ENVS*3300 Introduction to Controlled Environment Systems

Fall 2022
Section(s): 01

School of Environmental Sciences
Credit Weight: 0.50
Version 1.00 - September 07, 2022

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1 Course Details

1.1 Calendar Description

Controlled Environment Systems (CES), otherwise known as Controlled Environment Agriculture (CEA), is a rapidly evolving technological framework for producing crops in a stable, controlled and efficient manner. This CES/CEA technological platform is poised to play a significant role in current and emerging social and environmental issues including, but not limited to, climate change adaptation, food insecurity (urban and Northern/remote communities), local food supply, food supply chain stabilization, food safety, medicinal crop production and standardization, biodiversity preservation, functional foods/improved human nutrition, etc. Highly controlled production of plants in CES is even an absolute requirement in the global quest to explore and colonize the moon, Mars and beyond. This course will provide the student with a strong understanding of the principles of CES/CEA and will dig deep into the wide range of commercial, research, and human space exploration applications of CES/CEA. Through numerous guest speakers, students will also develop a sense of the career opportunities in this rapidly growing sector.

Pre-Requisites: BIOL*1050 or BIOL*1070

1.2 Course Description

Controlled Environment System (CES) plant production, aka Controlled Environment Agriculture (CEA),
has been around for centuries but only recently has the full scientific, commercial and space exploration
potential come to be appreciated. This introductory course explores the past, present and future of CES/A
and will provide insight and help foster an appreciation for the scientific principles, challenges, and
multiple applications of CES/A both now and in the future. The course will cover a broad

range of CES
applications and fields including molecular farming (aka ‘pharming’), vertical agriculture, medicinal crop
production, and bio-regenerative life-support for human space exploration. The course will also examine
the potential for CES/A to address food insecurity issues in remote communities as well as a potential role
in climate change adaptation.

This course provides students with direct training in both practical and academic/research skills used in
controlled environment systems. Within the context of current environmental challenges and the
potential for using CES to address these challenges, students will develop skills in some or all of the
following areas: literature-based research, experimental design within the limits of plant growth chamber
studies, oral and/or poster presentation, and written communication to diverse audiences. Students will
research and report on scientific issues being reported in the media within the context of CES/A.
The course will be based on a mixture of lectures to introduce new topics and CES/A concepts, seminar style
discussions, special guest speakers, inquiry-based learning, library/literature-based research, group
work and independent study.

1.3 Timetable

Timetable is subject to change. Please see WebAdvisor for the latest information.

1.4 Final Exam

There will not be a final exam. The exam is replaced with a final group presentation that will be organized in class and/or during a time that works for a large majority of the class.

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2 Instructional Support

The professor(s) will have regular office hours but also encourage students to reach out (email preferred) with questions or concerns at any point in the course. An 'open door' policy will be maintained by the instructor.

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3 Learning Resources

All required readings, videos, etc., will be available through CourseLink.

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4 Learning Outcomes

Specific Learning Outcomes:
The overarching objective of this course is to familiarize students with the depth and breadth of
Controlled Environment Systems and applications, leading to an appreciation for the role of CES in
addressing a wide array of environmental and social issues facing Canada and the world.
By the end of this course, students will be able to:

1. Demonstrate an understanding of key environment variables and their basic interactions as they
pertain to CES plant production;
2. Define and compare CES plant culture techniques;
3. Describe and appreciate the main economic, environmental, and societal factors driving CES;
4. Compare and contrast various CES based agricultural production technologies;
5. Explain the requirements of bio-regenerative life-support and the role CES plays in human space
exploration;
6. Relate current social and environmental challenges, such as food security and climate change
adaptation, to CES such that the student can postulate measures to help address these challenges.
7. Critically evaluate literature resources
8. Consider terrestrial transfer of space inspired technologies
9. Appreciate the diversity of career opportunities in CES agriculture

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5 Teaching and Learning Activities

5.1 Lecture

Weeks 1-2

Topics: Introduction and course structure

Welcome to ENVS*3300! We will spend a reasonable portion of the first lecture getting to know one another. We will be discussing, in broad strokes, what you can expect from the course and your instructors as well as what is expected of you. We will also have a crash course in CES just to get us warmed up - don't worry, we will build on it all throughout the semester.

