DEGREE/PROGRAM CHANGE
FORM C
Form Number: C1513

Fields marked with * are required

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Associated Forms exist? No

Initiator's Title Associate Professor: AS Biology General Administra

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Department Biology

Branch Albuquerque, Main Campus

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Proposed effective term

Semester Fall Year 2015

Course Information

Select Appropriate Program Undergraduate Degree Program

Name of New or Existing Program BS Biology - Biotechnology Concentration

Select Category Concentration Degree Type B.S.

Select Action New

Exact Title and Requirements as they should appear in the catalog. If there is a change, upload current and proposed requirements.
See current catalog for format within the respective college (upload a doc/pdf file)

Biotechnology_Concentration_catalogentry_revised12_14.docx
Biotechnology Concentration.docx

☐ **Does this change affect other departmental program/branch campuses? If yes, indicate below.**

Reason(s) for Request (enter text below or upload a doc/pdf file)
See File uploaded under Justification

Upload a document that inlcudes justification for the program, impact on long-range planning, detailed budget analysis and faculty workload implications.(upload a doc/pdf file)

biotech_concentration_UNM_CNM_final.docx

☐ **Are you proposing a new undergraduate degree or new undergraduate certificate? If yes, upload the following documents.**

Upload a two-page Executive Summary authorized by Associate Provost. (upload a doc/pdf file)

Upload memo from Associate Provost authorizing go-ahead to full proposal. (upload a doc/pdf file)

Biotechnology Concentration

Students earning the Biotechnology A.S. degree and Biotechnology Certificate at CNM may receive a Bachelor of Science degree in Biology with a concentration in Biotechnology. The concentration in Biotechnology will provide students with specific laboratory skills required for employment in biological and health professions, and make graduates more competitive and successful candidates for admission into graduate programs around the country. The concentration is based on existing CNM Biotechnology coursework and the curriculum is designed to meet competencies common to biotechnology programs around the nation and to be responsive to industry needs.

Majors in biology seeking a Bachelor of Science degree with a concentration in Biotechnology must satisfy the requirements given below in sections 1-5.

1. The B.S. program with a concentration in Biotechnology requires a minimum of 45 credit hours earned in biology courses. These courses must include: 201L, 202L, 203 and 203L, 204 and 204L; at least one of the following: 351 and 352L, 371L, 386L.

2. At CNM the curriculum includes 11 credit hours encompassed within three laboratory-based classes. The three classes are taught in sequential order, starting in the summer semester (Term 1 - BIOT 1020: Biotechnology Lab Techniques I), continuing in the fall semester (Term 2 – BIOT 2110: Biotechnology Lab Techniques II) and culminating the following spring semester (Term 3 – BIOT 2210: Biotechnology Lab Techniques III). These courses will transfer to UNM as BIOL 220 Biotechnology Lab Techniques I (4 credits), 221 Biotechnology Lab Techniques II (4 credits), and 222 Biotechnology Lab Techniques III (3 credits).

3. To satisfy an upper-division breadth requirement for the Biology B.S., each student must complete at least four 400-level courses that are spread across three of the following five categories: 1) Cell/Molecular (CM); 2) Physiology (PH); 3) Organismal (OR); 4) Ecology/Evolution (EE) or 5) Interdisciplinary Science (ID). Note: the category to which each eligible course belongs is listed in parentheses (CM, PH, OR, EE, or ID), and completing three of these courses from only one or two categories does NOT satisfy the breadth requirement.

4. Required Supportive Courses for the B.S.: MATH 180-181 or 162-163; PHYC 151-152 (or 160-161); CHEM 121, 123L, 122, 124L (or 131L-132L) and 301-303L (or 212). (For those interested in microbiology, molecular/cellular biology, physiology or medicine, CHEM 301-303L and 302-304L are recommended.)

5. Candidates for the B.S. degrees in Biology with a concentration in Biotechnology must take a minimum of 6 credit hours to be taken from a list of complementary interdisciplinary electives available from the department advisor.

- BIOL 110, 112L, 123, 124L, 136 and 239L do not count toward a biology major.
- A course fulfilling one requirement cannot be used towards another (e.g., no double-dipping); although each BIOL 419 section is considered a different course, if it has a different instructor/title.
- Student must verify that course work meets with requirements for a B.S. in Biology.
- Grade of C or better required in all of the above courses.
- Transfer students must complete at least 19 credit hours of biology course work at UNM.

