

## **BIMM 120, Microbiology: Proposed Syllabus and Suggested Reading**

The optional textbook is: *Microbiology: An Evolving Science*, Sixth Edition, by JL Slonczewski et al., 2024 (The 5<sup>th</sup> edition, 2020, is OK)

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### **I. Introduction. Monday, April 1, 2024. Week 1.**

- a. Classical prokaryotes and eukaryotes – an overview
- b. The Three Laws of Biology

\*\*Trevors JT, Saier MH, “Three Laws of Biology”, WASP, 2010.

- c. Evolution of the Genetic Code according to biochemical laws, **Wednesday, April 3**

\*\*Saier M. H., Jr (2019). Understanding the Genetic Code. *Journal of Bacteriology*, 201(15), e00091-19. [PMID: 31010904].

- d. CPR Nanobacteria and Asgard Archaea – Mostly Symbionts? Are the latter the Eukaryotic Cell Precursor(s)? **Friday, April 5**

\*\*Saier MH, Cooperation, not Competition, was and still is the Primary Driving Force for Biological Evolution (submitted for publication).

\*\*Castelle, C. J., & Banfield, J. F. (2018). Major New Microbial Groups Expand Diversity and Alter our Understanding of the Tree of Life. *Cell*, 172(6), 1181–1197.

- e. Actin Cytoskeleton and Complex Cell Architecture in Bacteria and Asgard Archaea  
**Monday, April 8, Week 2.**

\*\*Govindarajan, S., & Amster-Choder, O. (2016). Where are things inside a bacterial cell? *Current opinion in microbiology*, 33, 83–90, [PMID: 27450542].

### **II. Dissimilar Microbiomes in Various Tissues of the Human Body. Wednesday, April 10**

- a. The Systemic Microbiome of Humans

- i. A Multiplicity of Microbiomes -The Importance of the Gut Microbiome
- ii. The Effects of Oral Microbiota on Health
- b. iii. Modulating Brain Function with Microbiota **Friday, April 12**
- iv. Microbiota-Brain Axis: Context and Causality
- c. v. Microbiota and Maintenance of Skin Barrier Function **Monday, April 15, Week 3.**

\*\* The Many Faces of the Microbiota-Gut-Brain Axis in Autism Spectrum Disorders, Goncalves et al., 2024, *Life Sciences*, 337, 1 – 13, [PMID: 38123016].

\*\*Reddy BL and Saier MH, Autism and our intestinal microbiota, 2015, *Journal of Microbiology and Molecular Biotechnology*, [PMID: 25792275].

Tsuji H, Matsuda K and Nomoto K (2018) Counting the Countless: Bacterial Quantification by Targeting rRNA Molecules to Explore the Human Gut Microbiota in Health and Disease, *Front Microbiol*, 2018, [PMID: 30008707].

- d. Eating Animal Products: A Common Cause of Human Diseases. **Guest Speaker: Prof. Lakshmi Reddy, Wednesday, April 17**

\*\*Saier MH, Baird SM, Reddy BL, & Kopkowsky PW, 2022. Eating Animal Products: A Common Cause of Human Diseases, *Microbial Physiology*, 32, 146 – 157. [PMID: 35952632]

\*\*Reddy, B. L., & Saier, M. (2020). The Causal Relationship between Eating Animals and Viral Epidemics. *Microbial Physiology*, 30(1-6), 2–8, [PMID: 32957108].

### III. Prokaryotic Molecular Machines

- a. Bacteriorhodopsin and photosynthesis: light driven ion pumps. **Friday, April 19**

\*\*Light-driven Proton Transfers and Proton Transport by Microbial Rhodopsins – A Biophysical Perspective, 2022, Leonid S. Brown, *BBA Biomembranes*, [PMID: 35051382]

Microbial Rhodopsins, Gordeliy V. et al., *Methods Mol Biol*. 2022;2501:1-52. [PMID: 35857221].

Interdisciplinary Biophysical Studies of Bacteriorhodopsin (Brho), Fahmy K & Sakman TP, 2022, *Biophys Reviews*, [PMID: 36909961]. (Note: Only the section on Bacteriorhodopsin is relevant to our lecture material)

- b. Reversible rotary ATP synthetases: F-, V-, and A-types. **Monday April 22, Week 4**

\*\*Berry RM, 2005, ATP Synthesis: The World's Smallest Wind-Up Toy. *Curr Biol* [PMID: 36909961].

c. 'Switching' rotary flagella – organelles of motility. **Wednesday, April 24**

Minamino T & Kinoshita M, Structure, assembly and function of flagella, EcoSal Plus, 2023, [PMID: 37260402]

