

**NUTR 225**

**SYLLABUS**

**FALL 2017**

**Course Instructor**

Martin Obin, Ph.D.

Associate Professor

[martin.obin@tufts.edu](mailto:martin.obin@tufts.edu)

**Overall Goals**

The intent of this course is to familiarize you with fundamental techniques used to study nutrition science at the molecular, cell, tissue and whole organism level. These techniques will be referred to in classes and seminars throughout your training at the Friedman School of Nutrition and beyond. We will cover both well-established ('routine') techniques (e.g., chromatography, electrophoresis) as well as newer, cutting edge technologies (e.g., Next Generation Sequencing, genome editing). Eight (at times overlapping) classifications of techniques and experimental approaches will be presented over 12 weeks:

1. Partitioning techniques for biomolecule separation and downstream analysis by Mass Spectrometry
2. Physical separation of cell and tissue constituents
3. Analysis of cell constituents and biomolecules using antibody-based techniques in conjunction with...
4. Fluorescence, Bioluminescence and Imaging techniques.
5. Gene Expression: Analysis and Manipulation
6. 'Omics' and Systems Biology
7. Data Science (Informatics, Computational Biology)
8. Bioengineering and Synthetic Biology

For each technique we will emphasize the underlying principle/theory, work-flow and data output. The goal is to develop an understanding of how these different experimental techniques / technologies can be employed in a complementary and mutually-enforcing manner to address a research question in depth. An understanding of the strengths, limitations and 'best' sequence of these techniques is vital to becoming an adept experimentalist.

An additional goal of this course is to familiarize you with the "virtual" communities of scientists and the vast resources available to you in public domain websites managed by scientific and information consortia.

**General Approach**

The basic theory and implementation for individual laboratory techniques is standardized across many disciplines, and can be learned through self-directed study. The assignment for each week is web-based materials describing and/or demonstrating particular techniques as outlined in this syllabus.

**Class time will be devoted to a 20-30 minute quiz, discussion of the answers to the quiz and expanded discussion of techniques covered in your reading.** Yes, there *will* be a quiz at the first class.

**Prerequisites** Undergraduate biochemistry course

**Grading** This course is graded S/U and is required of all Biochemical and Molecular Nutrition (BMN) students. Grading is based on the average of the quizzes (75%) and classroom participation (25%). A grade of “S” requires an overall average of 70% or above.

**2017 Course Schedule** Class will meet Tuesdays from 1:30-3:00 for 12 weeks starting on September 5. Classes meet in the HNRCA mezzanine conference room. You will be granted access to the HNRCA as ‘guests’ and will be escorted from the security desk area to the classroom. **It is vital that foreign students have completed the ARS230 form and received approval.**

**Office Hours:** Tuesday 12:00-1:15 and by appointment.

## **Class #1. Biological Organization, Scientific Inquiry and Information Tools**

### **A. Levels of Biological Organization;**

<https://www.boundless.com/biology/textbooks/boundless-biology-textbook/the-study-of-life-1/themes-and-concepts-of-biology-49/levels-of-organization-of-living-things-269-11402/>

### **B. Modes and Methodology of Scientific Inquiry**

#### **1. Scientific Method(s)**

<https://explorable.com/what-is-a-paradigm>

<https://www.livescience.com/20896-science-scientific-method.html> (also understand “hypothesis”, “theory”, “law”, , deductive vs inductive reasoning)

<https://www.youtube.com/watch?v=uWuNfhDvZz8>

<http://www.zmescience.com/science/scientific-method-steps/>

<https://www.thoughtco.com/elements-of-a-good-hypothesis-609096>

<https://www.thoughtco.com/null-hypothesis-examples-609097>

#### **2. Reductionist vs Systems Biology Approaches**

<https://explorable.com/scientific-reductionism>

<https://irp.nih.gov/catalyst/v19i6/systems-biology-as-defined-by-nih>

[http://www.science20.com/knocking\\_lignocellulosic\\_biomass/reductionism\\_and\\_systems\\_thinking\\_complementary\\_scientific\\_lenses](http://www.science20.com/knocking_lignocellulosic_biomass/reductionism_and_systems_thinking_complementary_scientific_lenses)

#### **3. Mechanistic vs Mechanism-free Science**

Casadevall and Fang, 2009, *Mechanistic Science* (available in Resources on Trunk site)

