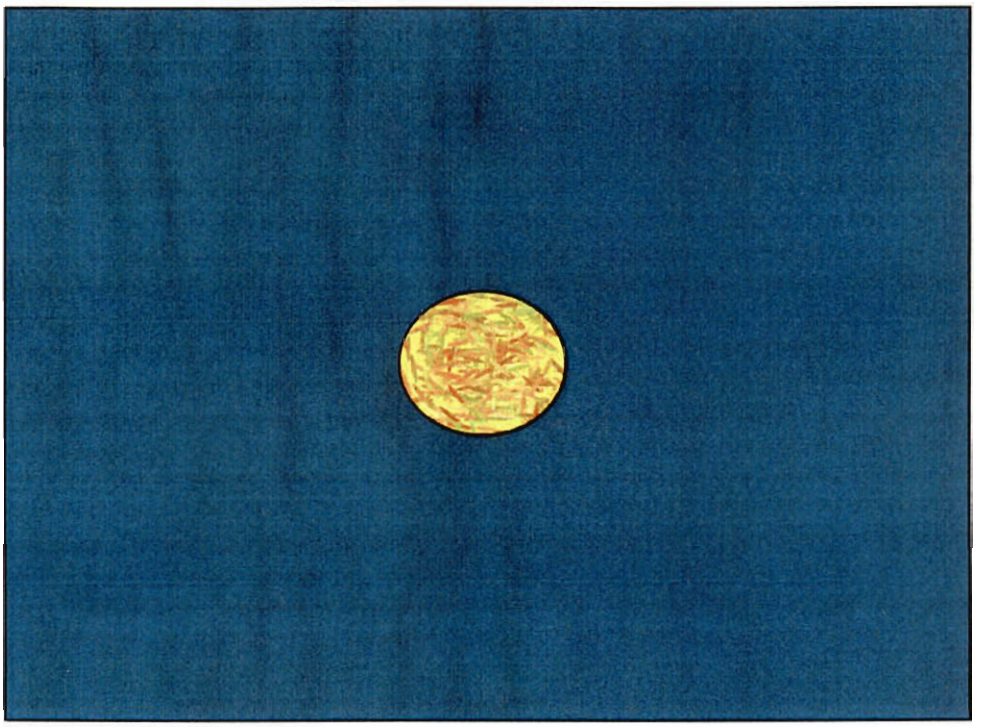
Audio:	Video:
For this procedure, you will need: A sterile solution of 0.25% trypsin in PBS, T flasks, A hemocytometer, An inverted microscope, Sterile PBS, Trypan blue dye, Some of your sterile media containing 10% fetal calf serum, sterile, 10 ml pipettes, and, A culture of confluent cells, which is a culture grown to the point where cells form a layer of continuous cells over the surface of the culture container.	Pan across the rest of the matierials. Show before and after shots of confluence. Show a microscope slide of confluent cells
To prepare for subculturing, first aspirate the media from your flask of cells.	Show aspirating media and disposing of it.
Add a small volume of PBS to prewash the cells. Rinse and dispose of this washfluid as well.	Show addition of the prewash.
Next add 1 ml of trypsin solution and let it stand for approximately two to five minutes.	Show trypsin addition.
View the cells under the microscope while they are incubating. Cells should begin to appear rounded.	Show microscope pictures
Continue incubating the cells until they begin to lift from the surface of the culture flask. This may take a few minutes. Then start to gently rock the flask until all the cells are removed.	Show rocking of cells.
Five ml of media containing serum should then be added to the flask. Pipette up and down to break up all the cell clumps, then transfer to a sterile conical centrifuge tube. Centrifuge and then remove media with a sterile aspirator. Resuspend cells in fresh media.	Show adding the media, dispersing cells, centrifugation, and aspiration (important). (use very quick vignettes)
Then count the cells as described previously.	Cell counting shot from previous footage.

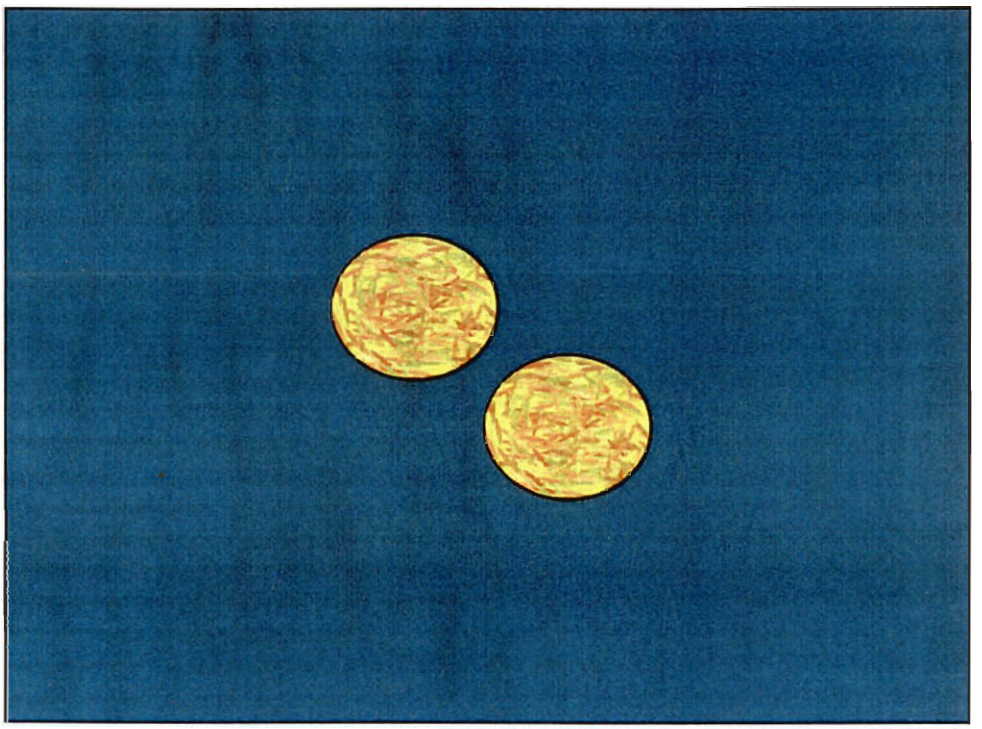
Audio:	Video:
Finally, dilute the cells to 10^4 per cm^2 in the new flask. You should be diluting only to the area the cells can adhere to, not to the entire volume of the flask. The cells will gradually settle to the bottom before they adhere and their growth is affected by the amount of surface area to which they adhere.	Show adding more media to dilute. Flash on screen: Adherent cells: 10^4 cells / cm^2
For suspension cultures, cells are usually diluted with new media to a density of 1-2 x 10^5 cells / ml.	Suspension cells: 1-2 x 10^5 cells / ml
Incubate as usual.	Show CO2 incubator
Scene 6	Harvesting cells
When it is time to harvest your cells, you need to know whether your goal is to harvest the cells or to remove the cells so you can purify some product, like an antibody, from their media.	Flow chart slide 1
This procedure differs somewhat depending on whether your culture is an adherent or suspension cell culture.	Show section of flow chart related to this.
If your culture contains suspension cells, transfer the cells into a centrifuge tube.	Show slide with arrow pointing down suspension path on flow chart.
Then centrifuge the cells into a pellet of cells and supernatant media.	Show slide of flow chart at this point
Decant the media to separate it from the cell pellet. Further separation and purification can now be performed either on the media or the cells themselves.	Show picture of the cells and media separated.
However, if your culture is adherent, determine whether the desired product is the media or the cells, as this dictates the procedure you will use for separation.	Show slide of flowchart going down the adherent path.
If your product is the media, simply decant it from the flask.	Show decanting the media.
However, if the desired product is the cells themselves, trypsinization of the cells is necessary. Trypsinization releases the cells from their adherent surface yielding a suspension culture. After you have the cells in suspension, follow the same process shown for suspension cultures.	Show process of trypsinizaton after decanting media. Cartoon only.

