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*)	Eckart 227

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
70% of the grade is based on a research project due on June 6 (2,500-word +references). The remaining 30% is based on quizzes and homework.

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

Graduate students: Letter grade or Satisfactory/Unsatisfactory

Schedule

Mon April 2	Introduction to the course
Wed April 4	Aerobic and anaerobic metabolism
Mon April 9	Respiratory pigments
Wed April 11	Physiological adaptations to hypoxia
Mon April 16	Carbonic anhydrase
Wed April 18	ATPases (e.g. Na^+/K^+-ATPase, V-H^+-ATPase)
Mon April 23	Comparative Immunology (Lena Gerwick)
Wed April 25	pH in biological systems
Mon April 30	Signal transduction-molecular sensors of CO_2, pH and HCO_3^-
Wed May 2	*Osedax* physiology
Mon May 7	Hagfish physiology
Wed May 9	Fish physiology
Mon May 14	Effects of OA on fish
Wed May 16	Physiology of fish larvae (Garfield Kwan)
Mon May 21	Coral cell biology and physiology
Wed May 23	Coral photophysiology (Daniel Wangpraseurt)
Mon May 28	Memorial day
Wed May 30	Effects of OA on corals
Mon June 4	Effects of OA on phytoplankton
Wed June 6	Research project due

Note: 1.20 h lectures

Required Reading material (uploaded to TED)

(Casey et al., 2010; Clifford et al., 2015; Hamilton et al., 2014; Heuer and Grosell, 2014; Hochachka and Somero, 2002; Kwan et al., 2017; Maren, 1967; Tresguerres, 2016; Tresguerres and Hamilton, 2017; Tresguerres et al., 2014; 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. (2014). 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.

Kwan, G. F., Hamilton, T. J. and Tresguerres, M. (2017). CO_2-induced ocean acidification does not affect individual or group behaviour in temperate damselfish (*Chromis punctipinnis*). *Royal Society Open Science* **4**, 170283.

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

Tresguerres, M. (2016). Novel and potential physiological roles of vacuolar-type H^+-ATPase in marine organisms. *Journal of Experimental Biology* **219**, 2088–2097.

Tresguerres, M. and Hamilton, T. J. (2017). Acid-base physiology, neurobiology and behaviour in relation to CO2-induced ocean acidification. *J. Exp. Biol.* **220**, 2136–2148.

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., 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.