***NOTE:** Departmental advisement is required for students who wish to complete the concentration in Biotechnology.

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3. To satisfy an upper-division breadth requirement for the Biology B.S., each student must complete at least three 400-level courses that are spread across three of the following five categories: 1) Cell/Molecular (CM); 2) Physiology (PH); 3) Organismal (OR); 4) Ecology/Evolution (EE) or 5) Interdisciplinary Science (ID). Note: the category to which each eligible course belongs is listed in parentheses (CM, PH, OR, EE, or ID), and completing three of these courses from only one or two categories does NOT satisfy the breadth requirement.

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Preliminary Review and Proposal Outline for a new Biotechnology Concentration in Biology

1. Program Description

UNM Biology and CNM would like to propose the creation of a new concentration in Biotechnology under the Bachelor of Science degree in Biology. All coursework for the concentration will be completed at CNM and will transfer in its entirety to UNM. This Biotechnology concentration will provide students with the bench skills that most traditional undergraduate Biology graduates are lacking. The acquisition of these specific skills will not only make UNM's Biology graduates more marketable candidates for jobs in biological and health professions, but also more competitive and successful candidates for admission into graduate programs around the country.

The creation of this concentration will serve UNM and CNM in a very specific way: the Biotechnology program is currently struggling since many of the students in the program do not complete the degree requirements. Most of the students are transferring into a 4 year bachelor's degree program and continuing their education. Since this is a pattern that students are already choosing, it is sensible to provide the students with this very useful education in a form that fits their current behavior. If we can tailor a concentration to the student needs, we will enjoy a higher completion rate and be able to salvage this very useful program. At the same time, our UNM graduates will gain employable skills and earn credit towards their UNM BS degree.

The creation of this concentration will serve UNM in some very concrete ways as well:

- UNM Biology will be able to create a new concentration at no cost to the department
- UNM Biology students will have a low cost opportunity to strengthen their credentials
- UNM Biology students will enjoy a competitive edge when seeking jobs in the biotechnology and health sciences sector, both locally and nationally.
- CNM students will be recruited into a program that will lead directly to a UNM program, thus working as a recruiting tool for UNM enrollment. Many students who begin at CNM, with its open enrollment policy, would never fulfill admission requirements at UNM. This certificate could represent a way of recruiting and preparing non-traditional students for entry into UNM and thereby bolster UNM's enrollment
- This certificate could set a precedent for a new model in higher education: community colleges offering certificates that can seamlessly transfer into 4 year schools as concentrations. The potential for innovation is especially strong in the Career Technical fields. For generations, students in Career Technical disciplines have had to virtually begin their academic careers anew if they changed career goals at some point and decided to pursue a traditional academic course of study. The existence of skills focused certificates that can transfer into traditional 4 year degree programs as concentrations provides a vehicle whereby students

will not be forced to waste time and effort in community college programs that have been typically classified as "terminal" and designed only for workforce placement.

Representatives of both CNM and UNM have worked to outline a strategy for integrating the Biotechnology coursework into the UNM Biology degree as a concentration. This strategy was developed with the support of the UNM Biology Department Chair, Dr. Rob Miller, and unanimous approval of the Biology undergraduate policy committee. This proposal was reviewed and approved by the Associate Provost for Curriculum, Dr. Greg Heileman, in October 2014. The current UNM Biology degree can accommodate 11 credit hours of Biotechnology coursework in transfer from CNM and all 11 hours will count toward the degree requirements. To accommodate the 11 hours of Biotechnology from CNM, UNM must create new catalog courses that will serve to accept transfer credit from CNM. In addition, any coursework completed at UNM that can be used to satisfy the CNM Biotechnology Certificate and/or Associate's degree will be accepted for transfer credit. UNM must also navigate the particular challenges of creating a new concentration, which may require that students declare a minor within the degree. CNM's challenge has been to create the new curriculum for the 11 hours of coursework that will provide the students with the requisite skills and abilities. Upon completion of these respective tasks and approval by both institutions' curriculum bodies, CNM and UNM will engage in cooperative efforts for advertising, advising and recruiting students into the program.