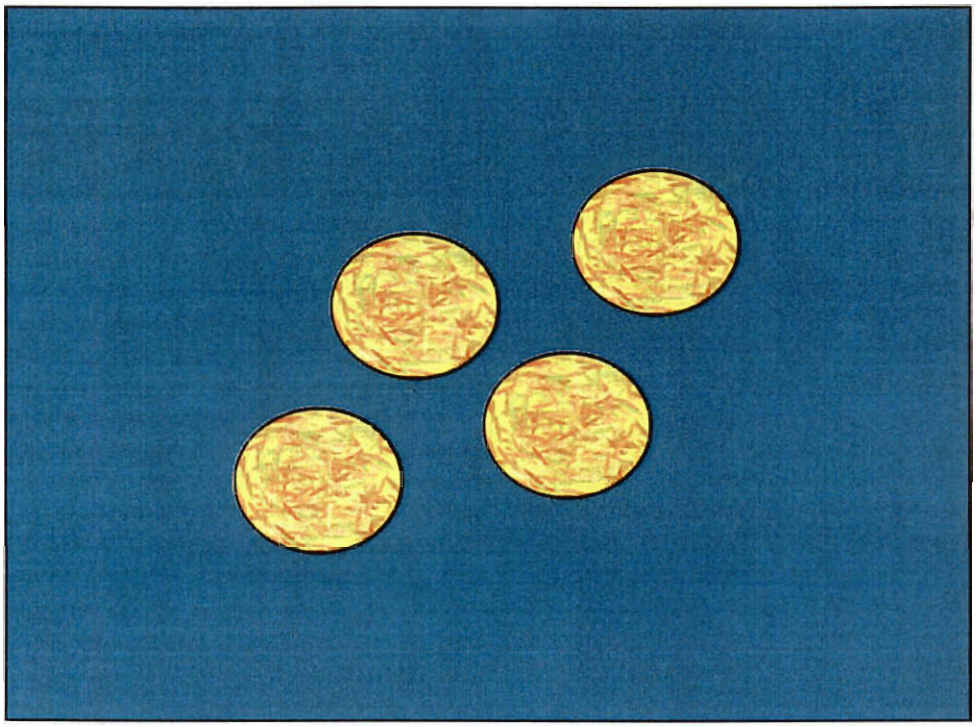
Audio:	Video:
In this video you have learned how to prepare media, how to initiate a cell culture from embryonic tissue, how to count cells and determine their viability, how to subculture and maintain a cell culture and how to harvest cells.	Start music back up. Show list on the screen. Maybe highlight each as they are said.
You have seen each of these topics executed with proper technique and lab equipment. You should use this information to improve your own technique and results when you begin your first animal tissue culture lab.	Show a previous clip of good technique. Maybe cleaning or sterilizing something.
Also remember that animal tissue culture is important in everyday life. Whether it be from helping someone heal their wounds, producing large amounts of medication, or from saving animal's lives; animal tissue culture has affected everyone's life in some positive way. The skills you learn today can help save lives in the future.	Short clips of burn victem, medication bottle or someone taking a pill, and animals running around. Show them as each is said.
End music. Begin new music with credits.	Credits

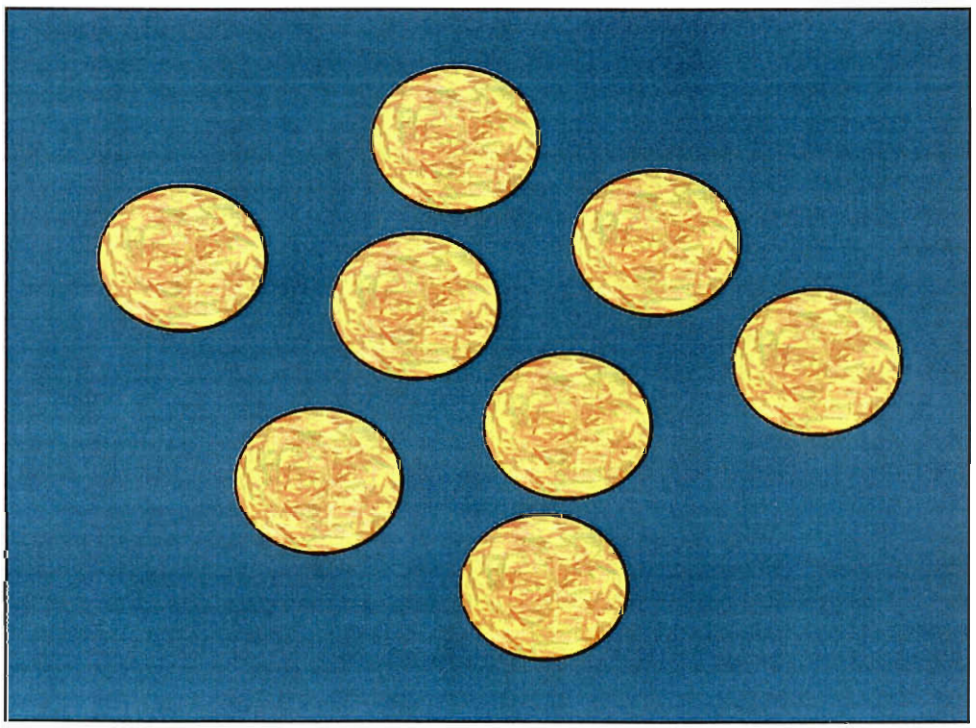
Appendix B:

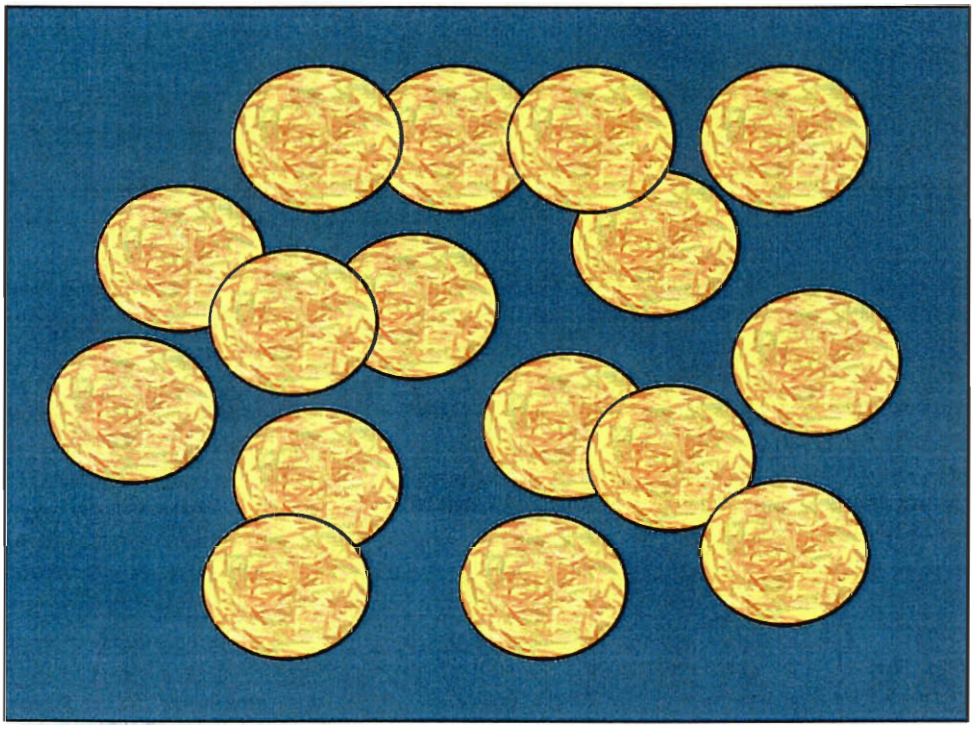
Video Graphics

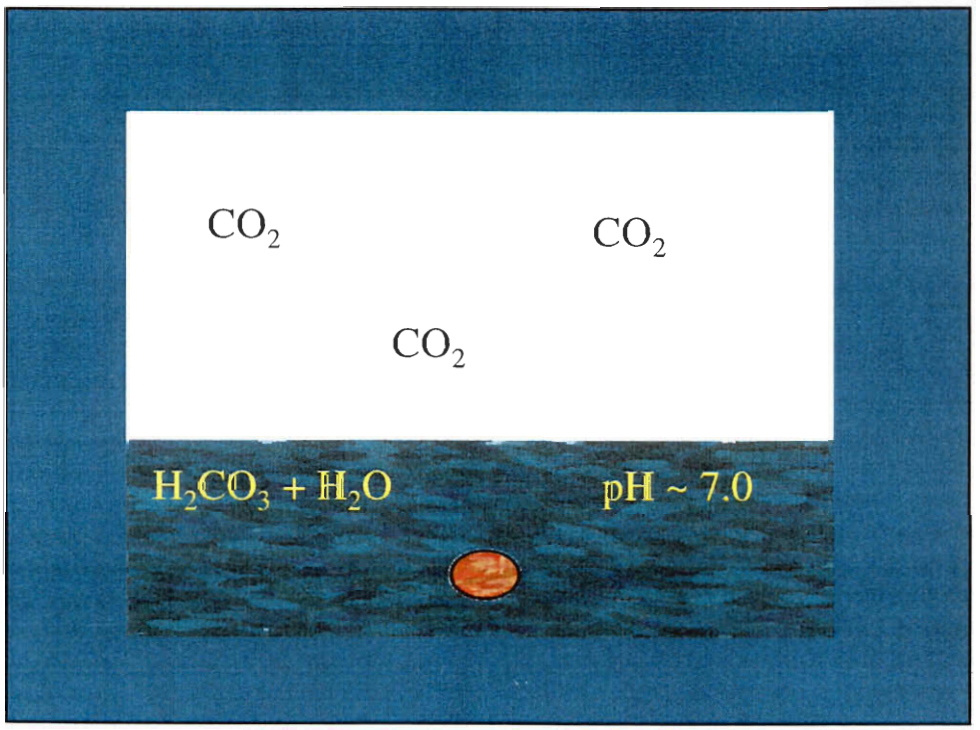


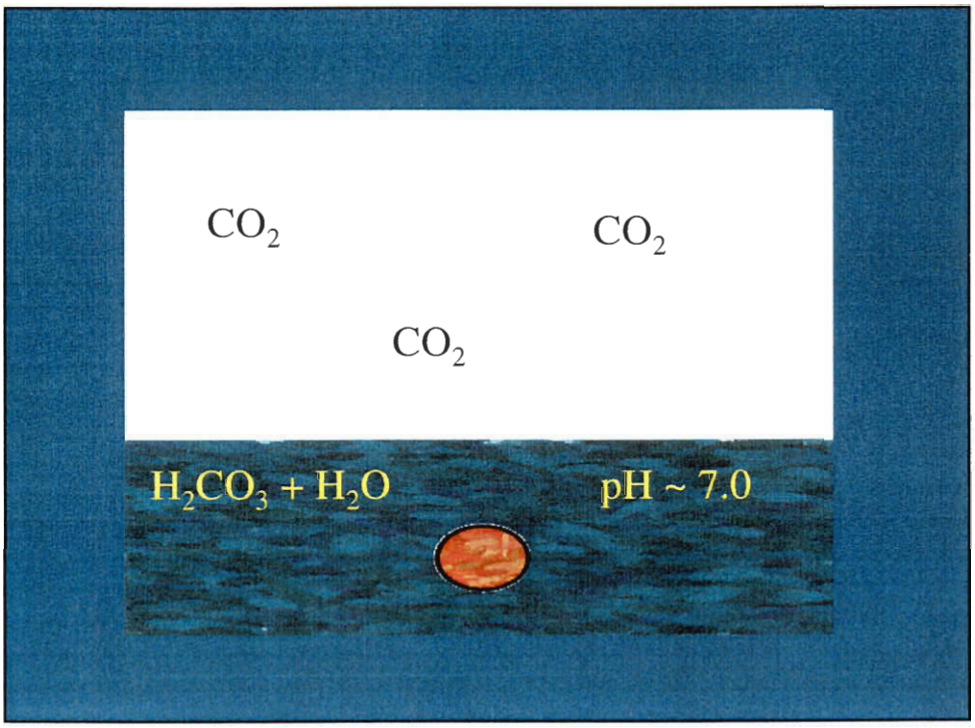









CO_2
CO_2
CO_2
$H_2CO_3 + H_2O$
pH ~ 7.0


CO_2
CO_2
CO_2