<https://www.wired.com/2008/06/pb-theory/>

### **C. Information Tools and On-line Knowledge Communities**

<https://hirshlibrary.tufts.edu/>

<https://hirshlibrary.tufts.edu/find/databases>

<https://hirshlibrary.tufts.edu/find/ejournals>

[http://researchguides.library.tufts.edu/nutrition\\_guide](http://researchguides.library.tufts.edu/nutrition_guide)

[http://researchguides.library.tufts.edu/biomedical\\_research](http://researchguides.library.tufts.edu/biomedical_research)

<http://www.ploscompbiol.org/article/info:doi%2F10.1371%2Fjournal.pcbi.1002202>

### **\*\*Assignment\*\*:**

1. Navigate each of the URLs in section D above to locate the 2008 *J. Nutrition* article, “Adiponectin Gene Variants Are Associated with Insulin Sensitivity in Response to Dietary Fat Consumption in Caucasian Men.” Be prepared to summarize the last paragraph of the Discussion section in one or two sentences in class.

2. Using Current Protocols in Bioinformatics download and read **The Importance of Biological Databases in Biological Discovery** by Baxevanis and Bateman.

### **Class #2. Separation / Partitioning Techniques: Gas and Liquid Chromatography:**

<http://elchem.kaist.ac.kr/vt/chem-ed/sep/chromato.htm> - please read introduction and links to "separations", "partitioning", "gas chromatography", "liquid" and "high-performance liquid chromatography"

<http://www.youtube.com/watch?v=q0pM-k0SvOQ&feature=related>

<http://www.youtube.com/watch?v=dffeilgeKx8&NR=1>

<https://www.youtube.com/watch?v=M8d1u7kFZe0>

<https://www.youtube.com/watch?v=gU2st5-T1Go>

<http://www.youtube.com/watch?v=q0pM-k0SvOQ&feature=related>

<https://www.youtube.com/watch?v=UuHOOIKvUbo>

[http://www.youtube.com/watch?v=kz\\_egMtdnL4&feature=related](http://www.youtube.com/watch?v=kz_egMtdnL4&feature=related)

[http://polymer.ustc.edu.cn/xwxx\\_20/xw/201109/P020110906263097048536.pdf](http://polymer.ustc.edu.cn/xwxx_20/xw/201109/P020110906263097048536.pdf)

### **Class #3: Mass Spectrometry**

<http://www.chemguide.co.uk/analysis/masspec/howitworks.html>

<http://www.chemguide.co.uk/analysis/questions/q-mshowitworks.pdf>

<https://www.youtube.com/watch?v=NuIH9-6Fm6U>

<http://www.youtube.com/watch?v=rBymrFzcaPM&feature=fvwrel> (lectures 1 -4)

[https://www.youtube.com/watch?v=qvX7Y\\_3aSPI](https://www.youtube.com/watch?v=qvX7Y_3aSPI)

[https://en.wikipedia.org/wiki/Tandem\\_mass\\_spectrometry](https://en.wikipedia.org/wiki/Tandem_mass_spectrometry) (Instrumentation section only)

### **Class #4: Working With and Fractionating Mammalian Cells**

#### **A. Cell Culture**

[https://www.youtube.com/watch?v=uEy\\_NGDfo\\_8](https://www.youtube.com/watch?v=uEy_NGDfo_8)

[http://www.youtube.com/watch?v=vJ\\_acpKglto&feature=related](http://www.youtube.com/watch?v=vJ_acpKglto&feature=related)

<http://www.promega.com/resources/multimedia/drug-discovery/cell-culture-video/>

<http://www.freewebs.com/Itaing/>

#### **B. Cell Fractionation**

<http://wn.com/ultracentrifugation>

<http://www.sumanasinc.com/webcontent/anisamples/microbiology/cellfractionation.html>

<http://wn.com/ultracentrifugation>

<http://homepages.gac.edu/~cellab/chpts/chpt3/table3-2.html> (no need to memorize - only understand the principle)

<http://homepages.gac.edu/~cellab/chpts/chpt3/table3-1.html> (no need to memorize - only understand the principle)

[http://nobelprize.org/educational/medicine/dna/a/translation/svedberg\\_unit.html](http://nobelprize.org/educational/medicine/dna/a/translation/svedberg_unit.html)

<http://homepages.gac.edu/~cellab/chpts/chpt3/figure3-5.html> (no need to memorize - only understand the principle)

<http://www1.qiagen.com/products/protein/proteomics/Qproteome/QproteomeCellCompartmentKit.aspx?ShowInfo=1#flow> (select USA, click and scroll through "Product Details")

### **Class #5 Separation and Initial Characterization of Proteins and Nucleic Acids**

<https://www.youtube.com/watch?v=3CrzY7jb9fQ>

<https://www.youtube.com/watch?v=p0ZxmVBkayo>  
<https://www.youtube.com/watch?v=HqmxLsHKxZE>  
<https://www.youtube.com/watch?v=bdBXwuuwSBo>  
<http://www.dnalc.org/resources/animations/gelectrophoresis.html>  
[https://www.youtube.com/watch?v=ZuhQtTX6\\_4U](https://www.youtube.com/watch?v=ZuhQtTX6_4U)  
<https://www.youtube.com/watch?v=vq759wKCCUQ>  
[http://www.youtube.com/watch?v=6\\_4AY3lYRgo&feature=related](http://www.youtube.com/watch?v=6_4AY3lYRgo&feature=related)

## **Class #6. Antibody and Fluorescence-Based Techniques**

### **A. Measuring Antigens in Biological Samples (blood, tissue homogenates, etc)**

[http://www.youtube.com/watch?v=Ys\\_V6FcYD5I&feature=related](http://www.youtube.com/watch?v=Ys_V6FcYD5I&feature=related)  
<http://www.youtube.com/watch?v=hQmaPwP0KRI&feature=BFa&list=PL12D59D28513CA093&index=1>  
<http://www.dnatube.com/video/2220/Antibodies>  
<http://www.dnatube.com/video/280/ELISA-Enzyme-Linked-ImmunoabSorbant-Assay>  
<http://www.sumanasinc.com/webcontent/animations/content/ELISA.html>

### **B. Fluorescence and Flow Cytometry**

<http://www.invitrogen.com/site/us/en/home/support/Tutorials.html> (complete tutorials 1 and 4)

## **Class #7. Imaging Techniques (Microscopy and *In Vivo* Imaging)**

<https://www.youtube.com/watch?v=01v2kR8dlN0>  
<http://www.youtube.com/watch?v=OH2GFeaGV6w>  
[http://media.pearsoncmg.com/bc/bc\\_campbell\\_genomics\\_2/medialib/method/IMF.html](http://media.pearsoncmg.com/bc/bc_campbell_genomics_2/medialib/method/IMF.html)  
<http://www.microscopy.fsu.edu/primer/virtual/confocal/index.html>  
<http://olympus.magnet.fsu.edu/primer/techniques/confocal/confocalintro.html> (first three paragraphs)  
<http://micro.magnet.fsu.edu/primer/virtual/confocal/index.html> (note difference between widefield and confocal; practice optical sectioning).  
<https://www.youtube.com/watch?v=YRQsjPAx9UU>  
<http://circ.ahajournals.org/content/117/3/379.full.pdf+html> (introduction and figures 3-7)  
[http://snmmi.files.cms-plus.com/docs/rpsc\\_SNMclass1.pdf](http://snmmi.files.cms-plus.com/docs/rpsc_SNMclass1.pdf) ( pages 1-9 and 20-40).

## **Class #8. Measuring Gene Expression**

### **A. PCR-based approaches: PCR, RT-PCR and Real-Time PCR.**

<https://www.youtube.com/watch?v=54kN88U4Y6w>  
<http://www.dnalc.org/ddnalc/resources/pcr.html>  
<http://www.dnalc.org/view/15475-The-cycles-of-the-polymerase-chain-reaction-PCR-3D-animation-with-no-audio.html>  
<http://www.bio.davidson.edu/people/kabernd/seminar/2002/method/lowry/RTPCR.htm>  
[http://www.bio.davidson.edu/courses/immunology/Flash/RT\\_PCR.html](http://www.bio.davidson.edu/courses/immunology/Flash/RT_PCR.html)  
<http://pathmicro.med.sc.edu/pcr/realtime-home.htm>  
<http://media.invitrogen.com.edgesuite.net/ab/applications-technologies/real-time-pcr/taqman-genex-assays/index.html> (select “Taqman Chemistry”)

### **B. High Throuput Methods: microarrays and RNA-seq**

<https://www.youtube.com/watch?v=ePFE7vg7LvM>  
[https://www.youtube.com/watch?v=pWk\\_zBpKt\\_w](https://www.youtube.com/watch?v=pWk_zBpKt_w)  
<https://www.illumina.com/techniques/sequencing/rna-sequencing.html>

### **Class #9. Manipulating Gene Expression I (Cell Transfection, Promoter Assays, RNAi)**

<http://www.jove.com/index/details.stp?ID=240>  
<http://www.cellbiolabs.com/viral-expression>  
<https://www.promega.com/resources/multimedia/reporter-assays-and-transfection/introduction-to-reporter-gene-assays/>  
<https://www.jove.com/video/51719/massively-parallel-reporter-assays-in-cultured-mammalian-cells>  
<http://www.nature.com/focus/rnai/animations/animation/animation.html> (modules 1 and 2)  
<http://www.promega.com/resources/multimedia/rna-analysis/introduction-to-rna-interference/>  
[http://www.youtube.com/watch?v=QA67v4vSg00&feature=player\\_embedded](http://www.youtube.com/watch?v=QA67v4vSg00&feature=player_embedded)

### **Class #10. Manipulating Gene Expression II: (Genome Editing)**

<https://www.youtube.com/watch?v=2pp17E4E-O8>  
<https://www.youtube.com/watch?v=MnYppmstxIs>  
<https://www.youtube.com/watch?v=JBp0JoF1ufE>

### **Class #11 “Omics, ” High Throuput Techniques and Systems Biology**

#### **A. Omics**

“Nut225-omics-slides” (this PDF is available in Resources section in Canvas)

#### **B. Next Generation Sequencing.**

<https://www.youtube.com/watch?v=jFCD8Q6qSTM>  
<https://www.illumina.com/techniques/sequencing.html> (cover DNA, RNA and Methylation sequencing methods; understand the steps in each “workflow.”)  
<https://www.illumina.com/science/technology/next-generation-sequencing/microarray-rna-seq-comparison.html>  
<https://www.illumina.com/techniques/sequencing/dna-sequencing/chip-seq.html>  
<https://www.illumina.com/areas-of-interest/microbiology/microbial-sequencing-methods.html>

#### **C. Bayesian Methods**

<http://betterexplained.com/articles/an-intuitive-and-short-explanation-of-bayes-theorem/>  
<http://www.nature.com.ezproxy.library.tufts.edu/nmeth/journal/v6/n11s/full/nmeth.1376.html>

#### **D. Systems Biology**

<https://irp.nih.gov/catalyst/v19i6/systems-biology-as-defined-by-nih> (refresher from week #1)  
Example: Systems Biology Approach to the Link Between Obesity and Colorectal Cancer  
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4540493/> (focus on Methods and Analysis)

### **Class #12. Data Science; Computational Biology and Bioengineering**

#### **A. Biomedical Informatics**

What is "Biomedical Informatics"?

## B. Computational Biology/Bioinformatics

<http://www.cbd.cmu.edu/about-us/what-is-computational-biology/>  
<http://ase.tufts.edu/biology/bioinformatics/exercise1.asp>

[https://www.researchgate.net/profile/Yuval\\_Kluger/publication/9046830\\_A\\_Bayesian\\_Networks\\_Approach\\_for\\_Predicting\\_Protein-Protein\\_Interactions\\_from\\_Genomic\\_Data/links/004635171142733860000000/A-Bayesian-Networks-Approach-for-Predicting-Protein-Protein-Interactions-from-Genomic-Data.pdf](https://www.researchgate.net/profile/Yuval_Kluger/publication/9046830_A_Bayesian_Networks_Approach_for_Predicting_Protein-Protein_Interactions_from_Genomic_Data/links/004635171142733860000000/A-Bayesian-Networks-Approach-for-Predicting-Protein-Protein-Interactions-from-Genomic-Data.pdf) (only to top of page 2)

<https://flavourjournal.biomedcentral.com/track/pdf/10.1186/2044-7248-2-4?site=flavourjournal.biomedcentral.com> (also available in Resources)

<https://www.ncbi.nlm.nih.gov.ezproxy.library.tufts.edu/pubmed/24786325> (Introduction, Methods and Figure 2).

## C. Bioengineering and Synthetic Biology

<http://journal.frontiersin.org/journal/bioengineering-and-biotechnology/section/synthetic-biology#about>

[https://www.ted.com/talks/geraldine\\_hamilton\\_body\\_parts\\_on\\_a\\_chip#](https://www.ted.com/talks/geraldine_hamilton_body_parts_on_a_chip#)

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4935447/>

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