- d. Poorly characterized types of prokaryotic motility.
- i. archaeal flagella: rotary type IV pili.
  - ii. Social gliding via retractable pili – Myxobacteria
  - iii. Adventurous gliding motility – Myxobacteria
  - iv. Ratchet structure involvement – Cytophaga/Flavobacteria
  - v. Internal fiber (actin/myosin?)-dependent motility – Mycoplasma

\*\*Jarrell KF, McBride MJ, 2008, Nat Rev Microbiol, 6, 466 -476. Diverse Ways Prokaryotes Move. [PMID 18461074]

**MIDTERM EXAM I, Friday, April 26. This exam will include topics covered during weeks 1 - 3.**

**Bacterial Sensing of Chemical and Physical Entities**

a. Chemotaxis – involving *mot*, *fla* and *che* genes **Monday April 29, Week 5.**

\*\*Multiple Functions of Flagellar Motility and Chemotaxis in Bacterial Physiology. Colin, R. et al., 2021, FEMS Microbiol Revs [PMID: 34227665]

b. Sensing physical forces

\*\*The Force Awakens: The Dark Side of Mechanosensing in Bacterial Pathogens, Mordue J. et al., 2021, Cell Signal [PMID: 33279672]

c. Bio-electricity and bacterial nanowires **Wednesday, May 1.**

\*\*Intrinsically Conductive Microbial Nanowires for 'Green' Electronics with Novel Functions. Lovely, D and Yao J, Trends Biotechnol, 2021, 39, 940 – 952. [PMID: 33419586]

d. Protein secretion systems (>24 distinct types) **Friday, May 3.**

\*\*Saier M, Protein Secretion and Membrane Insertion Systems, Adv Appl Microbiol. 2008; 65:141-97. [PMID: 19026865].

**More Molecular Compartments and Machines**

a. Chaparonins and proteosomes: **Monday, May 6. Week 6.**

\*\*Becker SH & Darwin KH, Bacterial Proteosomes: Mechanistic and Functional Insights, *Microbiol Molec Biol Revs*, 2017 [PMID: 27974513].

b. Carboxysomes, cellulosomes and metabolomes: **Wednesday, May 8.**

c. Sulfur granules and gas vacuoles

\*\*Saier M. H., Jr (2013). Microcompartments and protein machines in prokaryotes. *Journal of molecular microbiology and biotechnology*, 23(4-5), 243–269m [PMID: 23920489].

#### **IV. Prokaryotic membrane-bounded organelles Friday, May 10**

a. Intracellular membranes in *E. coli* and other bacteria (mitochondria precursors)

b. Chromatophores in photosynthetic bacteria (chloroplast precursors)

#### **V. Circadian Clocks in Cyanobacteria and other Protein Machines. Week 7.**

**a. The Prokaryotic Circadian Clock (Cyanobacteria) Guest speaker: Prof. Susan Golden, Monday, May 13.**

\*\*Swan JA et al., Structure, Function, and Mechanisms of the Core Circadian Clock in Cyanobacteria. 2018, [PMID: 29440392].

b. Magnetosomes in magneto-tactic bacteria, archaea and eukaryotes. **Wednesday, May 15.**

Lefevre CT et al., 2013, Ecology, Diversity and Evolution of Magnetotactic Bacteria, *Microbiol Mol Biol Rev* [PMID: 24006473]

c. Anammoxosomes in planctomycetes

d. Universal Acidocalcisomes – for H<sup>+</sup>, Ca<sup>2+</sup>, polyphosphate and energy storage

e. Outer membrane vesicles for communication and trafficking

\*\*Saier, M. H., Jr, & Bogdanov, M. V. (2013). Membranous organelles in bacteria. *Journal of molecular microbiology and biotechnology*, 23(1-2), 5–12.

**Midterm Exam II, Friday May 17. This exam will include topics covered during weeks 4 - 6.**

#### **VI. Cellular Polarity and Cell Interactions in a Prokaryotic World, Week 8.**

a. Bacterial Cell Polarity, **Monday, May 20,**

b. Bacterial Adhesins and Molecular Beacons

Complex Regulatory Pathways Coordinate Cell Cycle Progression and Development in *Caulobacter crescentus*, Brown PJB, 2009, *Adv Microb Physiology*, [PMID: 18929067]

c. Quorum sensing: group-dependent external chemical signaling **Wednesday, May 22.**

\*\*Striednig, B., & Hilbi, H. (2022). Bacterial quorum sensing and phenotypic heterogeneity: how the collective shapes the individual. *Trends in microbiology*, S0966-842X(21)00212-2 [PMID: 34598862].

**VII. Bacteria and Viruses in Human (and Animal) Health and Disease**

a. Diseases that Affected Our Ancestors: **Guest speaker, Prof. Steve Baird, Friday, May 24.**

**Memorial Day!!! Monday, May 27. Week 9**

Hu, H., Liu, M., & Sun, S. (2021). Pore-Forming Toxins During Bacterial Infection: Molecular Mechanisms and Potential Therapeutic Targets. *Drug design, development and therapy*, 15, 3773–3781.

b. Persister cells: formation, resuscitation and combative therapies

\*\*Wainwright, J., Hobbs, G., & Nakouti, I. (2021). Persister cells: formation, resuscitation and combative therapies. *Archives of microbiology*, 203(10), 5899–5906. [PMID: 34739553].

**VIII. Differentiation in Gram-positive Bacteria: *Bacillus* and *Streptomyces*. Wednesday, May 29 .**

\*\*Riley, E. P., Schwarz, C., Derman, A. I., & Lopez-Garrido, J. (2020). Milestones in *Bacillus subtilis* sporulation research. *Microbial cell (Graz, Austria)*, 8(1), 1–16. [PMID: 33490228].

Kroos L. (2017). Highly Signal-Responsive Gene Regulatory Network Governing *Myxococcus* Development. *Trends in genetics : TIG*, 33(1), 3–15. [PMID: 27916428]

Vollmer, B., Steblau, N., Ladwig, N., Mayer, C., Macek, B., Mitousis, L., Sigle, S., Walter, A., Wohlleben, W., & Muth, G. (2019). Role of the *Streptomyces* spore wall synthesizing complex SSSC in differentiation of *Streptomyces coelicolor* A3(2). *International journal of medical microbiology : IJMM*, 309(6), 151327. [PMID: 31324525]

**IX. Differentiation in Gram-negative Bacteria: Myxobacteria**

- a. Cell-cell interactions in embryogenesis and myxobacterial fruiting, **Friday May 31**
- b. Social Myxobacterial Microbes, **Monday, June 3, Week 10.**

\*\*Pathak et al., 2012. Myxobacterial Tools for Social Interactions. *Res Microbiol*, 163, 579 – 591, [PMID: 23123306].

**X. Viruses of bacteria and eukaryotes – including Coronaviruses. Wednesday, June 5**

Three Pandemics that Affected Our Ancestors. **Guest speaker: Prof. Stephen Baird**

Wong, N. A., & Saier, M. H., Jr (2021). The SARS-Coronavirus Infection Cycle: A Survey of Viral Membrane Proteins, Their Functional Interactions and Pathogenesis. *International journal of molecular sciences*, 22(3), 1308.

**XI. Mutagenesis, evolution and mobile genetic elements. Friday, June 7.**

\*\*Saier, M. H., Jr, Kukita, C., & Zhang, Z. (2017). Transposon-mediated directed mutation in bacteria and eukaryotes. *Frontiers in bioscience (Landmark edition)*, 22, 1458–1468, [PMID: 28199212].

Overview of required references:

10 weeks, 2 - 4 (required) references per week (indicated with double asterisks above).

Total number or assigned references: 24 for the quarter, or 2.4 refs per week on the average.

Feel free to discuss these (and other) topics with the professor (and the TA/IAs) during discussion sessions, office hours and out of class seminar sessions. Saier will also meet with you in person at other convenient times seven days/week (afternoons preferred), especially if other options don't work for you. Required references include material that can be the basis for exams and quizzes.

Final Exam: Wednesday, June 12, 11:30 to 2:30, room to be announced.

**Information for all weeks of the Spring quarter:**

- Class M/W/F in Center Hall Room 119, 12 - 12:50 pm
- Discussion Sessions on Fridays after class (1 - 1:50 pm) in Center Hall Room 119 (the exact same place as lecture and immediately after)
- All quizzes will be online via Canvas, with one quiz per week. The exams will be in-class and completed via scantron cards which we shall provide. Questions will comprise a series of multiple choice and True/False questions for all exams/quizzes.

**Midterms and Final:**

This class will have 2 midterms and 1 Final Exam. The final exam will be cumulative, but will be divided into 2 parts. Part 1 will primarily be material from the last four weeks of class after midterm 2, and the second part will be material covered in the entire class.

- Midterm 1: Friday Week 4, April 26th, 12:00-12:50 pm, Material from Weeks 1-3.
- Midterm 2: Friday Week 7, May 17th, 12:00-12:50 pm, Material from Weeks 4-6.
- Final Exams: Finals Week, June 12th, 11:30 am - 2:30 pm, Cumulative, 2 parts.

**Quizzes:**

Each week there will be a 10 point quiz. The quizzes will be online via Canvas, unlike the in-person exams. They will be open for 24 hours between Sunday 12:01 am - Sunday 11:59 pm. They will not be proctored through a program or zoom. These quizzes will be open book. Think of them as short, high point value, timed problem sets. They will all be 10 questions long, with 4 True/False and 6 Multiple Choice questions, and you will have 20 minutes to complete the quiz.