The Biotechnology courses are already approved as part of a transfer Associates degree with UNM, however, this concentration allows UNM students to directly supplement their UNM degree and more seamlessly reflect their Biotechnology skills into their UNM Biology degree. Assuming timely approval by UNM, the program would be implemented beginning Fall 2015.

2. Evidence of Need

a. **Student Demand:** In the last 5 years, 37% of students completing the Biotech Program were concurrent UNM-CNM students (the vast majority were full time at UNM, taking Biotech classes at CNM). These numbers indicate that there is a demand among UNM students for the skills taught by CNM's Biotech Program. An additional 44% of CNM students completing the program transferred into UNM (or another 4 year bachelor's degree program) in order to continue their education. Since this is a pattern that students are already choosing, it is sensible to provide the students with this very useful education in a form that fits their current behavior. All UNM students or those planning to transfer to UNM have expressed a desire to both gain employable skills and earn credit towards their UNM BS degree.

b. **Recruiting:** Recruiting for the Biotech Program at UNM is done using a combination of classroom visits by CNM Biotech faculty, promotion from UNM student organizations (SACNAS, for example), the Biotechnology Program

website, and e-mail communications to potential students. Creation of the Biotech concentration will create a powerful recruiting tool as it will allow UNM students to reflect their Biotechnology skills in their UNM Biology degree. CNM will seek assistance from UNM faculty and advisors to share information about the Biotech Program to potential students.

c. **Other Biotechnology Programs:** CNM's Biotechnology Program is currently the only such program in the state of New Mexico. Only three other states in the US do not have biotech programs: South Dakota, Alaska and Wyoming. (Biotechnology Degree Guide.org 2014) The loss of this program would be the loss of a significance resource to students interested in the field as well as future employers and their need for qualified employees.

d. **Demand for Graduates:** The biotechnology industry hires employees at all levels of education beginning with high school graduates through Ph.D. scientists. Several potential employers in the Albuquerque area, including the University of New Mexico, Lovelace Respiratory Research Institute and Tri-Core currently hire A.S. degree students. These employers, however, also have need of B.S.-level employees for technical or certification reasons. Employers often provide three to six months of post-degree training in technical skills and competencies for the employee to perform the duties and responsibilities of the positions. Because research scientists often conduct the training, employers expressed interest in the availability of bachelors-level technicians who already have technical skills and competencies in the laboratory.

- The Biotechnology Industry in New Mexico remains stable. Active efforts are underway to increase the presence of the Biotechnology Industry here in New Mexico, and a prepared workforce is a vital part of that effort (New Mexico Bio Medical and Biotechnical Association 2014).

- A Needs Survey was conducted by CNM in 2009 in support of the creation of the Biotechnology Post-Baccalaureate Certificate. Ten employer surveys, representing 7 different institutions or companies in New Mexico (Including UNM, LRRI and LANL) suggested that there is a continuing need for trained bachelors-level Laboratory Technicians in central New Mexico, both immediately and in the near future. Nearly all respondents expected their need for technicians or technologists to continue to grow.

    - Almost all respondents said it has been "somewhat" or "very" difficult to recruit and hire qualified Laboratory Technicians. Several emphasized the difficulty in hiring "qualified" individuals.
    - All respondents said there was at least 'some" shortage of Laboratory Technicians, half said that was a "serious" or "critical" shortage. Again, several noted that the shortage was of "qualified" personnel.

- Respondents were split between requiring an Associate's Degree versus a Bachelor's degree for the type of formal training currently required for Laboratory Technicians or Technologists. However, 7 of 10 respondents said they preferred Laboratory Technicians or Technologists to possess a Bachelor's Degree.
- All respondents said they supported the development of a post-baccalaureate Biotechnology Certificate at CNM.
- There is a continuing need for Laboratory Technicians in central New Mexico, both immediately and in the near future. Nearly all respondents expected their need for technicians or technologists to grow within the next 5 years.
- Almost all respondents said they would anticipate hiring CNM bachelors-level Biotechnology graduates in the future.

- A recent nationwide survey of Biotechnology employers found that 74% of job postings are looking for candidates with at least a bachelor's degree (Monster.com on behalf of the Biotechnology Industry Organization 2014).

3. Program Content and Quality

Curriculum: The curriculum for the proposed Biotechnology concentration is based on existing CNM Biotechnology coursework. This curriculum is designed to meet competencies common to programs around the nation and to be responsive to industry needs. The curriculum includes 11 credit hours encompassed within three laboratory-based classes. The three classes are taught in sequential order, starting in the summer semester (Term 1 - BIOT 1020: Biotechnology Lab Techniques I), continuing in the fall semester (Term 2 – BIOT 2110: Biotechnology Lab Techniques II) and culminating the following spring semester (Term 3 – BIOT 2210: Biotechnology Lab Techniques III). *Please see Appendix A for course descriptions.*

The Biotechnology courses which will make up the Biotechnology concentration already make up the core of the Biotechnology A.S. degree and Biotechnology Certificate. These courses were developed in 2013/2014 by revising existing Biotechnology coursework and have been designed to maximize student's knowledge of the field and hands-on laboratory experience while fitting into the 11 credit hours available under the UNM Biology degree. It is expected that student pursing the Biotechnology coursework will have already taken/or currently taking all required Biology, Biochemistry, Mathematics and Chemistry courses. Therefore, the focus of the courses is hands-on laboratory based learning supplemented with lecture and discussions.

As no new courses will be created, it is anticipated that there will be no impact on existing UNM or CNM courses.

a. **Learning Outcomes:** Learning outcomes have been developed for all three Biotechnology courses – *Please see Appendix B for detailed learning outcomes.* Program competencies for the Biotechnology Program are as follows:

Upon completion of the Biotechnology coursework students will have the ability to:

Quality Control: Demonstrate the ability to follow standard operating procedures, keep accurate records, and perform equipment validation in the laboratory.

Safety: Demonstrate an understanding of basic laboratory safety and the handling and disposal of biological, and chemical wastes.

Nucleic Acids: Demonstrate an understanding of the basic properties of nucleic acids, as well as, techniques used to isolate, purify, and analyze these molecules.

Proteins: Demonstrate an understanding of the basic properties of proteins, as well as, techniques used to isolate, purify, and analyze these molecules.

Computer Skills: Demonstrate command of basic bioinformatics skills used to perform literature searches and characterize nucleic acids and proteins.

b. **Instructional Model:** The Biotechnology coursework is focused on giving students hands-on laboratory skills, and the majority of class time is devoted to providing students with those experiences. Hands-on learning is supplemented with lectures, in-class discussions of scientific literature and current topics in Biotechnology and on-line bioinformatics/proteomics assignments.

c. **Accreditation:** At this time, national certification or accreditation for biotechnology programs and biotechnicians are not available. However, CNM's Biotechnology Program, like most community college biotechnology programs, have developed curriculums utilizing skills and content standards from documents including the *National Bioscience Industry Skill Standards* (http://www2.edc.org/bec/standards/industrystds.htm) and *National Science Education Standards* (http://www.education-world.com/standards/national/science/index.shtml). Occupational, academic and employability skills for the biotechnology industry have been identified via the Austin Competency Analysis Profile (ACAP's) (www.bio-link.org/docs/finalreport.doc) . These competencies have been identified by business and industry experts.

The Biotechnology Program is guided by an Advisory Board made up of stakeholders from the biotechnology industry in the Albuquerque and Santa Fe areas and include potential employers (scientists/researchers and HR professionals), articulation partners and economic development representatives.

The Advisory Board meets once a year to review the program's curriculum, goals, internships and employment opportunities.

4. Evaluation and Assessment

The Biotechnology coursework is part of an existing cycle of assessment that is on-going at CNM. Results will be shared annually with the UNM Biology assessment team for inclusion in our program reports. Student competencies are measured throughout the Biotechnology Program at the knowledge, skill and behavioral levels using CNM's established Student Academic Achievement Committee (SAAC) reports using the following general guidelines:

- Instruments will be identified or developed to monitor knowledge, skills and behavioral attributes for the program graduates.
- Criteria levels to demonstrate competency will be established.
- Progress in meeting criteria will be monitored annually.
- Based upon the results of this assessment, action plans will be developed and implemented.
- Effectiveness of action plan implementation will be evaluated annually

Briefly, program competencies are linked to the learning outcomes for each course. Specific learning outcomes are measured by a series of data points (embedded exam questions, etc.) and are measured in at least one course, but usually in all three. Data can be compared from one semester to the next (as students move from introduction to repetition to mastery of the skill) as well as from one cohort to the next (i.e. class of 2012 versus class of 2013). Action plans are created for competencies in which students do not achieve the desired outcome.

Measurement tools include in-class exams, lab practical exams, on-line assignments and a final comprehensive exam. The achievement target is 80% or better of students demonstrating satisfactory knowledge of the program outcome. "Satisfactory knowledge" is defined as earning 75% or greater of available points on a given embedded question.

5. Required Resources

Required Resources No additional funding is required or requested for the Biotechnology Concentration. All costs associated with the concentration, including personnel, contract services, equipment, travel and training will be covered by the existing CNM budget available for the Biotechnology Program.

Faculty: Existing CNM full-time and part-time faculty will teach the biotechnology courses.

Cost to Students: Additional student expenses associated with the Biotechnology courses are minimal – students are required to purchase a lab coat and laboratory

notebook. Certificate credits at UNM will not represent additional tuition needed to graduate.

6. Projected Enrollment and Costs

It is projected that with existing interest from CNM students and the creation of the concentration under the UNM Biology degree the Biotechnology Program will reach and sustain full enrollment (24 students) in the Fall of 2015.

No additional funding is required or requested for the Biotechnology Concentration. All costs associated with the concentration, including personnel, contract services, equipment, travel and training will be covered by the existing CNM budget available for the Biotechnology Program.

Appendix A: Course Descriptions for Biotechnology Coursework

BIOT 1020 Biotechnology Lab Techniques I 4 credit hours

Prerquisites: Bio 1510/1592, Chem 1710, Chem 1792; Pre or Corequisites: Bio 1610/1692, Chem 1810, Chem 1892 Provides theory and experience in laboratory safety and measurement, solution making, bacterial transformations and cloning, recombinant DNA, gel electrophoresis, tissue culture and basic bioinformatics skills. Current issues and topics related to biotechnology will be explored.

BIOT 2010 Biotechnology Lab Techniques II 4 credit hours

Prerequisite: BIOT I Provides theory and experience with protocols used to characterize and manipulate nucleic acids. Builds on techniques learned in Biotechnology I. Techniques include DNA isolation and quantification, PCR, qPCR, gel electrophoresis, recombinant DNA technology, cloning, DNA sequencing, site-directed mutagenesis, tissue culture, and basic bioinformatics skills. Current issues and topics related to biotechnology will be explored.

BIOT 2210 Biotechnology Lab Techniques III 3 credit hours

Prerequisite: BIOT II Provides theory and experience with protocols used to characterize and manipulate nucleic acids and proteins. Builds on techniques learned in Biotechnology II. Techniques include RNA and protein isolation and quantification, RT-PCR, RNA interference, mammalian transfections, polyacrylamide gel electrophoresis, 2-D gel analysis, Western blotting, ELISAs, and basic bioinformatics and proteomics skills. Current issues and topics related to biotechnology will be explored.

Appendix B. Learning Outcomes for Biotechnology Coursework

Term 1 – Biotechnology I (BIOT 1020):

Outcome #1: **Discuss the elements of laboratory safety**
Components:

a. Explain the four types of laboratory safety controls including how they are designed to keep laboratory workers safe
b. Identify individuals and organizations responsible for workplace safety
c. Recognize chemical, biological and physical hazards present in the biotechnology lab
d. Demonstrate the safe handling, labeling and disposal of chemical, biological and physical hazards

Outcome #2: **Demonstrate techniques of laboratory measurement.**
Components:

a. Explain the units of measurement used in the biotechnology laboratory
b. Define key terminology used in measurement and solution making
c. Demonstrate appropriate selection and usage of appropriate instruments for measurements based on the application they will be used for
d. Demonstrate the ability to accurately use pipet-aids (serological pipets), micropipettors, and electronic balances

Outcome #3: **Demonstrate the preparation of solutions.**
Components:

a. Solve basic equations used in making solutions including:
    - mass/volume solutions
    - percent solution
    - molar solutions
    - making dilute solutions using a concentrated stock
b. Demonstrate the basic steps used in solution making including technical considerations and safety
c. Demonstrate the ability to accurately use pH meters

Outcome #4: **Perform a bacterial transformation with plasmid DNA.**
Components:

a. Explain the fundamentals of bacterial transformation
b. Define plasmid or vector DNA
c. Explain and utilize antibiotic selection
d. Demonstrate correct standard practices used in working with bacteria
e. Perform a bacterial transformation experiment and interpret results
f. Calculate the transfection efficiency of a bacterial transformation.

Outcome #5: **Utilize a mini-prep to extract plasmid DNA from bacteria**
Components:

a. Explain the purpose of a mini-prep
b. Explain the function of the major steps in an alkyline lysis mini-prep
c. Perform a mini-prep

Outcome #6: **Utilize restriction enzymes to perform a restriction digest**

a. Explain what restriction enzymes are and how they are used in the biotechnology laboratory
b. Demonstrate an understanding of the technical considerations associated with using restriction enzymes, both singly and in a double digest
c. Utilize restriction enzymes to cut lambda DNA and plasmid DNA

Outcome #7: **Perform agarose gel electrophoresis**
Components:

a. Explain how gel electrophoresis is used to separate macromolecules

b. Demonstrate an understanding of how DNA migrates through an agarose gel and factors which can influence its' mobility
c. Explain the use of loading dye, ethidium bromide and DNA size markers or ladders in gel electrophoresis
d. Prepare and run agarose gels of different percentage
e. Interpret agarose gel results and properly label a gel photograph

Outcome #8: **Perform a basic subcloning experiment.**
Components:
a. Define subcloning
b. Utilize previously taught skills to move a gene from one plasmid to another
c. Intrepret results from subcloning experiment

Outcome #9: **Perform a ligation reaction**
Components:
a. Describe the use of ligations and their importance in recombinant DNA
b. Explain the chemical reaction involved in ligation and identify required reaction components
c. Utilize a ligation reaction in a cloning experiment

Outcome #10: **Demonstrate Cell Culture Techniques**
Components:
a. Define cell culture
b. Explain the usage of different cell lines, including immortalized and primary cells lines
c. Demonstrate knowledge of the proper selection, preparation and storage of media
d. Calculate quantities of reagents needed to formulate media
e. Describe important technical considerations associated with performing cell culture
f. Perform basic cell culture tasks, including:
- Starting cells
- Feeding cells
- Splitting & counting cells
- Harvesting cells

g. Utilize an on-line database to search for cell lines and appropriate growth media

Outcome #11: **Utilize online resources to perform basic bioinformatics tasks.**
Components:
a. Utilize PubMed to search for scientific papers by author, date, subject and relevance
b. Utilize an on-line search program to perform a basic restriction enzyme search and design a basic subcloning experiment

Outcome#12: **Discuss the history and the current state of the field of biotechnology**
Components:
a. Define biotechnology
b. Describe the many scientific disciplines that contribute to biotechnology
c. Provide examples of historic applications of biotechnology
d. Describe different types of biotechnology and their applications

Outcome #13: **Discuss current topics of importance in Biotechnology**
Components:
Stem Cells and Cloning
a. Explain what stem cells are and their origins
b. Explain why stem cells are so useful in biomedical research
c. Describe obstacles to using stem cells in research and/or therapies
d. Outline the ethical, religious and political concerns associated with embryonic stem cells
e. Identify the relationship between stem cells and cloning
f. Differentiate between therapeutic and reproductive cloning

Term 2 – Biotechnology II (BIOT 2010):

Outcome #1: **Perform phenol-chloroform DNA isolation**
Components:

a. Perform phenol-chloroform DNA isolation
b. Describe the function of the four basic steps of phenol-chloroform DNA isolation
c. Identify important technical considerations associated with working with DNA

Outcome #2: **Analyze the quantity and quality of DNA in a sample**
Components:

a. Describe how a spectrophotometer works
b. Utilize a spectrophotometer to quantify DNA samples
c. Interpret data provided by a spectrophotometer
d. Utilize an agarose gel to verify the quality of a DNA sample

Outcome #3: **Utilize the polymerase chain reaction (PCR) to amplify and analyze genetic sequences.**
Components:

a. Explain the uses of the polymerase chain reaction and its importance in Biotechnology
b. Identify the essential components of a PCR reaction and technical consideration associated with their use
c. Explain the importance of primer design to the success of a PCR reaction
d. Describe the three steps of the PCR reaction
e. Perform multiple PCR- based experiments and identify how PCR is used differently in those experiments.

Outcome #4: **Utilize real-time polymerase chain reaction (qPCR) to amplify and quantify a genetic sequence**

a. Explain the fundamental principle underlying real-time PCR
b. Describe the applications of real-time PCR
c. Explain similarities and differences in real-time versus traditional PCR
d. Describe the different types of reporter methods used in real-time PCR
e. Conduct a real-time PCR experiment and interpret results
f. Explain the use of and interpret results from a Melt Curve Analysis

Outcome #5: **Demonstrate the procedures required to determine the DNA sequence of a gene.**
Components:

a. Explain how the dideoxy or chain termination method of DNA sequencing works, both in manual and automated (i.e. dye terminator) sequencing reactions
b. Describe technical considerations associated with sequencing
c. Perform a sequencing reaction using fluorescently labeled dideoxynucleotides
d. Interpret a sequencing gel
e. Discuss goals and benefits of genome sequencing including the Human Genome Project.
f. Describe the three steps of genome sequencing: preliminary sequencing, finishing and annotating
g. Describe “next generation” high-through put sequencing methods.

Outcome #6: **Perform the techniques required to clone a gene.**
Components:

a. Describe the process used to clone a gene
b. Identify the characteristics of a cloning vector
c. Perform a variety of previously learned techniques in order to clone a gene, including:
    - Ligation
    - bacterial transformation
    - antibiotic screening
    - mini-preps
    - restriction enzyme digestion
d. Perform a variety of new techniques in order to clone a gene, including:
    - TA Cloning method
    - Blue-white screening

Outcome #7: **Perform a PCR-based site-directed mutagenesis protocol.**

Components:

a. Define site-directed mutagenesis and explain the theory underlying PCR-based site-directed mutagenesis
b. Describe the uses of site-directed mutagenesis and its importance in biotechnology
c. Outline the function of the three steps utilized in PCR-based site-directed mutagenesis
d. Discuss technical considerations associated with site-directed mutagenesis, particularly primer design
e. Perform a site-directed mutagenesis experiment and interpret results

Outcome #8**: Discuss techniques involved in DNA forensics and conduct a DNA fingerprinting protocol.**

Components:

a. Describe the basic premise underlying DNA forensics
b. Explain the uses of DNA forensics, including emerging uses
c. Explain what short-tandem repeat (STR) analysis is and why it is currently the forensic DNA technique of choice
d. Perform a basic DNA fingerprinting experiment (STR analysis) and interpret results

Outcome #9: **Utilize online resources to perform basic bioinformatics tasks.**

Components:

a. Utilize Genbank to search for genomic sequences using gene name or accession number; interpret data found in Genbank entry and link to related entries
c. Utilize BLAST to compare genomic sequences, find unknown genomic sequences, and find homologous genes in different species; interpret data from BLAST search and link to related entries
c. Utilize on-line primer design software to design and evaluate PCR primers for a given genomic sequence

Outcome #10: **Analyze scientific literature related to in-lab experiments**

Components:

a. Explain aims and methods of assigned scientific papers
b. Interpret and critically analyze results and conclusions from scientific papers
c. Relate material found in literature to in-class experiments

Outcome #11: **Discuss current topics of importance in Biotechnology**

Components:

Genetically Modified Organisms:

a. Describe the impact of biotechnology and GM crops on the agricultural industry, both in the US and worldwide
b. Outline the pros and cons of GM crops, including environmental, societal, and health concerns
c. Identify GM crops currently available on the market, and those in production
d. Describe the role of the USDA and/or EPA in regulating genetically modified crops
e. Describe current regulations for labeling of biotechnology products
f. Describe methods used to identify GM crops including ELISA and PCR

Gene therapy:

a. Define gene therapy
b. Explain different methods used in gene therapy
c. Explain the history of gene therapy, including the current state of gene therapy in the U.S.
d. Describe obstacles to using gene therapy in research and/or therapies
e. Outline ethical concerns associated with gene therapy

Term 3 – Biotechnology III (BIOT 2210):

Outcome #1: **Demonstrate the isolation of RNA from cell pellets.**
Components:

a. Identify technical consideration associated with working with RNA
b. Describe how the TRIzol or TriReagent method of RNA isolation works
c. Perform an RNA isolation from cell pellets
d. Quantify RNA using a spectrophotometer

Outcome #2: **Employ reverse transcriptase PCR (RT-PCR) protocols.**
Components:

a. Define RT-PCR
b. Describe the uses of RT-PCR and how these differ from traditional (DNA-based) PCR.
c. Describe the multi-step process used in RT-PCR
d. Explain the different methods of "priming" for cDNA synthesis and why one method might be chosen over another
e. Explain why primer design is critical when performing RT-PCR
f. Explain the importance of running a control PCR using a "housekeeping gene" following cDNA synthesis
g. Set up, run and interpret results from an RT-PCR reaction using freshly isolated RNA

Outcome #3: **Employ and analyze a real-time reverse transcriptase PCR protocol.**
Components:

a. Differentiate between applications of real-time PCR using DNA as a source versus real-time PCR using RNA as a source
b. Utilize real-time RT-PCR to quantify and analyze results from siRNA transfection

Outcome #4: **Describe RNA interference (RNAi)**
Components:

a. Define RNA interference and its role in transcriptional silencing
b. Explain the siRNA activation pathway
c. Describe the biological functions of RNAi
d. Explain the uses of siRNA technology in the field of biotechnology

Outcome #5: **Perform a mammalian transfection using siRNA**
Components:

a. Describe basic principles of transfection, including lipid-mediated transfections
b. Describe the applications of transfection in biotechnology
c. Describe factors which influence transfection efficiency
d. Perform a transfection of siRNA into mammalian cells
e. Utilize real-time PCR to analyze data from transfection and interpret results

Outcome #6: **Examine and utilize a variety of tools and techniques to characterize proteins**
Components:

a. Describe technical considerations associated with working with proteins
b. Define proteomics
c. Explain research applications of proteomics
d. Describe challenges associated with studying the proteome
e. Utilize low- and high-throughput proteomics techniques in the laboratory
f. Discuss proteins as biotechnology products in medicine, food and manufacturing

Outcome #7: **Perform protein quantification using a Bradford Assay**
Components:

a. Identify technical considerations associated with performing protein Set up and perform a Bradford assay to quantify protein
b. Utilize results from Bradford assay to generate a standard curve and quantify unknown protein samples

Outcome #8: **Examine the applications of and perform polyacrylamide gel electrophoresis**
Components:

a. Describe a polyacylamide gel including its composition and construction
b. Identify uses, advantages and disadvantages of polyacrylamide gels versus agarose gels
c. Describe technical considerations associated with pouring and running polyacrylamide gels
d. Prepare and run a polyacrylamide gel to separate protein molecules by molecular weight

Outcome #9: **Employ and analyze a 2-dimensional gel electrophoresis protocol**
Components:

a. Describe the function of 2D gels and identify the two dimensions used in 2D gel electrophoresis
b. Define isolelectric point and relate this to the pH of a protein
c. Explain the function of the isolelectric focusing and polyacrylamide gel electrophoresis steps
d. Explain how pH range of a strip gel affects resolution
e. Identify proper protein sample preparation techniques and precautions used in 2D gel electrophoresis
f. Prepare and run a 2-D gel electrophoresis to separate out molecules from a heterogeneous protein sample

Outcome #10: **Demonstrate a western blotting protocol.**
Components:

a. Describe the function of a Western blot
b. Describe steps used to prepare proteins prior to running on a Western blot
c. Explain how to correctly transfer a gel to a nitrocellulose membrane
d. Describe the principle behind blocking
e. Explain the principles and technique behind immunoblotting membranes for specific protein detection, including the function of the primary and secondary antibodies
f. Utilize a western blot protocol to detect a specific protein and interpret results including determining molecular weight

Outcome #11: **Perform an ELISA assay**
Components:

a. Define an ELISA
b. Identify the applications of ELISAs
c. Describe how an ELISA works; i.e. the roles of the different antibodies in the detection of specific proteins
d. Compare and contrast the function of an ELISA with that of a Western Blot
e. Utilize a simple quantitative ELISA protocol to detect a specific protein and interpret results

Outcome #12: **Analyze scientific literature related to in-lab experiments**
Components:

a. Explain aims and methods of assigned scientific papers
b. Interpret and critically analyze results and conclusions from scientific papers
c. Relate material found in literature to in-class experiments

Outcome #13: **Utilize online resources to perform basic bioinformatics and proteomics tasks.**
Components:

a. Utilize an on-line search program to search for transcription factors found within a given genomic sequence
b. Utilize appropriate on-line resources to identify unknown protein sequences