$H_2CO_3 + H_2O$
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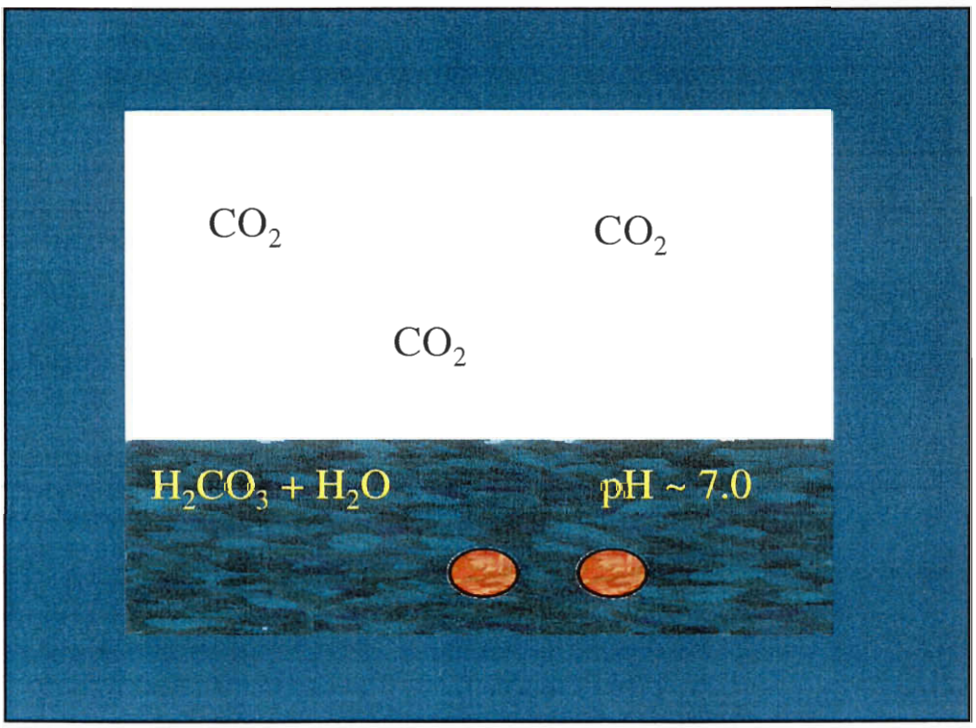
CO_2
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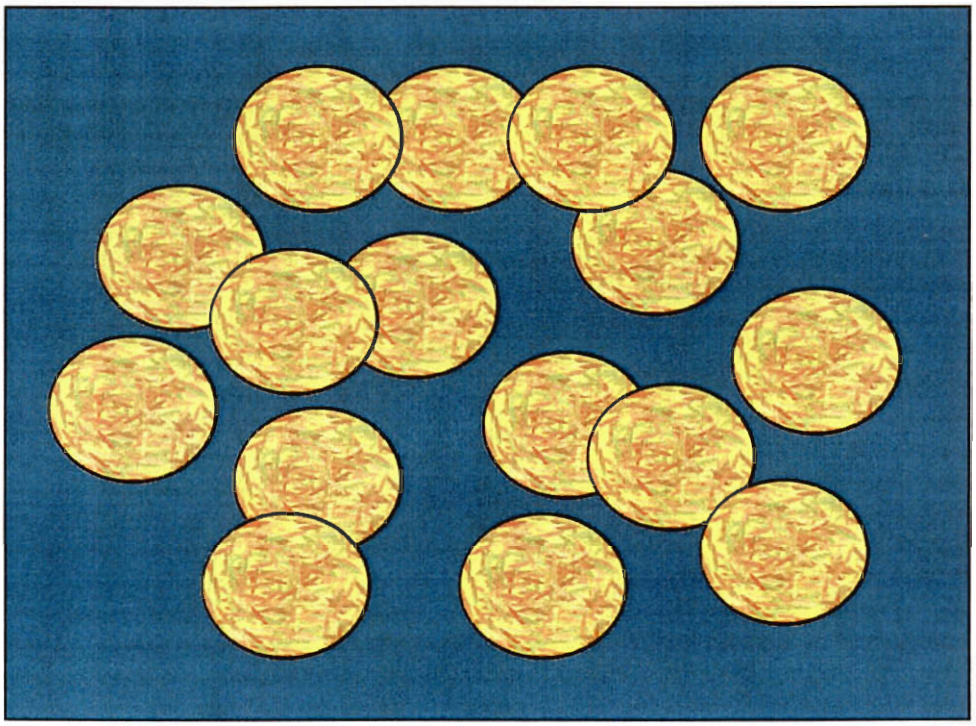