Over the whole course there will be 10 quizzes, 10 points each, 100 points total. Their question format and difficulty will be similar to questions on the exams.

**NOTE:** there will be quizzes for weeks 1, 4, 7 and 10, even on Sundays after weeks with exams.

**Discussion Sections:**

Discussion sections were scheduled by the registrar's office. Our weekly discussion sections are Fridays, immediately after Friday lecture, in the same lecture hall. So for those who would like to attend, we will end our lectures and transition to the discussion of the material for the previous week. Discussion sections are not required, but we shall review the class materials and answer any questions you may have.

The tentative schedule is: **Week 1**, Microbiological Diversity; **Week 2**, The Human Microbiomes; **Week 3**, The Cell Cytoskeleton; **Week 4**, Molecular Machines; **Week 5**, Flagellar Motility and Chemotaxis; **Week 6**, Intracellular Microcompartments (organelles); **Week 7**, Circadian Clocks and Magnetosomes; **Week 8**, Cell Polarity/Interactions, Quorum Sensing, Diseases; **Week 9**, Sporulation (*Bacillus*); **Week 10**, Fruiting Body/Sporulation (*Myxobacterium*); Viruses; Mutagenesis.

### **(Fully Optional) 2 unit Seminar Class:**

I shall be offering a seminar class (BIBC 194) which will meet on Thursdays at 1 PM until 2:20 PM. You may register for this class if you choose to, but there is no obligation. The topics will be the same as for the discussion sections cited above. This seminar class will allow you to gain a more detailed understanding of the topics we shall be covering in class, and should allow us to provide a more relaxed learning atmosphere including free discussions. It should allow you to ask questions and get peripheral information on any relevant topic according to your preferences. This class will be open not only to BIMM120 students, but also to those outside of our class, in which case YOU will be the more knowledgeable students in attendance. (currently to enroll you'll need to join the waitlist but we are trying to increase the size of the class)

### **Reading Assignments:**

Each week, there will be 2 or 3 required reading assignments. Most will be short reviews and scientific research articles. In general, the materials in these articles will be covered in class and will be fair game for questions to be included in the quizzes, midterm and final exams. The required readings will be released and made available to read and download Sunday each week as material for that coming week at the same time as the quizzes. For example, the week 2 quiz will be released at the same time as the required readings for week 3.

### **Grading Scheme:**

Quizzes: 100 points max (total)

Midterm 1: 100 points

Midterm 2: 100 points

Final Exam: Part 1 = 100 points, Part 2 = 100 points

**IMPORTANT:** For this class, your lowest score of the five will be dropped, and your class grade will be based on your total score for the remaining four scores. Thus, for example, if your part 1 of the final exam was the lowest score out of this series of items that are worth 100 points, it will be dropped. Or, if your quiz total is the lowest out of 100, then that will be dropped. 4 of the 5 scores that are each worth a maximum of 100 points will be what make up your final grade. Canvas will be programmed to do this automatically.

For grade estimation: 100% = 400 points
A+ = the top scores; B+, C+, D+ grades will be the top scores within their category of scores (see below).
A = at least 360 points (90%)
B = at least 320 points (80%)
C = at least 280 points (70%)
D = at least 240 points (60%)
F = lower than 240 points (59.75% and lower)

We are currently going to apply an absolute grading scale, but those in the top 1% of each letter grade can get a plus grade, but there are no minuses. Also, depending on the results, we may choose to apply a curve to the grade distribution, but this will only be in cases where the average grades are substantially lower than we expected. (Thus an 89% will get a B+)

### **Office Hours:**

Office hours are still to be determined and we will send out information when they are all scheduled. Dr. Saier and Jack Ord (the TA) will most likely have 2 office hours each, and each IA will have 1 set of office hours per week.

### **Personal Message to Students:**

Anything else? Do let us know!

Good luck with the material to be covered in BIMM120! I hope you will find it challenging and amazingly interesting.

Enjoy the class, [we shall do everything we can think of to make it optimally enjoyable], and I promise you, you will do better if you enjoy your Microbiology! (Milton Saier)

## Getting Help

Questions are essential in science and you must never be afraid to ask them. The preferred medium for asking course-related questions is via the TritonEd Discussions. If you are confused, chances are that another student has the same doubt, so by asking questions there and having them answered publicly, everybody will benefit.

## Academic Honesty and Plagiarism

There is a zero tolerance policy regarding academic dishonesty. See the Academic Integrity Agreement (which you must sign to receive a passing grade in the class) for more details on the topic. Violators of these policies may be subject to UCSD rules for academic integrity.

Plagiarism is the unacknowledged presentation of the work of another person as one's own. To present someone else's work as one's own is dishonest and academically worthless. Plagiarism is unethical and will be treated as a serious offense. If a student is uncertain whether a course of action might constitute plagiarism or cheating, they should consult the instructor in advance.