Principles in Fermentation

BIO/CHM/CPB/MBI 436

**FALL 2017**

**Instructors**

Luis Actis, Jason Beberich, Michael W. Crowder, Neil Danielson, Andor Kiss, Matthew McMurray, and Robert McCarrick

**Class Meeting time**

Wednesdays from 6:30 pm to 9:10 pm., Hughes Hall, room 141 or lab rooms, as determined.

**Office hours and contact information**

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| Luis Actis  097 Pearson Hall  [actisla@miamioh.edu](mailto:actisla@miamioh.edu)  Office hours by appointment | Jason Beberich  64P Engineering Building  [berberj@miamioh.edu](mailto:berberj@miamioh.edu)  Office hours: MWF 8:00 – 9:00 AM or by appointment |
| Michael W. Crowder  160 Hughes Hall  [crowdemw@miamioh.edu](mailto:crowdemw@miamioh.edu)  Office hours by appointment | Neil Danielson  360C Hughes Hall  [danielnd@miamioh.edu](mailto:danielnd@miamioh.edu)  Office hours by appointment |
| Andor Kiss  086C Pearson Hall  (513) 529-4280  [KissAJ@MiamiOH.edu](mailto:KissAJ@MiamiOH.edu)  Office Hours by Appointment | Robert McCarrick  055 Hughes Laboratories  (513) 529-0507  [rob.mccarrick@miamioh.edu](mailto:rob.mccarrick@miamioh.edu)  Office Hours by Appointment |
| Matthew McMurray  221 Psychology  (513) 529-2415  [mcmurrms@miamioh.edu](mailto:mcmurrms@miamioh.edu)  Office Hours: M 3-5 PM |  |

**Course Description**

Fermentation is the process of microbes (*i.e.*, single-celled organisms) transforming a substance. Examples of such transformations include grape juice into wine and milk into yogurt. For millennia, fermentation processes have been used to create foods, including pickles, sauerkraut, tofu, miso, ketchup, wine, beer, sourdough bread, kimchi, vinegar, cheese, kefir, masa/hominy, sausage, and sour cream. The range of flavors imparted by fermentation, the recent studies extolling the benefits of live foods, and trends towards more locally-produced foods have pushed the food and beverage industries towards revitalizing fermentation techniques. Fermentation also finds applications in areas outside of the food and flavors industry. High value chemicals including vitamins, hormones, steroids, and antibiotics are produced by fermentation. Industrial, diagnostic, and therapeutic enzymes and antibodies are also produced by fermentation. There is a growing interest in producing bulk and commodity chemicals via fermentation. Biofuels, such as ethanol, acetone, and butanol, receive much attention, but citric acid, adipic acid, and even the biodegradable polyester polyhydroxybutyrate can be synthesized using fermentation.

Industries using fermentation as an integral part of their production are significant and particularly pertinent in the agricultural, industrial, and distribution competencies of the Midwest, where most of Miami students come from and will work after graduation. For example, the US yogurt, ketchup, and beer industries have $7B, $3B, and $28B in annual revenue, respectively. In 2014, the craft beer market increased 18.0% in barrels (BBL) produced and 22% in retail dollars, while overall the production of beer, including both US macrobreweries (*i.e.* Anheuser Busch-InBev, Miller-Coors,) and imported beer, has only increased 0.5% in BBL produced (Brewers Association 2015). According to the Brewers Association (2015) the number of microbreweries currently open in 2014 is 1,871, and number of brewpubs are 1,412. This is an increase of 27.8% and 10.3%, respectively, since 2013. Industries that center on distilled products of fermentation are also large and significant. The spirit industry has one of the its important clusters near Louisville, KY, a 2-hour drive from Oxford, with FLAVORMAN (Louisville, KY) being one of the local and national beverage development leading companies. Additionally, there are three major flavor science firms, Flavor Systems International, Wild Flavors, and Givaudan in the greater Cincinnati area, all of whom rely on fermentation techniques in the creation of their products. Outside of the food area, Eli Lilly makes antibiotics, Martek (now Alltech) makes docosahexaenoic acid (DHA) using algae, and Alltech, a large agricultural company in Lexington, KY, makes proteins and has ties to the brewing industry (Kentucky Ale).

This course will inform students about fermentation processes, handling and characterization of yeast cultures, process control and monitoring, plus analysis of fermentation products. Topics related to finances, health and societal aspects of certain fermentation products will also be discussed.

**Course Objectives**

Through a combination of lectures from faculty and experts in the fermentation industry, hands-on laboratory experiences, and site visits, students will develop an understanding of the importance of fermentation in the food, beverage, and drug industry. Students will have the opportunity to learn how microbiology, biology, chemistry/biochemistry and engineering are interrelated in the fermentation industry. Students will have a basic understanding of biological processes involved in fermentation, the theory and design principles behind the equipment and facilities used in different fermentation/distillation processes, analysis and preservation of yeast strains and quality control of fermentation products. It is expected that students who successfully complete this course will be well-positioned to enter the fermentation industry and make relevant contributions to the different aspects and steps involved in this complex process that provides critical products for human consumption.

**Course Learning Outcomes**

Students will be able to:

* Describe and discuss the biological, chemical/biochemical and engineering factors involved in the fermentation process as it relates to food, beverage, and drug industry
* Explain how fermentation products are produced and characterized physically and chemically
* Compare and evaluate issues related to up-scaling fermentation processes from small to large commercial endeavors
* Understand how alcohol affects our bodies and behaviors

**Grading Information**

This course is three credit hours and carries a letter grade. Attendance is mandatory and class participation, both during class and in completion of the assignments, is required in order to earn credit. Absences must be cleared with the instructor(s) before class. Unexcused absences result in a loss of points.

Late assignments will automatically receive a 20% point reduction and will be accepted only at the next class meeting. If a student is absent when an assignment/presentation is due, he/she must have valid proof for why the assignment could not be turned in on time (proof: doctor’s note, official university excuse, family emergency etc.).

**Grading Scale**

>89% - A; 80-89% - B; 70-79% - C; 60-69% - D; <60% - F

**Assignments**

Lab Report 1 (Beer bitterness, color/turbidity, amylase activity) – due 9/27/17 30 pts.

Lab Report 2 (Sequencing Protocol and Background) – due 10/4/17 20 pts.

At home abstract and presentation (10/11/17) 10 pts.

At home project written report – due 10/18/17 20 pts.

Lab Report 3 (Lactic acid titration beer) – due 11/1/17 25 pts.

Lab Report 4 (Calcium in beer) – due 11/8/17 20 pts.

Lab Report 5 (Headspace GC/MS hops, alpha/beta acids HPLC hops) – due 11/15/17 30 pts.

Lab Report 6 (EPR) – due 12/6/17 25 pts.

**Grading (Available Points Breakdown)**

Mid-Term Exam – 10/11 200

Final Exam – 12/13 200

Project Presentation & Report 120

Assignments Participation 180

Total 700 pts

**Group Projects**

During the first class period, students will be divided into groups. During the course of the semester, these groups will work on two separate projects. Groups are encouraged to start work on these projects early in the semester. Each group will present a short presentation (5-10 minute description of the topic, the issues, problems, considerations, and potential solutions (if applicable) on the projects on **October 11th** after the mid-term exam. A final presentation (15 minutes long with 5 minutes for questions) of their projects will be given during the last week of classes (**December 6th**), and we will invite local guests to these presentations.

The presentations should have peer-reviewed sources, and the presentations should be professional, rehearsed, and make use of PowerPoint style slides. A rough rule of thumb is “one slide per minute” and “6 x 6” (no more than six lines of text and no more six words per line). Slides are a VISUAL medium – use pictures.

***At home project:*** Each group will complete an “at-home” project that involves fermentation. Potential projects include making of pickles, making of yogurt, or making of kimchi. These projects should be done individually and be completed by monitoring the fermentation process involved (pH electrodes are available to use with your cell phones – these electrodes will require a $30 deposit when you check them out). Further details on the suggested procedure and report guidelines will follow.

***Fermentation project:*** Each group will complete a project on a topic related to fermentation sciences. It can be something as simple as the rise of craft brewing, or the economics of cheese making, or the industrial manufacture of fermentation equipment, or the wastewater treatment in large brewing operations, or the large scale production of antibiotics. Any topic related to fermentation is fair game. In the past, groups identified problems that local craft brewers had and offered suggestions, based on science, to address the problems.

**Academic Integrity**

Academic Integrity is at the heart of the mission and values of Miami University and is an expectation of all students. Maintaining academic integrity is a reflection of your character and a means to ensuring that you are achieving the outcomes of this course and that your grades accurately reflect your learning and understanding of the course material.

All assignments must be turned in using the TurnItIn software, found on the Canvas site. TurnItIn will allow for you to determine the originality of your written work. You should never submit any work if your similarity score is above 20% or if there are large blocks of text that are similar/identical to other texts.

Any suspected instances of academic dishonesty will be handled under Miami University’s Academic Integrity policy found in Part 1, Chapter 5 of the Student Handbook, <http://blogs.miamioh.edu/miamipolicies/?p=2122>.

**Course Withdrawing**

Course dropping and withdrawing will be handled according to the guidelines described in <http://blogs.miamioh.edu/miamipolicies/?p=1981>.

**Learning Disability/Special Testing Requirements**

These conditions/requirements MUST BE NOTED AT THE BEGINNING OF THE COURSE to take and make proper actions and arrangements.

**Disruptive Behavior**

Disruptive classroom behavior, including repeated and disruptive tardiness, eating or drinking in class, electronic devices going off in class, sleeping or reading a newspaper/magazine, talking and unsolicited conversation, will not be tolerated in class.  This will be handled according to the guidelines from The Office of Ethics and Student Conflict Resolution. All cell phones and electronic devices must be turned off before class.  Any cell phone or electronic device observed during an examination will be confiscated and the examination will be terminated at that time.

**Tentative Course schedule**

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| --- | --- | --- | --- | --- | --- |
| **Date** | **Part 1 (6:30 – 7:20 PM)** | **Part 2 (7:25 – 8:15 PM)** | **Part 3 (8:20 – 9:10 PM)** | **Assignment** | **Note** |
| **8/30** | Class Intro, syllabus (all instructors) | Professor Matt McMurray | History of fermentation (Kiss); |  | $30 deposit on pH electrode; groups assigned |
| **9/6** | Fermentation I (Actis) | Fermentation II (Actis) | Description of home projects; pH electrode (Danielson) | TBA |  |
| **9/13** | Beer Brewing I (Crowder) | Beer Brewing II (Crowder) | Lab – amylase activity (Berberich) | TBA |  |
| **9/20** | Yeast (Kiss) | Lab - spectrophotometry-color, turbidity, bitterness (Danielson) | Lab – spectrophotometry-color, turbidity, bitterness (Danielson) | Lab report on amylase, bitterness, color, turbidity due 9/27 |  |
| **9/27** | Lab – Sequencing I (Kiss) | Lab – Sequencing II (Kiss) | Professor Rose Marie Ward | Lab report on sequencing due 10/4 |  |
| **10/4** | Miller Coors | Miller Coors | Miller Coors | TBA |  |
| **10/11** | **Mid-term** | Project Updates | Home project Abstract and discussion | Home project report due 10/18 |  |
| **10/18** | Cell growth and kinetics (Berberich) | Bioreactor design, sterilization, and scale-up (Berberich) | Spirits (Crowder) |  |  |
| **10/25** | Process monitoring and control (Berberich) | Lab: Lactic acid titration lab (Danielson) | Lab: Lactic acid titration lab (Danielson) | Lab report on lactic acid titration due 11/1 |  |
| **11/1** | Distillation (Berberich) | Plate theory and rate theory (Danielson) | Lab: Atomic absorption lab (Danielson) | Lab report on AA due 11/8 |  |
| **11/8** | GC and HPLC fundamentals (Danielson) | Lab: GC and LC (Danielson) | Lab: GC and LC (Danielson) | Lab report on GC and LC due 11/15 |  |
| **11/15** | Municipal brewery | Municipal brewery | Municipal brewery | TBA |  |
| **11/22** | No class | No class | No class |  |  |
| **11/29** | EPR lecture (McCarrick) | Lab: EPR (McCarrick) | Lab: EPR (McCarrick) | Lab report on EPR due 12/6 |  |
| **12/6** | Final project | Final project | Final project |  |  |
| **Wed 12/13**  **7:45 – 9:45 PM** | Final Exam | Final Exam | Final Exam |  |  |