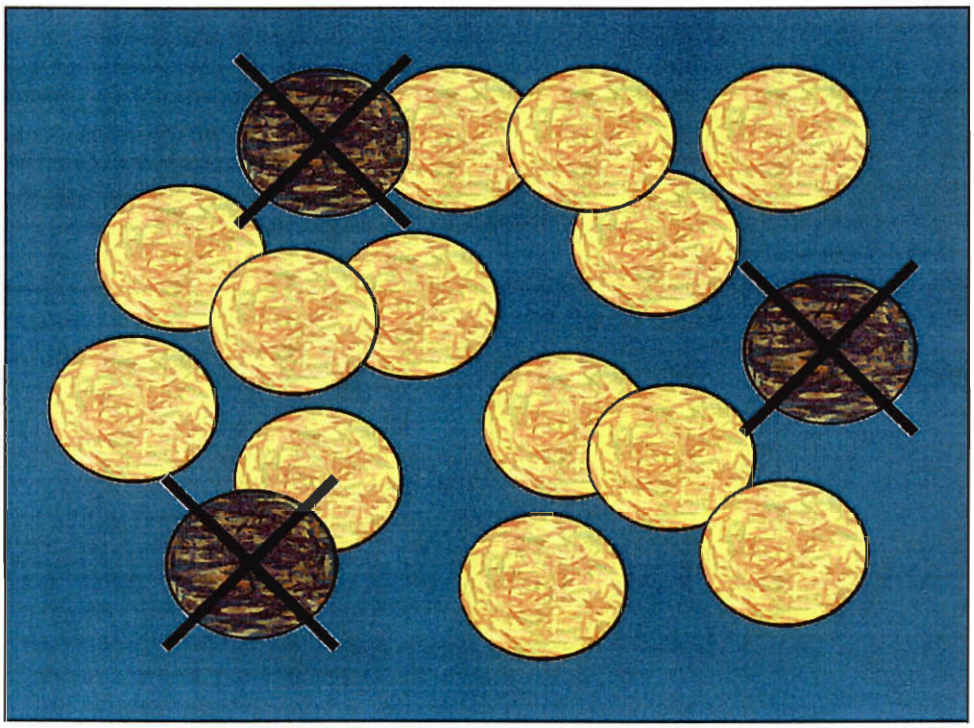
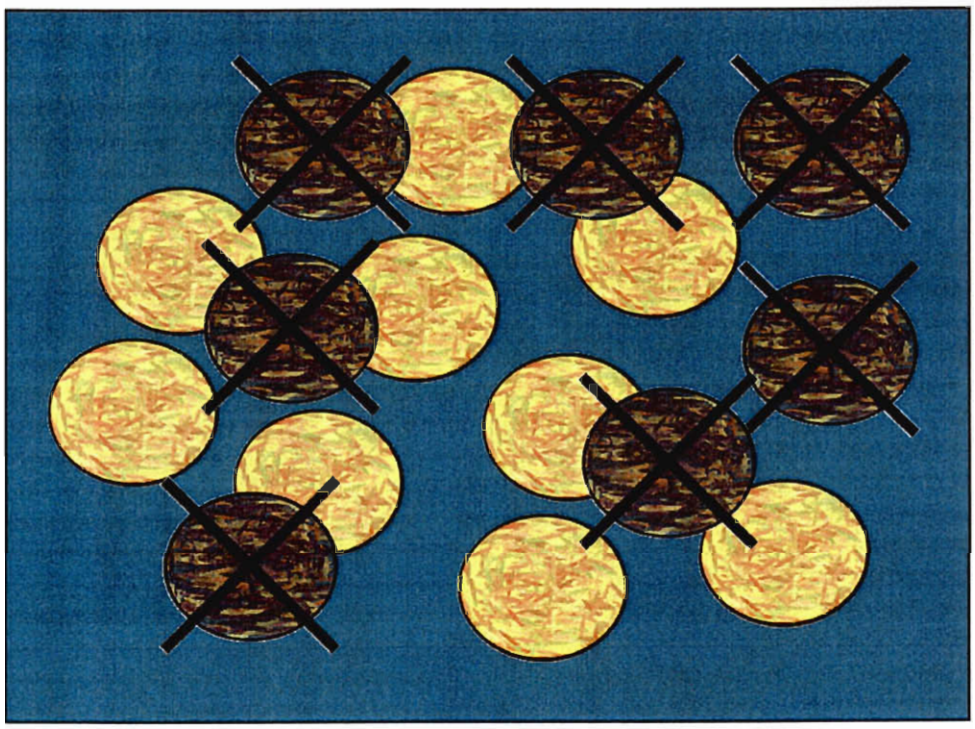
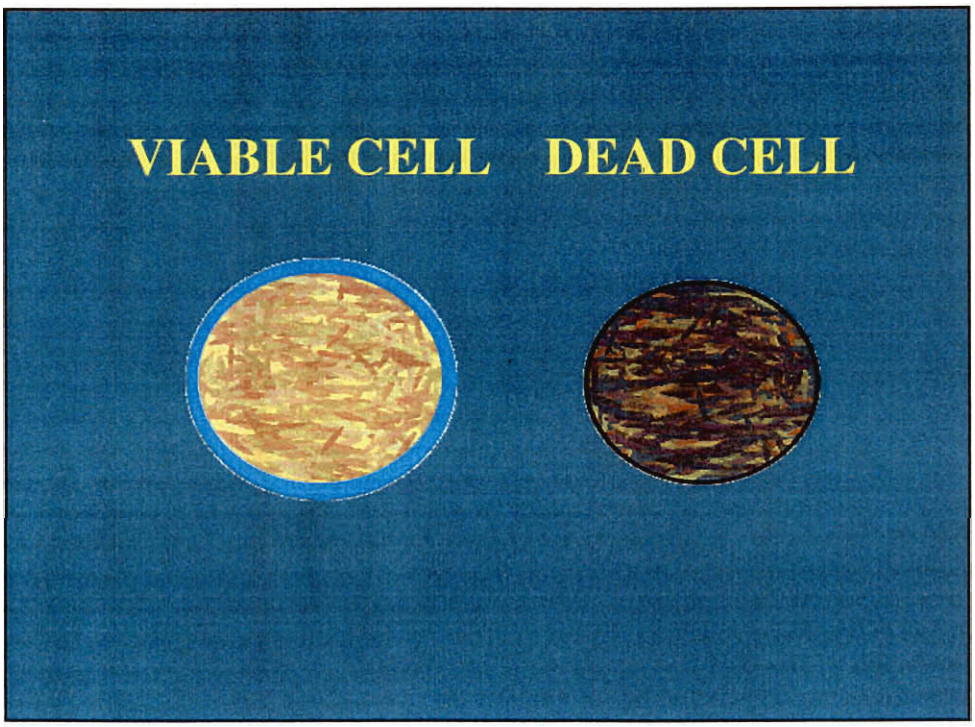
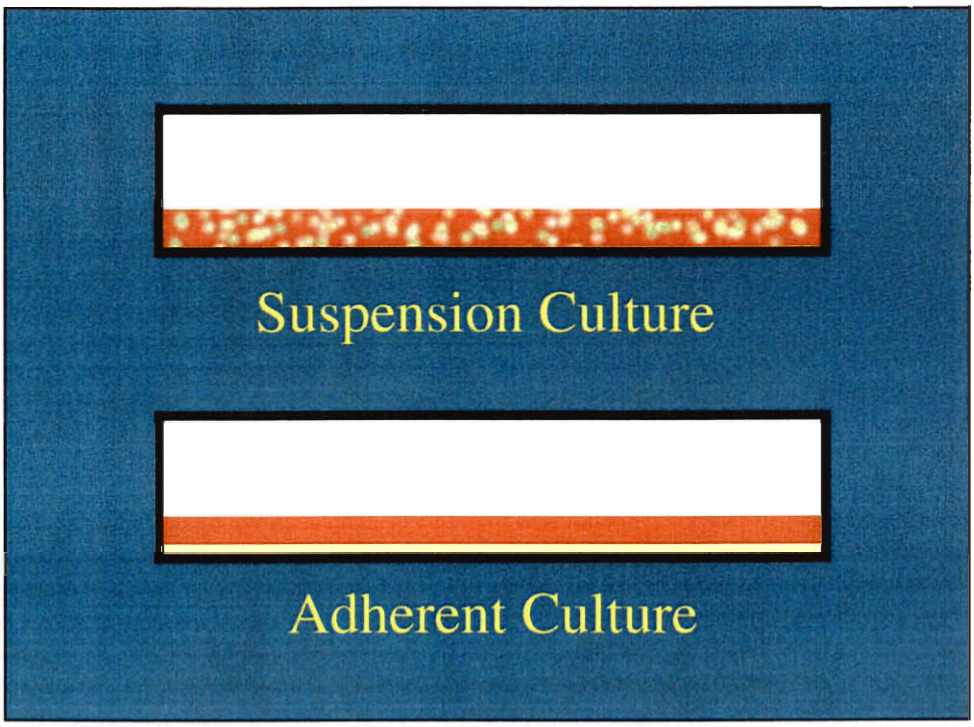
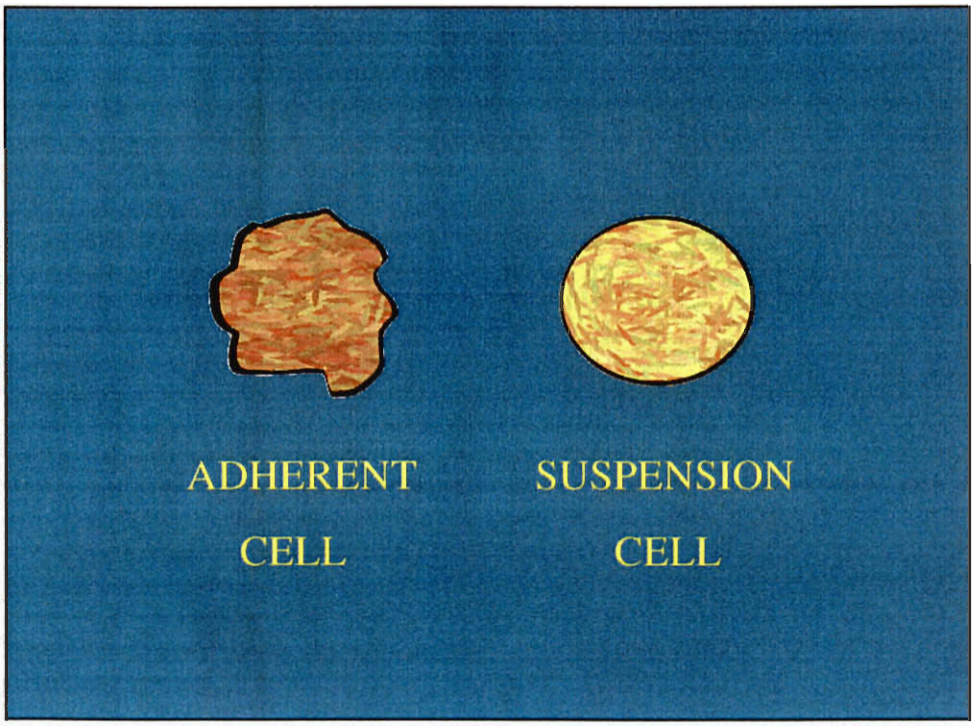