Lecture 02 will be an overview of the CESRF followed by a virtual tour during lecture 03. The tour will be led by Dr. Dixon who was instrumental in developing these research facilities.

General Items:

- Introductions and motivations regarding Controlled Environment Systems
- Details on the course structure and expectations for assigned readings, quizzes, final project/presentation, etc.
- CourseLink Modules and postings

- What ***are*** Controlled Environment Systems (and what they are not) Introduction to the University of Guelph's Controlled Environments Systems Research Facility (CESRF)
- Virtual Tour of the Controlled Environment Systems Research Facility (CESRF)

Week 3

Topics: Some of the ins and outs of CES

Lecture 04: The What, Why, & How

We will be going back and taking a high-level look at the concepts introduced in the first lectures/tour

Lecture 05 will be a walking tour of UoGs Bovey research greenhouse complex. This research greenhouse tour will be used to familiarize everyone with the key elements and challenges of greenhouse production in harsh climates and build a little on Lecture 04. There will be a lot of new material so ask lots of questions. If some of what you see and hear is totally new that is okay, we will sort it all out, taking a deep dive into these baseline topics.

General Items:

- A high-level crash course on what environmental parameters are important (hint, it is all of them), why we need to control them, and how we can control them

Virtual Tour of UoG's Bovey Research Greenhouse Complex

Week 4

Topics: The root zone

Controlled Root Environment Systems

This week we will first dive into the various types of production systems used in CEA, with a focus on solution-based systems generically referred to as 'Hydroponics' – but there is much more to it. We will define various systems and compare and contrast them in the context of CEA applications. We will consider things that are happening in and influencing the root zone environment. We will consider different growing substrates, system hygiene (root pathogen prevention) considerations/technologies, and nutrient management in CEA.

Week 5

Topics: Above 'ground' stuff

Now that we have an appreciation for the trials and tribulations of root zone management, we need to move up in the world and consider all the things that are influencing a plant from above. We will consider how light, CO_2, and water/water vapour influence a plant and how & why we need to manage these parameters. Guest lecture - TBD

Week 6

Topics: Now the fun begins

We are through all the baseline stuff and now it is time to explore the world of CEA/CES. The remainder of the course will look at the diverse reach of Controlled Environment plant production ranging from greenhouse food & flower production through to molecular farming and human space exploration. Several guest lecturers will be providing

commercial and public service perspectives on various CEA industries. Some sample topics (no particular order) are:

- Northern and remote community food insecurity
- Molecular pharming
- Phytopharmaceuticals
- Medicinal crops
- Urban agriculture & Vertical farming
- Research Applications
- Space Exploration

Week 7

Topics: High Intensity CES/Vertical Farming

High Intensity Urban Agriculture

High intensity urban and peri-urban agriculture, often (mistakenly) colloquially referred to as 'vertical farming' is an emerging segment of the overall agriculture industry. We will be digging into the pros and cons of this industry and address how it is and needs to evolve to realize its full potential. This is a rapidly expanding sector and there is a lot of contradictory and sometimes outright wrong information in the public domain. There is more than we can possibly cover in a few short lectures so there will be several videos that will be required (outside of lecture) viewing – these assigned videos will be the fodder for in class discussions as well as a preparation for a series of guest lectures.

Guest Lecturer: Mr. Jeff Huber - Vertical farming industry expert – day to be determine (subject to change)

Jeff Huber will provide a very practical perspective on vertical farming, including challenges and opportunities.

Weeks 8 & 9

Topics: Plants as Medicine and the critical role of CES

Molecular Farming, Phytopharmaceuticals, and Medicinal Crops in CEA

Controlled Environment Agriculture is about far more than food; it is now a significant tool for producing many non-food and medical products. The next few lectures and assigned readings/videos will introduce these applications. Topics to be covered include:

- Molecular Farming (also Pharming) – What is it and what is the Role of CEA
- Phytopharmaceuticals and Medicinal Crops (including cannabis)
- Regulatory issues, safety, biodiversity preservation, global market overview

Note: Several Guest Lecturers are planned but final dates have not been nailed down as of the start of the course.

Medicinal Crops and CEA

The global use and harvest of medicinal crops will be discussed with a focus on environmental impact, product safety, and active compound quality. The current regulations governing medicinal crops and active ingredients will be discussed. The benefits and limitations of adapting medicinal crops to CEA production will be explored in class discussions.

Food Insecurity: A role for CEA to play in reducing it

Food insecurity is a significant issue in many places around the world and Canada is no exception. The general state of Canada's food insecurity will be discussed along with CEA as a contributor to solutions to address this serious issue.

Weeks 10 & 11

Topics: Space the Final Agricultural Frontier

We will introduce the concepts of bioregenerative life-support and its absolutely critical role in supporting human space exploration. Additionally, we will talk big rockets and where life may already be and where we should go as human explorers.

Several Guest lectures will be slotted in, including people from NASA, the Canadian Space Agency, and other space research scientists

Last Week

Topics: Presentations

The last lecture slots are dedicated to the final presentations. If needed, additional time slots will be set up to complete all the presentations.

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6 Assessments

6.1 Assessment Details

Presentation Topic Outline & Annotated Bibliography (15%)
Date: Mon, Oct 31
General or proposed scope of the presentation; selected references/annotated bibliography; rationale for the project. Grades will be returned before the 40th class day.

Quiz 1 (5%)
Date: Week 4, on-line
Material from the first three weeks of classes will be included. The quiz will be on-line and students will have an ample window (5 days) to complete the quiz on their schedule. Grades available before 40th class day.

Quiz 2 (10%)
Date: Week 7
Material from the first six weeks of classes will be included, with a focus on material from weeks 4-6. The quiz will be on-line and students will have an ample window (5 days) to complete the quiz on their schedule. Grades available before 40th class day.

Quiz 3 (15%)

Date: Week 10
Material from weeks 1-10 will be included, with a focus on material covered in weeks 7-9. The quiz will be on-line and students will have an ample window (5 days) to complete the quiz on their schedule.

Group Presentation (40%)
Date: Last week of classes (note: additional times may be needed and will be set up accordingly), Virtual/In-person (COVID dependent)
A group presentation focusing on some aspect of CEA/CES.

Popular Press Article Evaluation (15%)
Date: Fri, Nov 18

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7 University Statements

7.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

7.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Graduate Calendar - Grounds for Academic Consideration
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

Associate Diploma Calendar - Academic Consideration, Appeals and Petitions
https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml

7.3 Drop Date

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic Calendars.

Undergraduate Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

Graduate Calendar - Registration Changes
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml

Associate Diploma Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml

7.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

7.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to make a booking at least 14 days in advance, and no later than November 1 (fall), March 1 (winter) or July 1 (summer). Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time.

For Guelph students, information can be found on the SAS website
https://www.uoguelph.ca/sas

For Ridgetown students, information can be found on the Ridgetown SAS website
https://www.ridgetownc.com/services/accessibilityservices.cfm

7.6 Academic Integrity

The University of Guelph is committed to upholding the highest standards of academic integrity, and it is the responsibility of all members of the University community-faculty, staff, and students-to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff, and students have the responsibility of supporting an environment that encourages academic integrity. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse

students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Undergraduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

Graduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

7.7 Recording of Materials

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

7.8 Resources

The Academic Calendars are the source of information about the University of Guelph's procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars
https://www.uoguelph.ca/academics/calendars

7.9 Disclaimer

Please note that the ongoing COVID-19 pandemic may necessitate a revision of the format of course offerings, changes in classroom protocols, and academic schedules. Any such changes will be announced via CourseLink and/or class email.

This includes on-campus scheduling during the semester, mid-terms and final examination schedules. All University-wide decisions will be posted on the COVID-19 website (https://news.uoguelph.ca/2019-novel-coronavirus-information/) and circulated by email.

7.10 Illness

Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g.. final exam or major assignment).

7.11 Covid-19 Safety Protocols

For information on current safety protocols, follow these links:

- https://news.uoguelph.ca/return-to-campuses/how-u-of-g-is-preparing-for-your-safe-return/
- https://news.uoguelph.ca/return-to-campuses/spaces/#ClassroomSpaces

Please note, these guidelines may be updated as required in response to evolving University, Public Health or government directives.
