Syllabus: **SIO 281B: Marine Physiology** **Fall 2024**

INSTRUCTOR	**E-mail**
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LECTURES	Eckert 227 - Tuesday & Thursday 3.30 pm- 4.50 pm
OFFICE HOURS	By appointment

COURSE GOALS

To provide an overview of biochemical and physiological adaptations in diverse marine organisms and how those adaptations are important in their natural environment and in relation to anthropogenic activities. To provide an evolutionary perspective of essential physiological mechanisms of marine organisms. To discuss classic and modern experimental techniques and research papers relevant for the students' own research. To promote critical thinking.

LEARNING OBJECTIVES

By the conclusion of the course, the students should be familiarized with biochemical and physiological adaptations used by marine organisms. This includes universal concepts as well as species-specific mechanisms. In particular, they should have learned principles on essential physiological processes such as:

-Aerobic and Anaerobic Metabolism: basic concepts, alternative endpoints of fermentation, Warburg effect, relevance for coral bleaching.

-ATPases, carbonic anhydrases: basic concepts, Na^+/K^+-ATPase, V-H^+-ATPase (VHA), carbonic anhydrase isoforms, conserved & unique functions in aquatic animals.

-Acid-Base (A/B) regulation: basic concepts, main sources of A/B stress, unique aspects of aquatic animals, A/B regulation of biological microenvironments and their effects on physiology, epithelial ion transport.

-Physiological responses to Ocean Acidification: effects on A/B regulation, behavior, photosynthesis, biomineralization from a mechanistic perspective.

-Carbon concentrating mechanisms (CCM): need for CCMs, importance of pH, evolution of VHA-dependent CCM, links between phagocytosis, CCM, symbiosis and symbiogenesis.

-Cellular biology of reef-building corals: morphology and anatomy, cell subtypes and their functions, energy metabolism of healthy and bleached corals, cellular and sub-cellular microenvironments, evolution of symbiosis, photophysiology.

The students will also become familiar with experimental techniques (including advantages and disadvantages) to study the physiology of marine organisms at the molecular, cellular and whole-organism level.

COURSE WEBSITE:

Course materials will be available through Canvas. Be sure to check the course website frequently for announcements, updates and assignments.

GRADING:

Weekly Assignments **60%**
-There will be three types of assignments:
1) a short presentation during Lecture 2, which should include your general and specific research interests, and potential links to biochemistry and physiology.

The other two types of assignments will be on Canvas:
2) Quizzes, True/False questions, fill out the blank questions and the like.
3) Short assays discussing how the material from the previous week may be relevant to the research project of the student (or to a research topic of their interest).

Final Presentation…….30%
-Each student will give a 10 min presentation about ideas to incorporate some of the material covered in this course to their own research.

Participation …………..**10%**
-This includes asking questions and participating in discussions during the lectures

SCHEDULE

Week #	Date	Topic
1		
	Thu Sept 26	1. General Introduction
2	Tue Oct 1	2. Students' present brief explanation about their own research
	Thu Oct 3	3. Enzymes, Energy Metabolism *Reading material: Alberts et al 2002*
3	Tue Oct 8	4. Coral Energy Metabolism *Reading material: Linsmayer et al 2021*
	Thu Oct 10	5. Coral Energy Metabolism – Bleaching *Reading material: Linsmayer et al 2024*
4	Tue Oct 15	6. V-H+-ATPase (VHA), Na^+/K^+-ATPase (NKA), and Carbonic Anhydrases (CAs) *Reading material: Tresguerres et al 2016*
	Thu Oct 17	7. Coral symbiosomal acidification *Reading material: Barott et al 2015*

5	Tue Oct 22	8. Links between phagocytosis, symbiosis and symbiogenesis *Reading material: Yee et al 2023*
	Thu Oct 24	9. Building a silica shell *Reading material: Yee et al 2019*
6	Tue Oct 19	10. Osedax worms: dissolving bones for nutrition *Reading material: Tresguerres et al 2013*
	Thu Oct 31	11. Acidification of fish retina *Reading material: Damsgaard et al 2020* (Bonus points for wearing a Halloween research-related costume :)
7	Tue Nov 5	12. pH and Acid-Base Regulation *Reading material: Tresguerres et al 2020*
	Thu Nov 7	13. Effects of Ocean Acidification on Fish: blood acid/base regulation *Reading material: Kwan et al 2024*
8	Tue Nov 12	14. Effects of Ocean Acidification on Fish: otolith biomineralization *Reading material: Kwan and Tresguerres 2022*
	Thu Nov 14	15. Effects of Ocean Acidification on Fish: behavior *Reading material: Tresguerres and Hamilton 2017*
9	Tue Nov 19	16. Coral photophysiology (Guest lecturer: Dr. Galindo Martínez)
	Thu Nov 21	17. Coral Cell Biology (Tresguerres et al 2017)
10	Tue Nov 26	18. Biomineralization
	Thu Nov 28	NO LECTURE (Thanksgiving)
11	Tue Dec 3	19. Student presentations (I)
	Thu Dec 5	20. Student presentations (II)

LITERATURE TO BE DISCUSSED DURING THE LECTURES

(*The students will be required to read the papers in advance, but the instructor will present the papers and lead the discussions*).

Lecture #	Paper
3	"How Cells Obtain Energy from Food". Molecular Biology of the Cell. 4th edition. New York: Garland Science (2002). Alberts B, Johnson A, Lewis J, et al. https://www.ncbi.nlm.nih.gov/books/NBK26882/
4	"Dynamic regulation of coral energy metabolism throughout a diel cycle". *Sci Rep* 10:19881 (2020). Linsmayer LB, Deheyn DD, Tomanek L, Tresguerres M.
5	"Effects of bleaching on oxygen dynamics, energy metabolism, and genotype of symbiotic algae in two Caribbean coral species". *Sci Tot Environ* 919: 170753 (2024). Linsmayer LB, Noel SK, Leray M, Wangpraseurt D, Hassibi C, Kline DI, Tresguerres M.
6	"Novel and potential physiological roles of vacuolar-type H^+-ATPase in marine organisms". *J Exp Biol* 219:2088-2097 (2016) Tresguerres M.
7	"Coral host cells acidify symbiotic algal microenvironment to promote photosynthesis". *PNAS* 112(2): 607-612 (2015). Barott K.L., Venn A., Perez S.O., Tabutteé S., Tresguerres M.
8	"The V-type ATPase enhances photosynthesis in marine phytoplankton and further links phagocytosis to symbiogenesis". *Current Biology* 33: 1-7 (2023). Yee DP, Samo TJ, Abbriano RM, Shimasaki B, Vernet M, Mayali X, Weber PK, Mitchell BG, Hildebrand M, Decelle J, Tresguerres M.
9	"Dynamic subcellular translocation of V-type H^+-ATPase is essential for diatom silica cell wall biomineralization". *New Phytologist* 225(6): 2411-2422 (2019). Yee D.P., Hildebrand M., Tresguerres M.
10	"How to get into bones: proton pump and carbonic anhydrase in *Osedax* boneworms". *Proc Roy Soc B* 280 (1761) 20130625 (2013). Tresguerres M., Katz S., Rouse G.W.
11	"The choroid rete mirabile in the teleost eye is a proton-excreting gland that greatly enhances oxygenation of the retina". *eLife* 9e:58995 (2020). Damsgaard C., Lauridsen H., Harter T.S., Kwan G.T., Thomsen J.S., Funder A.M.D., Supuran C.T., Tresguerres M., Matthews P.G.D., Brauner C.J.
12	"Evolutionary links between intra- and extracellular acid-base regulation in fish and other aquatic animals". *J Exp Zool A* 2020: 1-17 (2020). Tresguerres M., Clifford A.M., Harter T.S., Roa J.N., Thies A.B., Yee D.P., Brauner C.J.
13	"Gill ionocyte remodeling mediates blood pH regulation in rockfish (*Sebastes diploproa*) exposed to environmentally relevant hypercapnia". *Physiol Genomics* (in press), Kwan GT, Clifford AM, Prime KJ, Harter TS, Tresguerres M.
14	"Elucidating the acid-base mechanisms underlying otolith overgrowth in fish exposed to ocean acidification". *Sci Tot Environ* 823: 153690 (2022). Kwan G.T. & Tresguerres M.
15	"Acid-base physiology, neurobiology and behaviour in relation to CO_2-induced ocean acidification". *J Exp Biol* 220:2136-2148 (2017). Tresguerres M. & Hamilton T.J.
18	"Cell biology of reef-building corals. Ion transport, acid/base regulation, and energy metabolism" DOI:10.1007/978-3-319-39617-0_7 (2017). Tresguerres M., Barott K.L., Barron M.E., Deheyn D.D., Kline D.I., Linsmayer L.B.