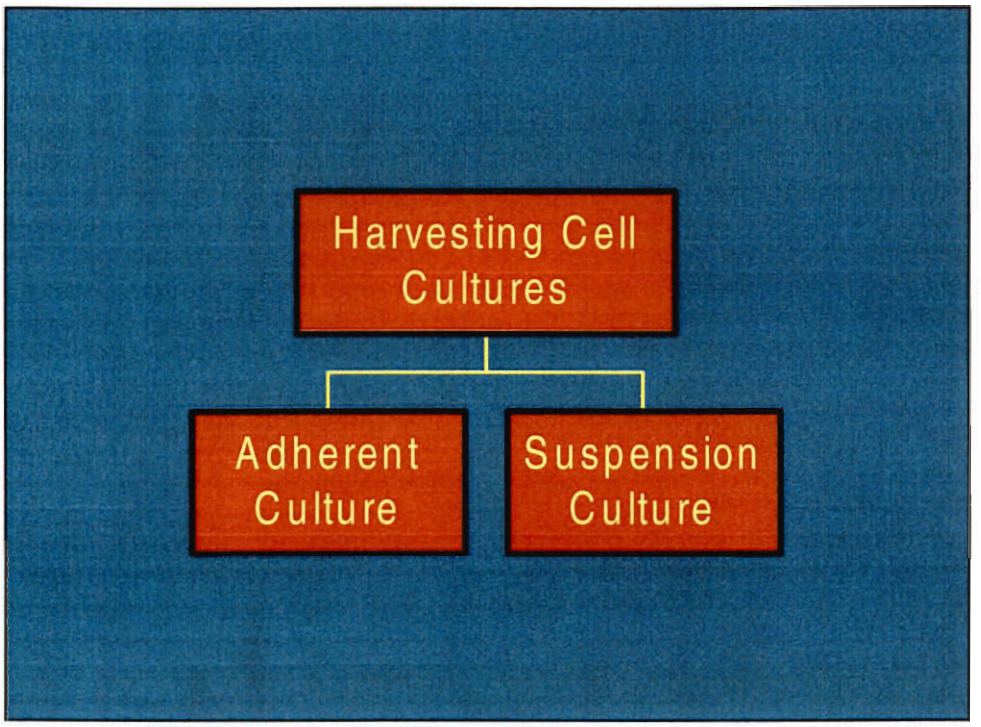


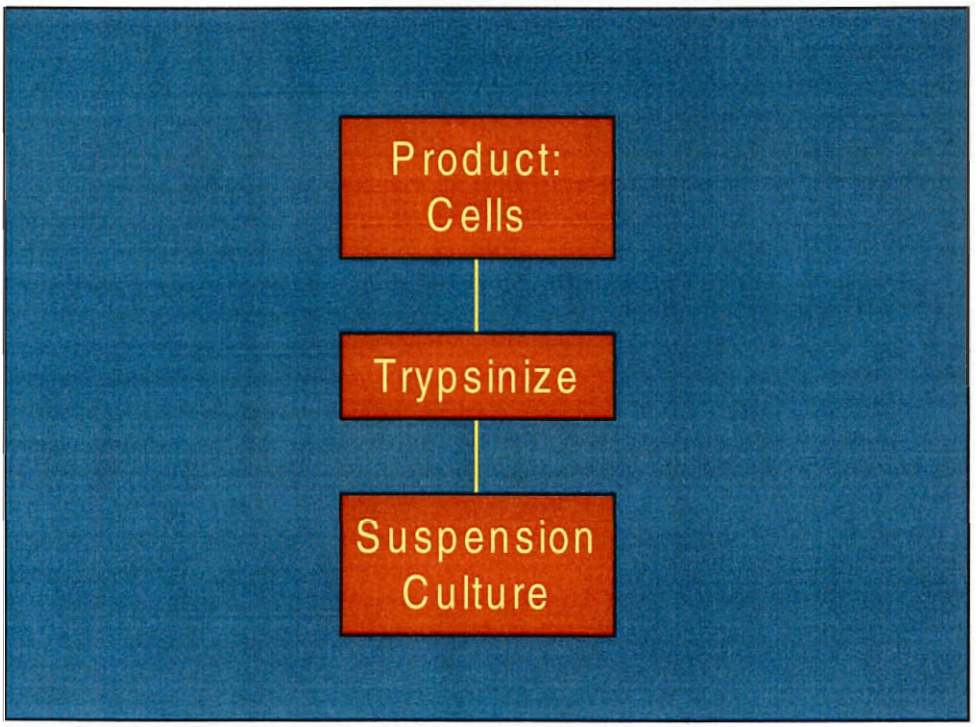


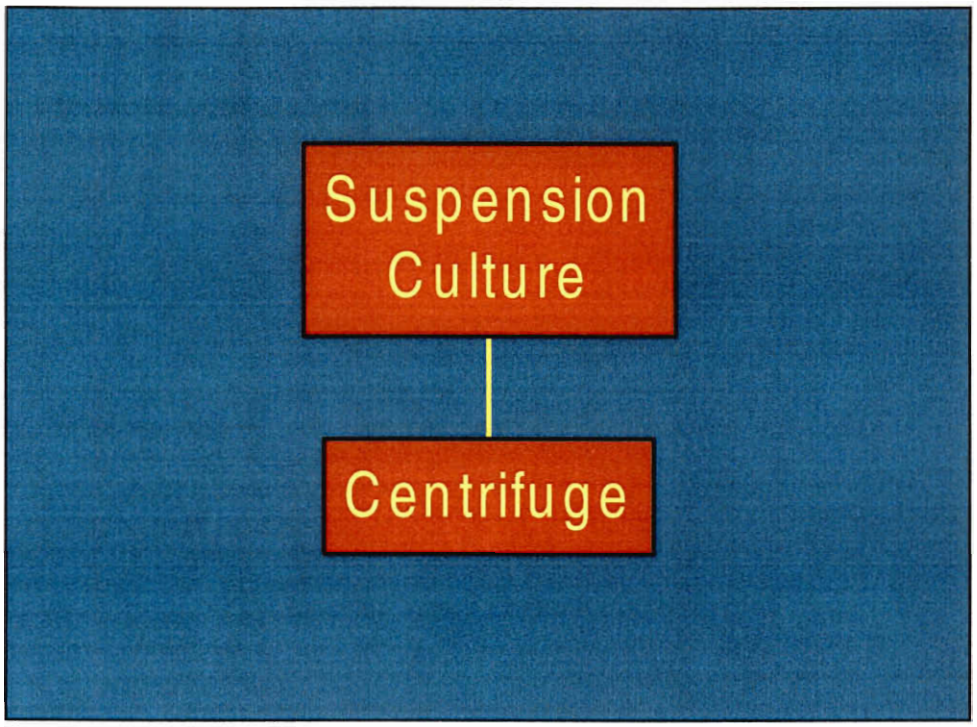

VIABLE CELL
DEAD CELL

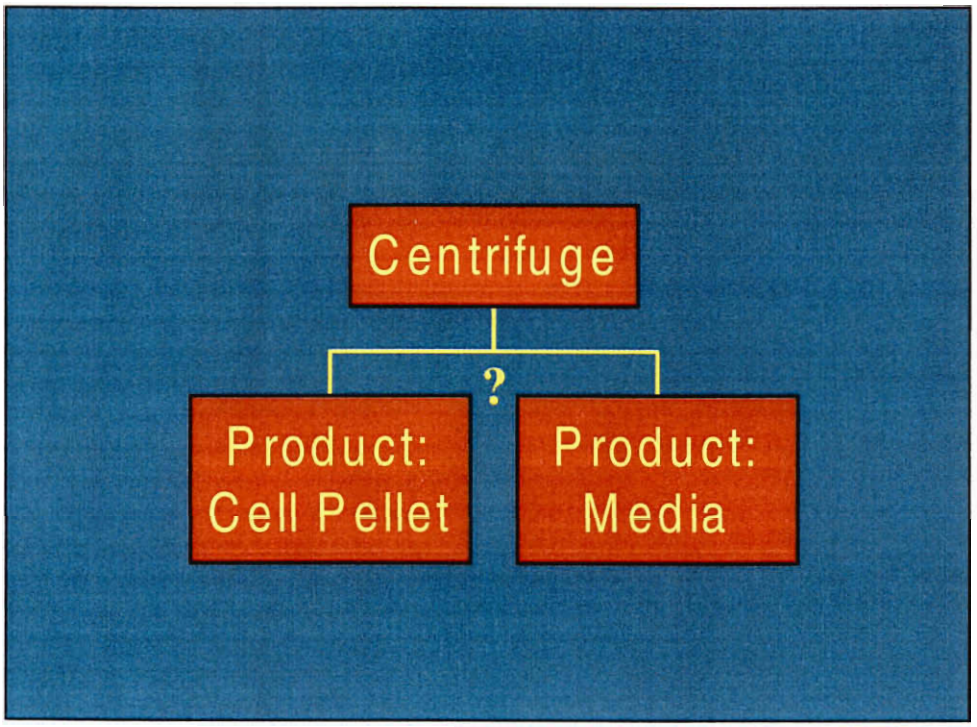

Suspension Culture
Adherent Culture

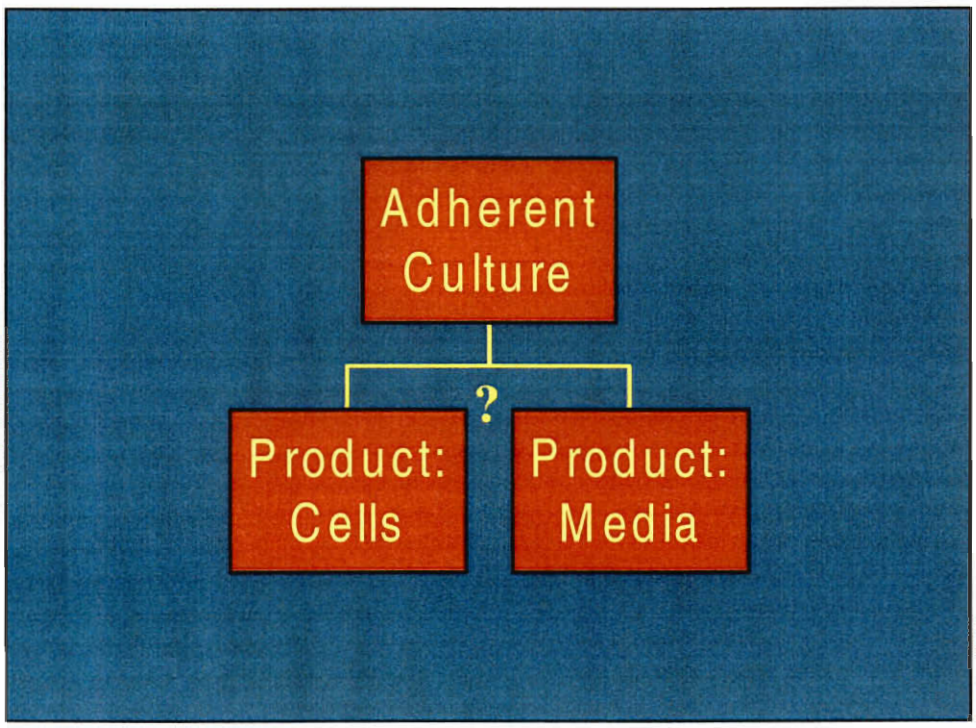

ADHERENT CELL
SUSPENSION CELL

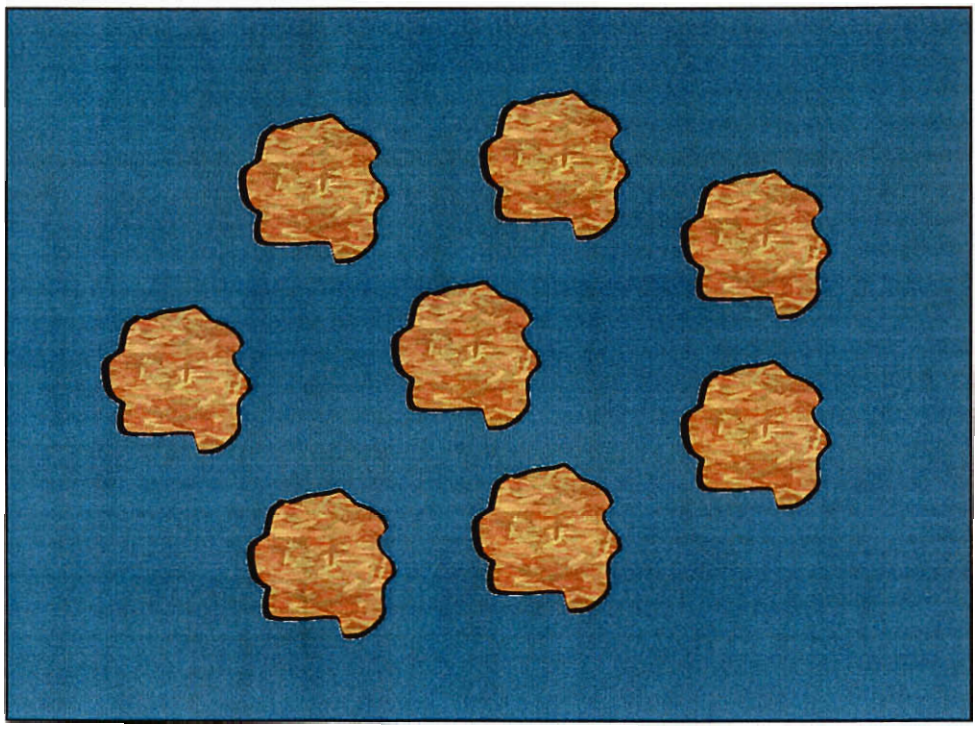

Harvesting Cell Cultures
Adherent Culture
Suspension Culture

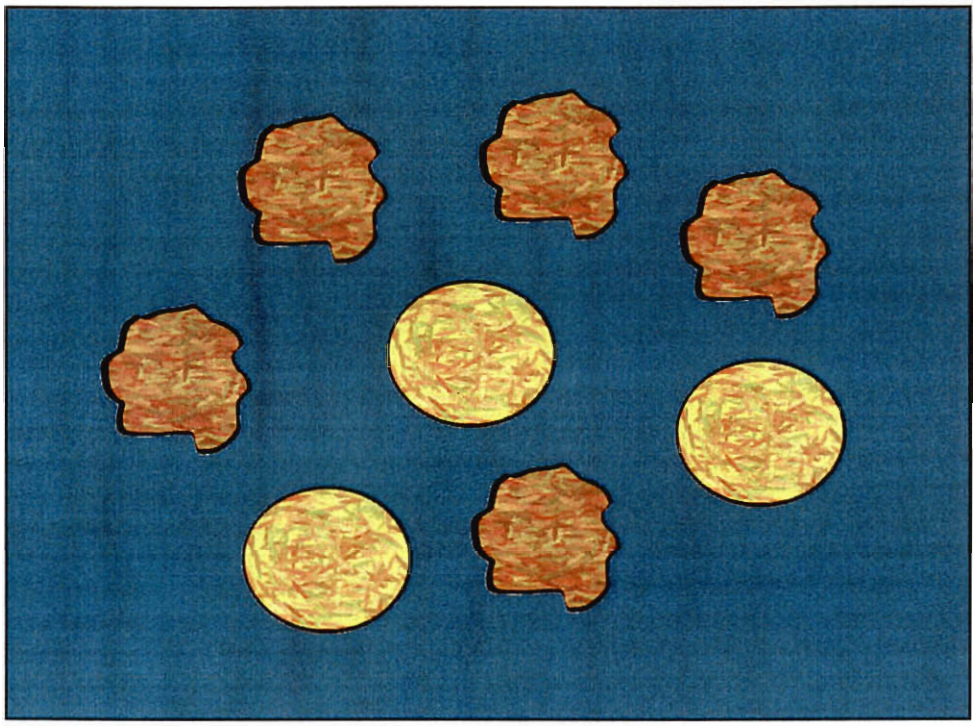

Product: Cells
Trypsinize
Suspension Culture

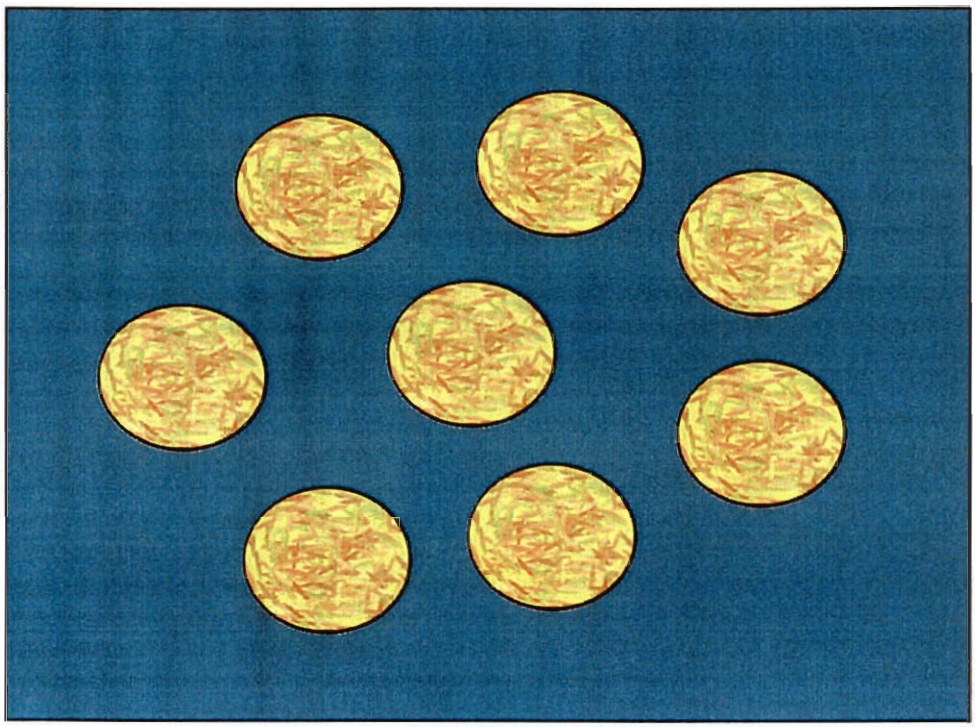

Suspension Culture
Centrifuge


Centrifuge
?
Product: Cell Pellet
Product: Media


Adherent Culture
?
Product: Cells
Product: Media







Appendix C: Blank Instructor

Evaluation Form

Animal Tissue Culture Video Instructor Survey

Please fill out the following information by circling the proper response.

Demographics

Gender:	Male	Female		
Years Teaching:	1-5	6-10	11-15	16+
Grades Taught:	Junior High	High School	2 yr. College	4 yr. College
Subjects Taught:	Biology	Chemistry	Physics	Other:_____
Degree:	BA/BS	MA/MS	Ph.D.	Other:_____

Please circle the response that best indicates your opinion.

Animal Tissue Culture Video: (General Questions)	Strongly Agree	Agree	Disagree	Strongly Disagree
1. The Animal Tissue Culture Video was clear and easy to understand.	4	3	2	1
2. I found this video interesting.	4	3	2	1
3. I would use this video in my classes if it were available.	4	3	2	1
4. I have access to the materials and equipment in this video.	4	3	2	1
5. This video is as good as, if not better than other instructional videos I have seen.	4	3	2	1
6. I feel that my students would enjoy this video.	4	3	2	1
7. I feel that this video would hold the interest of my students.	4	3	2	1
8. The concepts in this video would be understood by my students.	4	3	2	1

