UMBC UGC Instructions for New Course Request Form (revised 2/2015)

Course number & title: Enter the number and title of the course at the top of the page. Contact the Registrar's Office to confirm that the desired course number is available.

Date submitted: The date that the form will be submitted to the UGC.

Effective date: The semester the new course is in effect, if approved.

Contact information: Provide the contact information of the Chair or UPD of the department or program housing the course. If the course is not housed in a department or program, then provide the same information for the head of the appropriate academic unit. (See UGC Procedures) If another faculty member should also be contacted for questions about the request and be notified about UGC actions on the request, include that person's contact information on the second line.

Course number: For cross-listed courses, provide all the numbers for the new course.

Transcript title: Limited to 30 characters, including spaces.

Recommended Course Preparation: ***Please note that all 300 and 400 level courses should have either recommended course preparation(s) or prerequisite(s) and that 100 or 200 level courses may have them.***
Here fill in what previous course(s) a student should have taken to succeed in the course. These recommendations will NOT be enforced by the registration system. Please explain your choices in the "rationale" (discussed below).

Prerequisite: ***Please note that all 300 and 400 level courses should have either recommended course preparation(s) or prerequisite(s)*** Here fill in course(s) students need to have taken before they enroll in this course. These prerequisites will be enforced through the registration system. Please explain your choices in the "rationale" (discussed below).

NOTE: Please use the words "AND" and "OR", along with parentheses as appropriate, in the lists of prerequisites and recommended preparation so that the requirements specified will be interpreted unambiguously.

NOTE: Unless otherwise indicated, a prerequisite is assumed to be passed with a "D" or better.

Maximum total credits: This should be equal to the number of credits for courses that cannot be repeated for credit. For courses that may be repeated for credit, enter the maximum total number of credits a student can receive from this course. E.g., enter 6 credits for a 3 credit course that may be taken a second time for credit, but not for a third time. Please note that this does NOT refer to how many times a class may be retaken for a higher grade.

Grading method(s): Check all that apply.

Proposed catalog description: Provide the exact wording of the course description as it will appear in the next undergraduate catalog. Course proposals should be a) no longer than 75 words, b) stated in declarative sentences in language accessible to students, and c) avoid reference to specific details that may not always pertain (e.g., dates, events, etc.). Course descriptions should not repeat information about prerequisites (which are always listed alongside the course description)."

Rationale: Please explain the following:
a) Why is there a need for this course at this time?
b) How often is the course likely to be taught?
c) How does this course fit into your department's curriculum?
d) What primary student population will the course serve?
e) Why is the course offered at the level (ie. 100, 200, 300, or 400 level) chosen?
f) Explain the appropriateness of the recommended course preparation(s) and prerequisite(s).
g) Explain the reasoning behind the P/F or regular grading method.
h) Provide a justification for the repeatability of the course.

Cross-listed courses: Requests to create cross-listed courses must be accompanied by letters of support via email from all involved department chairs. Proposals for new courses or the addition of a cross-listing to an existing course must include as a part of the rationale the specific reason why cross-listing is appropriate. Email from all involved department chairs is also required when cross-listing is removed and when a cross-listed course is discontinued. Please note that Special
Topics courses cannot be cross-listed.

Course Outline: Provide a syllabus with main topics and a weekly assignment schedule which includes complete citations for readings with page numbers as appropriate. Explain how students' knowledge and skills will be assessed.

Note: the UGC form is a Microsoft Word form. You should be able to enter most of the information by tabbing through the fields. The document is protected. In the rare case that you need to unprotect the document, use the password 'ugcform'. Beware that you will lose all the data entered in the form's fields if you unlock and lock the document.

UMBC UGC New Course Request: BIOL 415 / 615 Systems Biology

Date Submitted: August 2016 Proposed Effective Date: Spring 2017

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Dept Chair or UPD	Philip Farabaugh (Chair)	farabaug@umbc.edu	410-455-3018	Biology
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COURSE INFORMATION:

Course Number(s)	BIOL 415
Formal Title	Systems Biology
Transcript Title (≤30c)	Systems Biology
Recommended Course Preparation	N/A
Prerequisite **NOTE:** Unless otherwise indicated, a prerequisite is assumed to be passed with a "D" or better.	You must have completed BIOL 303 AND [BIOL 313 OR CMSC 201 OR MATH 152] with a grade of C or better.
Credits	4
Repeatable?	☐ Yes ☒ No
Max. Total Credits	4 This should be equal to the number of credits for courses that cannot be repeated for credit. For courses that may be repeated for credit, enter the maximum total number of credits a student can receive from this course. E.g., enter 6 credits for a 3 credit course that may be taken a second time for credit, but not for a third time. Please note that this does NOT refer to how many times a class may be retaken for a higher grade.
Grading Method(s)	☒ Reg (A-F) ☐ Audit ☐ Pass-Fail

PROPOSED CATALOG DESCRIPTION (no longer than 75 words**):**

This course introduces the fundamentals of Systems Biology from an interdisciplinary perspective. Topics include the design of biological systems, network structures and motifs, their dynamic and emergent properties, and methods to infer them from experimental data. The course will study biological systems and their control mechanisms at all levels from gene to population networks, and will cover recent applications in science and medicine that allows us to predict cellular behaviors and design optimal drug responses.

RATIONALE FOR NEW COURSE:

The field of Systems Biology has grown rapidly, drawing together researchers from every scientific domain: there is an Institute for Systems Biology in Seattle, a new Department of Systems Biology in various institutions (including notably Harvard, Columbia, and Stanford), a Nature journal, and an International Conference with over 1,000 attendants every year. However, there is not a course in the catalog that will prepare students well to undertake the quantitative thinking and systems reasoning that, at the core of Systems Biology, has made this field so indispensable in the new era of quantitative biology and personalized medicine. The proposed topics are not covered in the two most closely related courses, BIOL 412 (Microbial Systems and Synthetic Biology), which has a focus in bacterial physiology, genetics, and metabolism, and BIOL 410 (Modeling in the Life Sciences), which has a technical focus in computer-based models. This course will lay out the fundamentals behind Systems Biology together with its applications along almost all fields in biology. The material covered is advanced and uses critical analysis of the current scientific literature, yet the field, and hence topics, are interdisciplinary. Therefore, the students will require basic knowledge either in quantitative biology, computer science, or math. In particular, the prerequisites consist of BIOL 313 (Introduction to Bioinformatics and Computational Biology) or CMSC 201 (Computer Science I) or MATH 152 (Calculus and Analytic Geometry II). This course will satisfactory serve as a capstone course for students who wish to undertake graduate studies in Systems Biology or related quantitative fields or are in their first years of

graduate school, which is the justification for the 4XX / 6XX designation. The course will be offered once per academic year in the spring. The course (which is non-repeatable) is designed with the standard A-F grading scale, with appropriate emphasis on team and in-class work, problem sets, and presentations. Finally, the course will use the established student-centered pedagogical techniques already in existing departmental course offerings (see below in the course outline).

ATTACH COURSE OUTLINE (mandatory):

Schedule of classes, projects, and readings (Note: The course was designed for a 100 minute, MW or TR format)

Week	Unit	Topic	Reading
1	Introduction to Systems Biology	Biology in time and space *Pre test*	(Kitano 2002)
		Computational and mathematical modeling and tools *How to work in teams - Assign teams #1*	(Bartocci & Lió 2016)
2	Network structures, dynamics, and function	Network motifs	(Milo et al. 2002)
		Temporal programs	(Hester et al. 2011)
3	Design of biological systems	Modularity, robustness, and optimal designs	(Clune et al. 2013)
		Presentations project 1 - Assign teams #2	
4	Mathematics of biological systems	Kinetic, Constraint-Based and Boolean Modeling	(Ederer et al. 2010)
		Numerical simulation	(Miura & Maini 2004)
5	Model inference and fitting	Optimization and reverse-engineering methods	(Lobo & Levin 2015)
		Presentations project 2 - Assign teams #3	
6	Stochastic systems	Fluctuations and variability	(Kaern et al. 2005)
		Biological function of noise	(Losick & Desplan 2008)
7	Gene systems	Transcription networks	(Davidson 2010)
		Presentations project 3 - Assign teams #4	
8	Protein systems	Protein activity and dynamics	(Peshkin et al. 2015)
		Protein-protein interaction networks	(Szklarczyk et al. 2015)
9	Metabolic systems	Flux analysis and enzyme kinetics	(Orth et al. 2010)
		Presentations project 4 - Assign teams #5	
10	Signaling systems	Intra- and intercellular communication systems	(Samaga & Klamt 2013)
		Dynamic and regulatory features	(Lobikin et al. 2015)
11	Population systems	Population dynamics	(Pagel & Schurr 2012)
		Presentations project 5 - Assign teams #6	
12	Integrative systems	Multiscale systems	(Karr et al. 2012)
		Complex phenotypes	(Green et al. 2010)
13	Systems biology of development	Spatial systems	(Sheth et al. 2012)
		Presentations project 6	
14	Systems biology in medicine	Drug development and personalized medicine	(Niklas et al. 2013)
		Systems biology of cancer	(Marusyk et al. 2014)

All readings come from the primary literature. Papers and homework will be posted on BlackBoard. If review textbooks are needed, recommendations are:

Systems Biology: A Textbook (2nd edition), E. Klipp, W. Liebermeister, C. Wierling, and A. Kowald, Wiley-Blackwell, 2016, ISBN# 978-3527336364

Fundamentals of Systems Biology: From Synthetic Circuits to Whole-cell Models, M.W. Covert, CRC Press, 2014, ISBN# 978-1420084108.

A First Course in Systems Biology, E. Voit, 2012, ISBN# 978-0815344674

An Introduction to Systems Biology: Design Principles of Biological Circuits, U. Alon, Chapman & Hall/CRC, 2006, ISBN# 978-1584886426

Structure of Course

The class is designed for ~30 students with diverse backgrounds to enhance a student-centered learning environment ideal for the topic of Systems Biology, an inherently interdisciplinary field. The format of the course follows a 100-minute instruction period with a high emphasis in interdisciplinary student teams. To ensure the diversity of the teams, they will be formed by four students chosen randomly and reshuffled every two weeks. In preparation for the class period, students will have read (outside of class) the paper(s) to be discussed. The start of class will be lead off with a lecture of the principles and concepts in the paper(s) (50 min). The students will then work with their team mates for an in-class activity or problem set (25 min). Finally, the in-class activity will be discussed as an entire group (25 min). The in-class activity will be collected for assessment and grading. In addition, during each two-weeks period, the teams will work in a project of their choosing. For each project, the teams will submit a document and deliver a short presentation in class with the results of their projects. The projects will replicate the interdisciplinary environment characteristic of Systems Biology in particular and modern Biology in general and teach the students how to work efficiently with team mates with other backgrounds.

Assessment

Lecture - The lecture will cover key principles and ideas from the reading. It will not substitute for the students reading the paper, as the lecture will be brief and may incorporate information from other journal papers and text books. It is designed to be a short review and to focus the students' thinking in preparation for the in-class activity.

In-class activity - During the class period, students will work with their team mates on a set of problems dealing with the reading and lecture materials. The in-class activity will assess the students' problem solving ability in an interdisciplinary group format. In addition, the in-class activity will be the lead-in for the final part of the class time, which is a general discussion of the readings and associated concepts. The assessment criteria for the in-class activity and general discussion will include the level of participation of the student in class, the understanding of the biological problem discussed in the reading and in the class, and their ability to apply the learned approaches and techniques to similar problems.

Projects: writing - The course projects will be a core component of the course. The students will work in teams of four students for a total of six projects with a duration of two weeks each. Each team will deliver a short document presenting and discussing the results. This written document will assess their critical reading and writing ability in addition to their comprehension of the concepts.

Projects: presentation - At the end of every two-week-period, every team will give a short presentation of their projects in class. Every student in the team will be responsible for one segment in the presentation (background, problem, results, and conclusion). Students will be evaluated both on the completed presentation, their own individual speaking segment, and their ability to answer questions and lead discussion on their project.

Projects: peer evaluation - Students will provide quantitative feedback of their team mates every two weeks. The criteria for the evaluation will include the perceived effort, creativity, and easiness to work with of the student. At the end of the course, after each student had worked on six projects with three different teammates on each, everyone would have eighteen data points. Importantly, this quantitative feedback will be available to the students (and instructor) *during* the course, which will incentivize and allow the promptly correction of any team problems before the course ends. The evaluations obtained by the students from their peers, together with the participation in the peer evaluation process, will count towards the grade.

Final exam – One final exam will be given at the end of the course. The exam will cover all material presented in the course, out of readings, lectures, in-class activities, and projects. Exams are meant to test the student's synthesis of concepts from diverse sources. The exam will be short written answer format.

Pre Test - An ungraded test will be given at the start of the course to be compared with the final exam test. These pre / post tests will be used for instructor identification of their teaching effectiveness for the semester. Both tests will have questions that will assess student learning before and after the course.

Assessment	% Final Grade
Projects - writing	20%
Projects - presentation	20%
Projects - peer evaluation	20%
In-class activity	20%
Final	20%

Reading references

Bartocci, E. & Lió, P., 2016. Computational Modeling, Formal Analysis, and Tools for Systems Biology. *PLOS Computational Biology*, 12(1), p.e1004591.

Clune, J., Mouret, J.B. & Lipson, H., 2013. The evolutionary origins of modularity. *Proceedings of the Royal Society B: Biological Sciences*, 280, p.20122863.

Davidson, E.H., 2010. Emerging properties of animal gene regulatory networks. *Nature*, 468, pp.911–920.

Ederer, M. et al., 2010. An introduction to kinetic, constraint-based and Boolean modeling in systems biology. In *2010 IEEE International Conference on Control Applications*. IEEE, pp. 129–134.

Green, A.A. et al., 2010. Genetic control of organ shape and tissue polarity. *PLoS Biol*, 8, p.e1000537.

Hester, S.D. et al., 2011. A Multi-cell, Multi-scale Model of Vertebrate Segmentation and Somite Formation. *PLoS Computational Biology*, 7, p.e1002155.

Kaern, M. et al., 2005. Stochasticity in gene expression: from theories to phenotypes. *Nat Rev Genet*, 6, pp.451–464.

Karr, J.R. et al., 2012. A Whole-Cell Computational Model Predicts Phenotype from Genotype. *Cell*, 150, pp.389–401.

Kitano, H., 2002. Systems biology: a brief overview. *Science*, 295, pp.1662–1664.

Lobikin, M. et al., 2015. Serotonergic regulation of melanocyte conversion: A bioelectrically regulated network for stochastic all-or-none hyperpigmentation. *Science Signaling*, 8(397), p.ra99.

Lobo, D. & Levin, M., 2015. Inferring regulatory networks from experimental morphological phenotypes: a computational method reverse-engineers planarian regeneration. *PLoS Computational Biology*, 11, p.e1004295.

Losick, R. & Desplan, C., 2008. Stochasticity and cell fate. *Science*, 320, pp.65–68.

Marusyk, A. et al., 2014. Non-cell-autonomous driving of tumour growth supports sub-clonal heterogeneity. *Nature*, 514, pp.54–58.

Milo, R. et al., 2002. Network motifs: simple building blocks of complex networks. *Science*, 298, pp.824–827.

Miura, T. & Maini, P.K., 2004. Periodic pattern formation in reaction-diffusion systems: an introduction for numerical simulation. *Anatomical science international*, 79, pp.112–123.

Niklas, J. et al., 2013. Quantitative Evaluation and Prediction of Drug Effects and Toxicological Risk Using Mechanistic Multiscale Models. *Molecular Informatics*, 32(1), pp.14–23.

Orth, J.D., Thiele, I. & Palsson, B.Ø., 2010. What is flux balance analysis? *Nature Biotechnology*, 28(3), pp.245–248.

Pagel, J. & Schurr, F.M., 2012. Forecasting species ranges by statistical estimation of ecological niches and spatial population dynamics. *Global Ecology and Biogeography*, 21(2), pp.293–304.

Peshkin, L. et al., 2015. On the Relationship of Protein and mRNA Dynamics in Vertebrate Embryonic Development. *Developmental Cell*, 35(3), pp.383–394.

Samaga, R. & Klamt, S., 2013. Modeling approaches for qualitative and semi-quantitative analysis of cellular signaling networks. *Cell Communication and Signaling*, 11(1), p.43.

Sheth, R. et al., 2012. Hox Genes Regulate Digit Patterning by Controlling the Wavelength of a Turing-Type Mechanism. *Science*, 338(6113), pp.1476–1480.

Szklarczyk, D. et al., 2015. STRING v10: protein–protein interaction networks, integrated over the tree of life. *Nucleic Acids Research*, 43, pp.D447–D452.