Syllabus: Marine Physiology (SIO 281)

Instructor
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Office hours By appointment
Time (*Lectures*) Monday/Wednesday 3.30 - 4.50 pm
Location (*Lectures*) IGPP 4301

Course Goals
To educate about physiological adaptations in diverse marine organisms, covering a wide spectrum from the biochemical to the cellular to the whole-organism level. To understand and be able to predict how adaptations are relevant in the natural environment and in relation to anthropogenic activities.

Learning Objectives
By the conclusion of the course, the students should be familiarized with biochemical and physiological adaptations in marine organisms. In particular, they should have learned principles on essential topics such as:
-ATPases (sodium/potassium, proton, calcium)
-Carbonic anhydrase
-Carbon concentrating mechanisms
-CO_2, pH and HCO_3^- sensing and regulation
-Epithelial ion transport
-Physiological responses to Ocean Acidification in phytoplankton, corals, mollusks and fish.
-Aerobic and anaerobic metabolism
-Comparative immunology
-Oxygen transport by respiratory pigments (hemocyanin, hemoglobin)

SIO 281 discusses classic and modern experimental techniques and research papers.

Course Website
Course materials will be available through the course website (http://ted.ucsd.edu). All students will need to be able to access this site. Be sure to check the course website frequently for announcements and updates.

Grading
Grades will be based on a 5-page (+references) research project due on June 6th (70%), quizzes and homework (30%).

Student choice
Undergraduate students: letter grade or Pass/No Pass

Graduate students: Letter grade or Satisfactory/Unsatisfactory

Schedule

Mon March 28	Introduction to the course
Wed March 30	Aerobic and anaerobic metabolism
Mon April 4	Cellular and molecular adaptations to hypoxia
Wed April 6	Hypoxia in the aquatic environment (Horst Felbeck)
Mon April 11	Ecophysiology of the deep sea environment (Tony Koslow)
Wed April 13	Solute transporting proteins (ions, glucose, amino acids)
Mon April 18	ATPases (e.g. Na^+/K^+-ATPase, V-H^+-ATPase)
Wed April 20	Carbonic anhydrase
Mon April 25	pH in biological systems
Wed April 27	Signal transduction-molecular sensors of CO_2, pH and HCO_3^-
Mon May 2	*Osedax* and hagfish physiology
Wed May 4	Fish cell biology and physiology
Mon May 9	Effects of OA on fish
Wed May 11	Effects of OA on invertebrates
Mon May 16	Coral cell biology and physiology
Wed May 18	Effects of OA on corals
Mon May 23	Effects of OA on phytoplankton
Wed May 25	Comparative Immunology (Lena Gerwick)
Mon May 30	Memorial day
Wed June 1	Respiratory pigments
Mon June 6	***Research project due***

Note: 1.20 h lectures

*Guest lecturer, exact date to be confirmed

Required Reading material (uploaded to TED)

(Casey et al., 2010; Clifford et al., 2015; Hamilton et al., 2013; Heuer and Grosell, 2014; Hochachka and Somero, 2002; Maren, 1967; Tresguerres et al., 2014; Tresguerres et al., 2016; Tresguerres et al., 2010a; Tresguerres et al., 2013; Tresguerres et al., 2011; Tresguerres et al., 2010b)

Casey, J. R., Grinstein, S. and Orlowski, J. (2010). Sensors and regulators of intracellular pH. *Nat. Rev. Mol. Cell Biol.* **11**, 50–61.

Clifford, A. M., Goss, G. G., Roa, J. N. and Tresguerres, M. (2015). **Acid/base and ionic regulation in hagfish**. In *Hagfish Biology*, pp. 277–297. CRC Press.

Hamilton, T. J., Holcombe, A. and Tresguerres, M. (2013). CO_2-induced ocean acidification increases anxiety in Rockfish via alteration of $GABA_A$ receptor functioning. *Proceedings of the Royal Society B: Biological Sciences* **281**, 20132509–20132509.

Heuer, R. M. and Grosell, M. (2014). Physiological impacts of elevated carbon dioxide and ocean acidification on fish. *Am. J. Physiol. Regul. Integr. Comp. Physiol.* **307**, R1061–84.

Hochachka, P. W. and Somero, G. N. (2002). *Biochemical Adaptation*. Oxford University Press, USA.

Maren, T. H. (1967). Carbonic anhydrase: chemistry, physiology, and inhibition. *Physiological Reviews* **47**, 595–781.

Tresguerres, M., Barott, K. L., Barron, M. E. and Roa, J. N. (2014). Established and potential physiological roles of bicarbonate-sensing soluble adenylyl cyclase (sAC) in aquatic animals. *J. Exp. Biol.* **217**, 663–672.

Tresguerres, M., Barott, K. L., Barron, M. E., Deheyn, D. D., Kline, D. I. and Linsmayer, L. B. (2016). Cell biology of reef-building corals. Ion transport, acid/base regulation, and energy metabolism. In *Acid-base balance and nitrogen excretion in invertebrates* (eds. O'Donnell, M. and Weihrauch, D., Germany: Springer.

Tresguerres, M., Buck, J. and Levin, L. R. (2010a). Physiological carbon dioxide, bicarbonate, and pH sensing. *Pflugers Arch - Eur J Physiol* **460**, 953–964.

Tresguerres, M., Katz, S. and Rouse, G. W. (2013). How to get into bones: proton pump and carbonic anhydrase in *Osedax* boneworms. *Proceedings of the Royal Society B: Biological Sciences* **280**, 20130625–20130625.

Tresguerres, M., Levin, L. R. and Buck, J. (2011). Intracellular cAMP signaling by soluble adenylyl cyclase. *Kidney International* **79**, 1277–1288.

Tresguerres, M., Parks, S. K., Salazar, E., Levin, L. R., Goss, G. G. and Buck, J. (2010b). Bicarbonate-sensing soluble adenylyl cyclase is an essential sensor for acid/base homeostasis. *Proc. Natl. Acad. Sci. U.S.A.* **107**, 442–447.