Animal Tissue Culture: (Introduction)	Strongly Agree	Agree	Disagree	Strongly Disagree
1. The introduction was clearly presented.	4	3	2	1
2. The introduction was a good background to the video.	4	3	2	1
3. I found the introduction to be interesting.	4	3	2	1
4. The images and photographs presented in the video helped to reinforce the concepts explained.	4	3	2	1

Animal Tissue Culture Video: (Laboratory Demonstration Questions)	Strongly Agree	Agree	Disagree	Strongly Disagree
1. The video demonstrated proper Animal Tissue Culture techniques adequately.	4	3	2	1
2. I have prior experience with Animal Tissue Culture techniques.	4	3	2	1
3. I feel that I would be able to conduct an Animal Tissue Culture experiment after seeing this video.	4	3	2	1
4. I would run these experiments in my classes if this video were made available to me.	4	3	2	1
5. The Animal Tissue Culture video was of adequate length.	4	3	2	1
6. I feel that this video is a good introduction to Animal Tissue Culture.	4	3	2	1
7. This video would become a part of my curriculum if it were available to me.	4	3	2	1
8. My students would have no problems with the concepts and vocabulary in this video.	4	3	2	1
9. I would recommend this video to others to illustrate the techniques of Animal Tissue Culture.	4	3	2	1

Written comments:

Appendix D: Completed

Instructor Evaluation Forms

Animal Tissue Culture Video Student Survey

Please fill out the following information by circling the proper response.

Demographics

Gender:	Male		Female			
Grade Level:	8	9	10	11	12	college
Scientific Interests:	Biology		Chemistry		Physics	Other:_____

Please circle the response that best indicates your opinion.

Animal Tissue Culture Video: (General Questions)	Strongly Agree	Agree	Disagree	Strongly Disagree
