LOCALLY DEVELOPED COURSE OUTLINE

Synthetic Biology 15-3

Submitted By:

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Board Motion

Motion Conclusion

Motion Date

Motion Number

Motions

Course Basic Information

Course Name	Synthetic Biology 15
Credit Number	3
Hours of Instruction	62.50 hrs
Implementation Dates	9/1/2015 - 8/31/2019
Proposal Type	Authorization
Development Type	Developed
Designed Grade Level	Grade 10 Grade 11 Grade 12
Acknowledgment	Developed in collaboration with Dr. Magdalena Pop

Course Description	This is an elective, project-based course in which learners in grades 9 to 12 collaborate to identify a problem of interest for their local community, and to build a solution to this problem using synthetic biology – a new and innovative form of genetic engineering. All the steps in the process, from research to project design and lab experimentation, including the interpretation and discussion of the results, need to be documented in a digital/wiki format. The course culminates with an oral- and a poster presentation of the project, prepared and carried out as a team. The course components: · Finding and Designing the Project · Carrying out of the Project – Lab Work · Human Practices and Biosafety Investigation · Digital (wiki) Documentation of the Project · Oral and Poster Presentation This learner-centred course involves multiple subject areas - such as Sciences, Language Arts, and Social Studies - in an inter-disciplinary fashion, and it enables the acquisition of in-depth knowledge and the development of literacy and numeracy skills along with many of the cross-curricular competencies essential to an educated Albertan of the 21st century. The Science component focuses on molecular and synthetic biology concepts together with the spectrum of competencies related to the scientific inquiry process. A major part of the course addresses societal and environmental implications, and considers the safety and ethical aspects of the project. Opportunities for learning in the Language Arts occur throughout the course as learners complete the various communication and presentation components of the project. Learners are encouraged to use Visual Arts to enhance their communication and presentation in creative ways. The majority of the research, the communication with the wider synthetic

	biology community, as well as the documentation and presentation of the project in digital format enables the development of literacies and competencies related to communication and information technologies. Depending on the topic, the project could also include a modelling component – another opportunity for advanced learning in information technology. The whole course emphasizes competencies related to collaboration and effective team work.
Course Prerequisite	

Philosophy

This course aims to make learning meaningful and enduring by giving learners the opportunity to select, carry out and present to the public an authentic synthetic biology project. While its knowledge base is in molecular and synthetic biology, the course is cross-disciplinary in nature, and learning is driven and sustained through its strong emphasis on problem solving, collaboration and communication.

Forming engaged thinkers: As members of a team and in collaboration with their community and experts, learners gather and analyze information and knowledge from a variety of sources, and they identify a project to pursue. Throughout the course, from the brainstorming to the experimental and concluding stages of the project, critical thinking is encouraged by constantly engaging learners in reflecting and evaluating their ideas and results.

Forming ethical citizens: One of the primary goals of the course is to address the safety and ethical aspects of synthetic biology research, and in particular of the project under investigation. A project component called Human Practices aims to develop and strengthen awareness and competence around issues of bioethics and biosafety – as these issues often arise concern and controversy when it comes to synthetic biology endeavours.

Cultivating an entrepreneurial spirit: While guidance and mentorship are available from the advisor teacher, experts, and other members of the community, learners must take initiative and ownership at all the stages of the project. They are to pursue their ideas, tackle challenges and assume their team roles with independence and perseverance. The project, along with its innovative contributions and potential, must be presented publicly in three different formats - digital/wiki, oral presentation, and poster – and its quality and merits must be evaluated by the wider community. To further the competitiveness embedded in the course, teams have the option to register to participate in the iGEM high-school competition held annually at the end of the school year.

Rationale

This course has the potential to awaken and raise the learners' intellectual engagement – which is a primary goal in education. It is an opportunity to increase youth's interest and motivation for learning by challenging them to find and build solutions to real-world problems, and to share their efforts and findings with the wider community.
Given the untraditional, project-based, and authentic nature of the course work and its outcome, learners are expected to invest themselves more, and to become more engaged emotionally and cognitively as compared to traditional courses.
This course is well aligned with the new curriculum vision and direction, as it is centred on the learner, focused on cross-curricular competencies, and it allows for local decision making and greater depth of learning. Its innovative aspects reside both in the content matter – synthetic biology being a field at the frontier of science – and in its being structured and designed to make a real difference, ie. create new knowledge relevant for the learners and their local communities.

Learner Outcomes

This course empowers learners to initiate, conduct, document and present to the local and global community an original research project in the new field of synthetic biology. Regardless of the particular topic that learners choose to investigate, this is an opportunity for the development and strengthening of learners' theoretical and practical knowledge of synthetic biology including associated ethical and safety issues.

The course engages the whole spectrum of skills in scientific inquiry, and it requires effective collaboration within the team, as well as with the wider community. A major emphasis is placed on communication of information, ideas, and results pertaining to the different stages of the project. A thorough documentation and presentation of both the process and the project outcome is expected, using various media and formats, e.g. online journal, wiki page, poster, and live talk.

The course offers learners the opportunity to work towards meeting many of the literacy and numeracy benchmarks as described in Appendix F of the draft of the Curriculum Development Prototyping Guide (August 2013). Developing age-appropriate skills in literacy, such as the ability to extract correct meaning from a variety of sources of information, and the ability to communicate complex ideas and concepts effectively to diverse audiences and using various communication media, is a prominent goal of the course. There are many opportunities for growing and practicing numeracy skills, such as using abstract models and representations of concepts and ideas, evaluating and integrating various types of data to draw valid conclusions and derive new meaning, and designing innovative yet realistic problem-solving strategies.

General Outcomes

1 Understand and explain the fundamental concepts of molecular biology, and how these concepts are used in genetic engineering and the new field of synthetic biology (learn synthetic biology) gain the following specific knowledge, understanding and skills by independent study, by interacting with teachers, mentors and colleagues, and from the direct experience of working on the project, thus growing my competence for knowing how to learn.

2 Evaluate information and data competently and critically, and design a synthetic biology project aimed at solving a problem relevant to me and my community (learn to research effectively).

3 Understand and apply correctly the main principles and techniques of scientific inquiry as they pertain to a synthetic biology project (learn to design and conduct a scientific investigation); gain the following knowledge and skills through direct, hands-on experience and exploration, which will grow my competence for knowing how to learn; use a wide range of tools and resources, to apply and develop multiple literacies.

4 Understand the importance of the safety and ethical implications of synthetic biology, and apply an open-minded and responsible approach to our project (learn the impact of science on the environment and the society).

5 Collaborate with others by producing, evaluating and integrating ideas, completing tasks and taking on responsibilities in such a way as to contribute effectively to the teamwork (learn collaborative skills); develop competency for working cooperatively with others.

6 Communicate ideas clearly and persuasively within the team, as well as when addressing diverse audiences, using a variety of media and communication technologies (learn communication skills).

Specific Learner Outcomes

1 Understand and explain the fundamental concepts of molecular biology, and how these concepts are used in genetic engineering and the new field of synthetic biology (learn synthetic biology) gain the following specific knowledge, understanding and skills by independent study, by interacting with teachers, mentors and colleagues, and from the direct experience of working on the project, thus growing my competence for knowing how to learn.	**15-3**
1.1 Describe the structure of genes and explain the role of each part.	X
1.2 Explain the concept of recombining parts from different genes to create new DNA constructs.	X
1.3 Describe and explain the main tools and techniques used in synthetic biology.	X

2 Evaluate information and data competently and critically, and design a synthetic biology project aimed at solving a problem relevant to me and my community (learn to research effectively).	**15-3**
2.1 Access, interpret and evaluate information, ideas, and problems relevant to my community and myself, which will increase my competence at managing information.	X
2.2 Analyze, evaluate and apply knowledge and data from synthetic biology to design and generate new solutions to problems, which will grow my competence for thinking critically, identifying and solving problems, and innovation.	X

3 Understand and apply correctly the main principles and techniques of scientific inquiry as they pertain to a synthetic biology project (learn to design and conduct a scientific investigation); gain the following knowledge and skills through direct, hands-on experience and exploration, which will grow my competence for knowing how to learn; use a wide range of tools and resources, to apply and develop multiple literacies.	**15-3**

3.1 Explain and apply correctly the standard protocols and techniques in synthetic biology.	X
3.2 Initiate and plan synthetic biology experiments pertaining to the team's project.	X
3.3 Conduct experimental work and record complete observations and results.	X
3.4 Analyze and evaluate results to draw meaningful conclusions.	X

4 Understand the importance of the safety and ethical implications of synthetic biology, and apply an open-minded and responsible approach to our project (learn the impact of science on the environment and the society).	**15-3**
4.1 Evaluate and explain the ethical and safety aspects of synthetic biology, and in particular of our project, which will grow my competence at managing information and technology in a responsible manner.	X
4.2 Describe ways in which our project and synthetic biology in general are beneficial to the communities by creating new opportunities, which develops my entrepreneurial spirit.	X
4.3 Explain how our project strives to provide an economical, socially-acceptable and environmentally sustainable solution to demonstrate global and cultural understanding.	X

5 Collaborate with others by producing, evaluating and integrating ideas, completing tasks and taking on responsibilities in such a way as to contribute effectively to the teamwork (learn collaborative skills); develop competency for working cooperatively with others.	**15-3**
5.1 Share ideas and information constructively with the team.	X
5.2 Evaluate different views and integrate ideas respectfully and productively.	X
5.3 Cooperate effectively with the group in carrying out the experimental work.	X
5.4 Contribute appropriately and responsibly to the various presentations.	X

6 Communicate ideas clearly and persuasively within the team, as well as when addressing diverse audiences, using a variety of media and communication technologies (learn communication skills).	**15-3**
6.1 Make effective use of a variety of communication tools and resources throughout the duration of the project, which allows me to apply and develop multiple literacies.	X
6.2 Present information, findings and results convincingly and confidently to audiences of various backgrounds; develop good communication skills.	X
6.3 Create and deliver presentations effectively and using various media by applying multiple literacies and good communication skills.	X

Facilities or Equipment

Facility

A regular science laboratory with space available for setting up a few larger pieces of equipment and for preparing and conducting aseptic and molecular biology work.

Equipment

Large equipment required: fridge and – 20 Celsius freezer, waterbath with thermostat, centrifuge, micro-centrifuge, incubator, shaker or rotator, autoclave, gel electrophoresis apparatus, PCR machine
Smaller equipment and Reagents: micro-pipettes, Bunsen burner, wire loops, serological pipettes, bottles, flasks, beakers, cylinders.

Learning Resources

·Course sequence and timeline – Accompanying document:
Course Sequence and Timeline

·Synthetic biology / iGEM e-guidebook for high-school - crea
the geekStarter mentor group

·Web resources for synthetic biology / iGEM: http://igem.org
http://syntheticbiology.org/

·One-on-one teacher assistance, regular seminars offered b
teacher advisor

·iGEM Registry of Standard Biological Parts:
http://parts.igem.org/Main_Page

·funding available through geekStarter/AITF program – appl
required
http://www.albertatechfutures.ca/AcademicProgramsiCORE/geek
px

·mentorship in synthetic biology – the geekStarter/AITF mer
provides in-person and web-facilitated advice and guidance, cons
and workshops; synbio experts are available on the web-platform
(Virtual Researchers On Call http://www.vroc.ca/vroc/en/)

Others

Identification of Controversial or Sensitive Course Com

The course must comply with the policies, procedures and strategies in the *Guide to Education: ECS to Grade* 12 and School Act (Section 45(8)) to ensure a welcoming and caring environment for all the students, and to foster and maintain respectful and responsible behaviours.

Because it involves the manipulation and engineering of live micro-organisms, the new field of synthetic biology is viewed by some as “playing God” and it rises debates, controversies and opposition. Therefore, for the project’s mandatory Human Practices component, learners consider and address sensitive issues related to the ethics and social acceptance, environmental sustainability, and economical feasibility of the project and of synthetic biology in general.

Particular attention is given to the extent of humans’ moral right to alter biology and the blueprint of life - the DNA – in the increasingly powerful ways permitted by recent technological advances. Indeed, emerging biotechnologies, such as synthetic biology, afford humans the upper hand over the natural world more than ever before. But, while they expand our understanding and capabilities in unprecedented ways, new biotechnologies can also open the door to extremist and dangerous ideas, such as a reductionist take on life, or the view that science shouldn’t be bound by ethics. It is therefore imperative that students taking this course know and understand the various ethical challenges posed by humanity’s new biotechnological powers, and that they learn to tackle these challenges in a thoughtful and responsible manner. Synthetic biology, as taught in this course, is an engaging and morally sound scientific practice, respectful of divergent opinions and of all forms of life.

Identification of Safety Components

This course requires students to conduct work with live microorganisms, primarily laboratory bacteria that are non-infectious and non-pathogenic. Safety aspects and possible biohazards of synthetic biology are addressed in one of the components of the course, and are included among the requirements/outcomes of the project.

Learning and practicing biosafety is given utmost priority, with rules and measures strictly followed and reinforced, e.g. working aseptically at all times and autoclaving/sterilizing all materials that come in contact with live microorganisms prior to disposing them as waste. In addition to all the safety regulations applying to any high-school science laboratory, e.g. obeying WHIMS and MSDS instructions for all the chemicals utilized, the following must be given particular attention:

· Disinfecting and sterilizing the workspace and the equipment

· Wearing of protection equipment: gloves, lab coats, lab specs

· Handling of sterilization agents, such as 70% ethanol, bleach, and detergents

· Manipulation of equipment that pose special safety hazards, e.g. autoclave, centrifuge, thermocycler, electrophoresis apparatus, Bunsen burners – use of this equipment requires prior training, as well as supervision at all times.

· Autoclaving or bleaching of any materials that come in contact with live microorganisms prior to their disposal. Conducting work outside the school must comply with regulations from the *Off-campus Education Handbook*

Significant Overlap with Provincial Curriculum

Rather than overlapping with it, this course *expands* on Unit C – Cell Division, Genetics, and Molecular Biology – of the current Biology 30 course, by encouraging authentic project-based learning and by shifting emphasis and focus on the learner, the development of competencies as envisioned in the AB curriculum redesign, and offering opportunities for local decision making and greater depth of study.

Assessment

Formative (assessment *for* learning) – provides feedback on how each student is progressing toward meeting each of the learning outcomes: informal/individualized/flexible. Accompanying document: SynBio Course Formative Assessment

· *learn synthetic biology*: understand and explain the fundamental concepts of molecular biology, and how these concepts are used in genetic engineering and the new field of synthetic biology

· *learn to research effectively*: evaluate information and data competently and critically, and will be able to design and carry out a new synthetic biology project that is relevant to me and my community

· *learn to design and conduct a scientific investigation*: understand and apply correctly the main principles and techniques of scientific inquiry as they pertain to a synthetic biology project

· *learn the impact of science on the environment and the society*: understand the importance of the safety and ethical implications of synthetic biology, and apply an open-minded and responsible approach to our project

· *learn collaborative skills*: collaborate with others by producing, evaluating and integrating ideas, completing tasks and taking on responsibilities in such a way as to contribute effectively to the teamwork

· *learn communication skills*: be able to communicate ideas clearly and persuasively to diverse audiences, using a variety of media and communication technologies

Summative (assessment *of* learning) – indicates how well each student has met the learning outcomes by the end of course.

· Summative assessment of learning outcomes – INDIVIDUAL SCORE – students will choose the learning outcomes to be assessed based on their roles in the project Accompanying document SynBio Course Summ Assess Learning Outcomes

· Summative assessment of cross-curricular competencies – INDIVIDUAL SCORE - Accompanying document SynBio Course Summ Assess Competencies

· Outside evaluation – oral and poster project presentation(s) to the wider community + the online wiki – GROUP SCORE – Accompanying document SynBio Course Outside Evaluation

· ·optional: response/awards received by projects registered to participate in the iGEM competition

Course Evaluation and Monitoring

The principal of the school will monitor the implementation of the course and will report to the Associate Superintendent of Curriculum and Instruction who will ensure that a course evaluation is conducted in keeping with the jurisdiction's Administrative Regulation: http://www.redeemer.ab.ca/documents/general/Authorized%20Jr%20and%20Sr%20High%20Complementary%20Courses.pdf

Appendix I

1 SynBio Course Formative Assessment.docx

2 SynBio Course Summ assess Competencies.docx

3 SynBio Course Summ assess Learning Outcomes.docx

4 SynBio Project Outside Evaluation.docx

Appendix II

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