Online Masters' Degree Program in Biotechnology to Mitigate Climate Change

Curriculum

Semester	Course Number	Title	Credits
Fall I	BTEC 575	Introduction to Climate Change	3
Fall I	BTEC 501	Genetic Engineering / Advanced Molecular Biology	3
Fall I	BTEC 531	Research Ethics	2
Spring I	BTEC 580	Emerging Diseases	3
Spring I	BTEC 502	Protein Structure, Function, & Dynamics	3
Spring I	BTEC 650	Plant Biotechnology	3
Fall II	BTEC 675	Mitigation of Climate Change through Biotechnology	3
Fall II	BTEC 680	Data Science	3
Spring II	BTEC 515	Environmental Policy & Management	3
Spring II	BTEC 685	Food Security & Safety	3
Spring II	BTEC 696	Capstone experience	1

BTEC 575 Introduction to Climate Change 3 Credits

This course aims to address the whole complexity of climate change as an issue, by bringing together the science, impacts, economics, abatement technologies, and policy solutions into one course. Through this course, we will address several important questions. What is the scientific basis for our understanding of climate change, and in what ways is that scientific basis uncertain? What changes in climate might we expect over the coming centuries? What would be the impacts of these changes in climate for human well-being and the natural world? What are the sources of emissions of greenhouse gases? What technologies exist and might be developed to allow us to slow climate change, and what international policy solutions might be necessary or preferred? Students will be expected to show mastery of relevant concepts drawn from the Earth sciences, biology, chemistry, physics, engineering, economics, and political science, and be able to explain the relevance of these concepts for our present understanding of human-caused climate change and for the viability of different proposed solutions.

By the end of this course, students will be able to:
- Explain and evaluate the evidence for human-caused climate change, in the context of historical climate change, as well as the relevant scientific uncertainties and possible evidence to the contrary.
- Explain and quantify the impacts of climate change on food security and evaluate means by which these impacts can be reduced (adaptation).
- Explain and quantify the impacts of climate change on emerging diseases and evaluate means by which these impacts can be reduced (adaptation).
- Explain how biotechnology has been and currently is being applied to mitigate the impacts of Climate Change

- Explain the human causes of climate change, including the sources of greenhouse gas emissions. Because energy consumption is central to greenhouse gas emissions, students will understand the global energy infrastructure in a historical context and evaluate technological options for reducing emissions.
- Apply quantitative analysis of concepts relevant for climate change, drawn from chemistry, physics, and economics, through homework problems.
- Evaluate the successes and failures of past national and international efforts to address climate change and evaluate prospects for future management of climate change.
- Evaluate the issue of climate change from the perspective of individual nations.

BTEC 501 Genetic Engineering / Advanced Molecular Biology 3 Credits
Global climate change is one of the greatest threats to humankind in recent history. Biotechnology can help to mitigate some of the future devastating effects of climate change. This course will examine the discovery, development, and application of different molecular approaches used to manipulate an organism or its products. The techniques include but are not limited to traditional recombinant DNA technology, synthetic biology, recombineering, CRISPR/Cas genome editing, and Agrobacterium mediated transformation. These tools will be discussed in the context of emerging biotechnologies such as biofuels, carbon sequestration, bioplastics, fuel cells, advanced crops and biosensors that have been developed to specifically address global climate change.

BTEC 531 Research Ethics 2 Credits
Ethical issues in research including, but not limited to: Responsible Conduct of Research, Human Subjects research, Animal Care and Use, Student Data and Intellectual Property, Science, Technology, and Society, and requirements of regulatory agencies. Topics will be addressed from a global perspective and the ethics involved in developing climate change policy. Two lectures or meetings per week.
MEASURABLE OUTCOMES:
Written and/or oral response to case studies using the following guidelines and teaching strategies including FlipGrid will be utilized.
For each case study students will clearly and briefly state:
1) the nature of the ethical dilemma (do not simply summarize the scenario)
2) legitimate expectations of all interested parties
3) proposed actions you would take and their consequences. Also, respond directly to any question(s) asked.
4) obligations or duties of the protagonist and any professional duty of the scientist
5) implications of climate change

BTEC 580 Emerging Diseases 3 Credits

The World Health Organization warned in its 2007 report that infectious diseases are emerging at a rate that has not been seen before. Since the 1970s, nearly 40 infectious diseases have emerged as a major threat to humans, including SARS, MERS, Ebola, chikungunya, avian flu, swine flu, Zika and now a new coronavirus-COVID19. Even though COVID19 has taken a central stage among the emerging diseases, emergence or reemergence of new pandemic cannot be ignored.

This course will describe the major courses of emergence of potentially lethal diseases and teach how biotechnology can be used to combat the new threats. How climate change and global warming play an important role in emergence of major epidemics and pandemics. Other factors including living in more densely populated areas, migration from rural areas to cities, international air travel, poverty, wars, and destructive ecological changes due to economic development and land use, coming into closer contact with wild animals, and deforestation, increases potential for emerging infectious diseases to spread rapidly and cause global epidemics. In addition, there is the potential for diseases to emerge as a result of deliberate introduction into human, animal, or plant populations for terrorist purposes (i.e., anthrax, smallpox, tularemia and Ebola).

Many emerging diseases arise due to zoonoses. However, climate change is an important factor in the emergence of infectious diseases. As Earth's climate warms and habitats are altered, diseases can spread into new geographic areas. For example, warming temperatures allow mosquitoes - and the diseases they transmit - to expand their range. Emergence of antimicrobial resistance microbes. Bacteria, viruses, and other microorganisms are evolving and developing resistance to multiple drugs.

We will discuss numerous factors that create the environment for the emergence of new epidemics or pandemics. We will learn from the past pandemics and discuss the strategies that can teach us how to prevent the future emerging diseases. We will also cover the new frontiers in Biotechnology that can assist us in combating the new emerging diseases.

BTEC 502 Protein Structure, Function, & Dynamics 3 Credits

This is a course on advanced concepts on protein structure and function relationships. It presents several biophysical approaches to problems in protein-protein and protein-ligand interactions, protein folding, structure prediction, protein dynamics and Boltzmann distributions in protein ensembles, and principles in molecular evolution. Students are also exposed to the most current research on the unfolded state of proteins and hierarchical approaches to protein folding.

The course includes multiple biophysical chemistry problem sets, Monte Carlo atomic simulations of protein folding and dynamics, and lab modules making use of Claflin's 3D projection system to examine the atomic structure of proteins and protein-ligand interactions.

In accordance with the philosophy of Claflin University and the Biotechnology Program, students enrolled in this course will be encouraged to master the concepts of protein structure and function, so that they "can demonstrate a general knowledge and understanding of the spectrum of information in the biological sciences and related disciplines, including both historical roots of the various biological disciplines and modern theories and technologies".

This course is also intended to augment "The Claflin University imperative. Preparing Students for Leadership and Service in a Multicultural, Global and Technological Society to meet the Challenges of the Twenty-First Century" by (a) grooming students to articulate a holistic, interdisciplinary understanding of the relationship between science and contemporary issues; (b) fostering student research skills and ability to apply mathematical data analyses and

interpret observed phenomena; and (c) relate concepts of statistics, thermodynamics, and mathematics to biological systems

BTEC 650 Plant Biotechnology 3 credits

Climate change as a result of global warming has major impact on agricultural production due to changes in rates of plant growth, transpiration, respiration and photosynthesis. Increase in atmospheric CO2, rising temperature and altered precipitation patterns also affects crop production. Climate change alters ecosystem that results both biotic and abiotic stresses on plants. These stresses change the status of weed, pest resistance, disease resistance, drought tolerance, cold tolerance, increases salinity and water deficit, and reduces soil fertility. To overcome climate change effect on agriculture in general and crop production in particular, it is important to reduce the impact of climate change owing to global warming by adopting two-prong strategy by reducing fossil fuel consumption and development of biotic and abiotic stress tolerant crops. Fossil fuel consumption can be gradually reduced by using bio-fuel, and development of fuel-efficient vehicles.

The plant biotechnology online MS course will focus mainly on development of genetically modified plants (GMP), to adapt changed climate condition for normal growth and development. The development of GMP involves identification of biotic and abiotic stress tolerant genes, their isolation and cloning in appropriate vectors, and their introduction into desired plant genome through genetic transformation. Additionally, students will gain advanced knowledge on plant biotechnology techniques and tools that can be applied for the following: to develop and improve plant biotechnology products; for improving quantity and quality of food, feed, fiber and renewable energy needs; the use of transgenic plants as bioreactors to produce pharmaceuticals such as vaccines and therapeutic proteins; and to clean environmental pollutants to provide healthy living environment. This course will also provide sound knowledge of genetically modified organisms (GMO) with reference to the legislative framework and economic, social, moral and ethical issues, thereby further preparing students for productive careers in the plant biotechnological sciences. The course will focus on the following topics:

1. Plant genomes: the organization and expression of plant genes
2. Plant tissue culture
3. Techniques for plant transformation
4. Binary vectors for plant transformation
5. The genetic manipulation of herbicide resistance
6. The genetic manipulation of pest resistance
7. Plant disease resistance
8. Reducing the effects of viral disease
9. Strategies for engineering stress resistance
10. The improvement of crop yield and quality
11. Molecular farming
12. Science and Society: public acceptance of genetically modified (GM) crops
13. Beyond genetically modified crops

BTEC 675 Mitigation of Climate Change 3 Credits

In this course, learners will identify the types of actions that we can pursue to address climate change. These actions fall into two broad categories: 1) mitigation, which refers to efforts to reduce greenhouse gas emissions or enhance carbon sinks, and 2) adaptation, which refers to our preparations for climate impacts. We will explore the use of biotechnologies, programs, and policies related to both mitigation and adaptation. These strategies include specific uses of agricultural biotechnology in the design of salt tolerant crops, drought resistant crops, heat stress enable crops as well as the genetic manipulation of microorganisms involved in fishery management, bio-fuel production, and carbon sequestration. Learners should leave the course with an improved ability to identify and evaluate climate actions undertaken by communities, governments, and businesses.

This course focuses on the climate impacts occurring and expected to occur across the United States and around the world. Our approach will be regional and sectoral, with consideration of impacts on water resources, transportation, energy, agriculture, forests, health, and coastal/marine resources. We will also look at how you can apply bio-technological approaches to address these problems.

Learning outcomes
Students should be able to:
i) differentiate between the different types and goals of mitigation strategies
ii) identify technological options to reduce emissions, their barriers and costs and co-benefits.
iii) explain climate policy tools, their theoretical merits and practical experiences as applied to biotechnology mitigation strategies
v) recognize co-benefits, tradeoffs, potentials, and limitations of a wide range of climate change mitigation options, from the energy to the land sector (including negative emission technologies and geoengineering).

Competences:
The student should be able to
i) Identify, find and interpret relevant knowledge in the scientific literature on climate mitigation.
ii) Explain the terminology and principles for assessing climate mitigation measures.
iii) Identify actors and assess potential challenges and barriers associated with the implementation of climate mitigation measures and policies as well as the consequences of these.
iv) Quantify climate change impacts and mitigation benefits through appropriate metrics.
v) Report and discuss climate-relevant aspects in a scientifically rigorous way.

BTEC 515 Environmental Policy and Management 3 Credits

This course focuses on planning, management of hazardous wastes (including industrial and medical wastes), and conservation of terrestrial, aquatic and forest resources for sustainable use. Topics covered include sources and types of wastes, waste classification, environmental laws and regulations and physicochemical and biological treatment methods. Environmental laws and regulations will focus on the following topics: water pollution, public health and sanitation, energy policy and climate change. The course will also cover alternative energy production

technologies encompassing solar, biomass, and industrial and agricultural waste conversion to useful products. This is a discussion-based course along with the review of relevant case studies.

BTEC 685 Food Security and Safety 3 Credits

This course focuses on addressing challenges associated with food production (pathology, pests, environmental stress, climate change), role of plant biotechnology and transgenics to overcome these challenges, implementation of alternative modern-day technology (CRISPR/cas9) and sustainable approaches (biocontrol) in food security. Topics covered include history of agriculture, origin of diverse crops, evolution of cultivated crops through agricultural technology such as classical breeding and domestication, identify challenges in growing, harvesting, and processing food, explore the role of scientific research and cutting-edge precision agriculture in addressing challenges in food security, opportunities and limitations of new technologies, consumer approach on adopting food from field to table, how growing population and increased food demand affecting socioeconomic growth and development, international standards on food safety and nutrition and its impact on human health, FAO's food safety approach, awareness on prevention of food-borne outbreaks, and modern food legislation on food safety and quality.

BTEC 696 Capstone Experience 3 Credits

In this course, learners will synthesize what they have learned about the specific impacts of climate change and the types of actions that we can pursue to address them. As a capstone experience, the student will design a Proposal for the Mitigation of a Climate Change Impact using biotechnology. In this course, students will learn how to craft such a proposal that meets both scientific and industrial standards. The proposal will contain an extensive review of the literature surrounding the climate change impact identified and current technologies in place to mitigate its effects. The student will propose their own experiment or solution implementation and provide descriptions of both the materials and methods of the research/implementation. The student will also be instructed how to identify clear objectives and specific aims that fit within a reasonable timeline as well as a cost analysis.

Course Objectives: After completing this course students should be able to:

1. Write a scientific proposal
2. Justify a specific scientific response to a problem created by climate change.
3. explain climate policy tools, their theoretical merits and practical experiences as applied to biotechnology mitigation strategies
4. recognize co-benefits, tradeoffs, potentials, and limitations of a wide range of climate change mitigation options,
5. Identify, find and interpret relevant knowledge in the scientific literature on climate mitigation.
6. Explain the terminology and principles for assessing climate mitigation measures.
7. Identify actors and assess potential challenges and barriers associated with the implementation of climate mitigation measures and policies as well as the consequences of these.
8. Quantify climate change impacts and mitigation benefits through appropriate metrics.

9. Report and discuss climate-relevant aspects in a scientifically rigorous way.

COURSE OUTLINE

1. The Scientific Method
    - Proposing mitigation strategies and experimentation
    - Review case studies of climate mitigation approaches (3)
    - Discuss the role of policy, stake holders, and limitations of specific mitigation efforts
2. Teamwork, collaboration, and group writing
    - Identifying potential stakeholders,
    - Identifying constraints, factoring in stakeholder needs (Workshop)
3. Writing a Proposal
    - Strategies for writing a literature review (Workshop)
    - Principles in writing a Materials & Methods Section (Case study Workshop)
    - Writing Specific Aims in a Biotechnology Proposal (Workshop)
    - Creating reasonable Timelines (Workshop)
4. One-on-one workshops to provide mentoring for proposal.