1. I found this video to be clear and easy to understand.	4	3	2	1
2. I feel that I would be able to perform the following procedures as shown in this video:				
a) media preparation	4	3	2	1
b) cell counting	4	3	2	1
c) subculture	4	3	2	1
d) harvesting cells	4	3	2	1
3. I learned a lot about animal tissue culture by watching this video.	4	3	2	1
4. I found this video to be interesting.	4	3	2	1
5. I found this video to be entertaining.	4	3	2	1
6. This video is better than other lab videos I have watched.	4	3	2	1
7. I understand the following topics from this video:				
a) cell counting	4	3	2	1
b) assay of cell viability	4	3	2	1
c) cell growth and CO_2 incubation	4	3	2	1
d) subculturing	4	3	2	1
e) harvesting	4	3	2	1
8. I would like to perform the experiments presented in this video.	4	3	2	1
9. I enjoy science.	4	3	2	1
10. I would like to perform more labs in my science classes.	4	3	2	1
11. I consider myself a good student.	4	3	2	1
12. I have had exposure to the following topics in the biology classes I have taken:				
a) cell biology	4	3	2	1
b) tissue culture	4	3	2	1
c) sterile technique	4	3	2	1
13) I have prior experience with Animal Tissue Culture techniques.	4	3	2	1

Animal Tissue Culture Video: (Laboratory Demonstration Questions)	Strongly Agree	Agree	Disagree	Strongly Disagree
1. I understand the importance of Animal Tissue Culture in research and industry.	4	3	2	1
2. I understand the importance of each of the animal culture procedures demonstrated in the video.	4	3	2	1
3. I understand the concept of logarithmic growth of cells.	4	3	2	1
4. I understand the importance of cell counting.	4	3	2	1
5. I understand the definition of confluence.	4	3	2	1
6. I understand why trypsinization of adherent cultures is important.	4	3	2	1
7. I understand the concept of CO2 incubation.	4	3	2	1

Written comments: