

Chemistry and the Marine Environment: a Faculty-led Study Abroad Course

This is a faculty led study abroad course that combines classroom study at Rutgers, SCUBA certification, and experiential learning during a two-week trip to Bonaire, an island that serves as a model for marine conservation in the Caribbean. The purpose of this class is to expose students of the *chemistry* to global environmental issues for which their training is likely to ultimately have great impact. Students of the chemistry are a fundamental part of the next generation of scientists that are striving to gain a deeper understanding of how *Nature* works at its most fundamental level. It is thus of critical importance that, early on, these young scientists are made aware of environmental issues that are likely to reshape the global landscape in years to come. Most of all, it is the hope that this course will allow students to get a first-hand glimpse of the rich diversity of life that thrives in a coral reef ecosystems, and to become, as a SCUBA diver, invested in issues involving marine conservation. In this way we hope to motivate and empower the next generation of graduates that have training in physical and chemical sciences to make real differences on global issues.

The proposed faculty-led study abroad course has several novel aspects that enhance its academic merit. These include: 1) facilitation of new partnerships between academic and recreational programs, 2) enhance cross-campus interactions between faculty and degree programs in the Schools of Arts and Sciences and School of Environmental and Biological Sciences, and 3) provide students with a global perspective that introduces them to the importance of research that brings principles of the chemical and physical sciences to bear on complex problems involving biological and environmental issues. This course will actively leverage synergies with other on-going courses in chemistry, marine science and environmental science, entice undergraduates at an early stage to engage in research, and serve as a feeder mechanism to increase the number of undergraduate majors in these fields.

This class will be open to a broad range of students, but will especially target students in the early stages of their undergraduate career in order to help create a pipeline for recruitment of majors in chemistry, marine sciences and environmental sciences. The initial target number of students in the course will be 8-12.

The course will have main components: ***Classwork at Rutgers, PADI Open Water SCUBA certification***, and a two-week ***Study Abroad Experience*** at the CIEE Research Station in Bonaire. These three elements work together to provide a foundation of knowledge in how chemistry and the physical sciences have impact on global environmental issues, practical training in SCUBA diving, and experiential learning that introduces research in an international setting.

1. **Classwork at Rutgers**. There will be a significant classroom component at Rutgers that will include three components: 1a) classroom lectures, 1b) invited research talks and 1c) class projects.
 - a. **Classroom lectures**. A series of lectures will be given on topics that tie together chemistry with issues related to the marine environment. The purpose of this aspect of students training is to illustrate how what they have learned in gateway STEM classes, and in particular General Chemistry, has direct and broad significance to the marine environment: *it is all chemistry*. This introductory part of the course brings to light examples of the diversity of chemical processes in the marine environment, and the factors that influence their delicate balance which, in turn, have profound impact on fragile ecosystems

such as coral reefs. This part of the course is meant to be a *survey*, and is designed to stimulate interest in and complement foundational full semester classes offered through Marine Sciences (e.g., Dynamics of Marine Ecosystems, Chemical Oceanography, and Environmental Sciences (e.g., *Chemical Principles of Environmental Science*), as well as Rutgers signature courses such as *Energy and Climate Change*. On the other hand, it is expected that this class will serve as a pipeline for students to take these higher-level classes, and help to reduce the rate of attrition of majors in these STEM areas. Lecture survey topics will cover a range of important chemical concepts in the marine environment and will include: 1) Chemistry and the Global Environment which will cover critical and timely topics such as: carbonate chemistry in the ocean and ocean acidification, chemistry of ionic solutions 2) Chemistry and the coastal Marine Environment relevant topics will include: anthropogenic nutrient enrichment and eutrophication in coastal systems, 3) Chemistry of Coral Reefs relevant topics will include calcification dynamics, biochemical molecules used in defense strategies 4) chemical dynamics in Mangrove systems, including aerobic and anaerobic cycling of carbon in mangrove ecosystems. 5) Chemistry of SCUBA Diving: relevant topics will include gas partial pressures in pressurized systems such as the chemistry of the “bends”.

- b. **Invited research talks.** In addition to these general survey areas, there will be an invited guest talks by faculty involved in research associated with the marine environment, broadly defined. The course will target 2-3 invited research talks by faculty in chemistry, the institute of marine and coastal sciences, and environmental sciences.
 - c. **Class projects.** Students in the course will be assigned to project teams of 2-3 people in order to prepare talks associated with the thematic area of the course, and to further prepare them for the study abroad component of the course that will take place in Bonaire. Projects can be chosen from a list of topics, or else suggested by the student teams (and approved by the instructor). Represented topics include: 1) Climate influences on History and Culture of Bonaire, 2) Ecosystem influences on tropical flora of Caribbean Coral Reefs, 3) Fauna of Caribbean Coral Reefs, 4) Invasive Fish Species in the Caribbean, 5) Carbon and energy flux in Mangrove Forests, 6) Impact of Humans on Coral Reef chemistry and Ecology, 7) Political Challenges for Marine Conservation. 7) Geochemistry of ocean salts
2. **PADI Open Water SCUBA Certification.** As part of the course requirements, students will obtain their SCUBA certification through the Professional Association of Diving Instructors (PADI), the world’s largest recreational diving membership and diver training organization. Certifications will be organized through the Rutgers SCUBA program in partnership with *Ocean Explorers*, located in Edison, NJ. Certification in SCUBA diving consists of 3 components: classroom instruction, confined water (pool) training, and open water dives. Classroom instruction and pool training will take place at the Aquatics Facilities at the Cook Campus or Werblin Recreational Center. Open water dives will be completed at the Dutch Springs, a 50-acre lake that serves as a recreational and diver training facility located in Bethlehem, PA (<http://www.dutchsprings.com/index.html>). PADI Open Water (OW) or Advanced Open Water (AOP) certification will be a requirement for the course, and well as CPR/First Aid training.
 3. **Study Abroad Experience.** The Study Abroad component of the course will occur during a two-week trip to Bonaire over the summer. Bonaire is an island in the Dutch Caribbean, and is the least populated of the “ABC” islands of the Leeward Netherland Antilles, and has served as an exemplary model for marine

conservation in the Caribbean. The entire reef system surrounding the island is accessible by shore, and is protected as a marine park for divers. Bonaire is thus known as the “Land of Diving Freedom”, having calm, clear waters with little or no currents on the leeward side of the island, as well as the uninhabited island of Klein Bonaire located approximately 1.5 km to the west and is protected as a turtle sanctuary (it is an interesting fact that turtles inhabiting the Lac Bay area of the island have growth rates more than twice that of any other area in the Caribbean). The inhabitants of Bonaire speak Dutch and native Papiamentu, although English is also commonly spoken. Bonaire has a rich history, dating back to 1000 AD when the Caquetios Indians came by canoe from Venezuela to become the first recorded inhabitants, to its European occupation in the 1500’s where it proved a valuable resource in the harvesting of sea salt. Today the salt pans are still operational in the southern part of the island, and the slave huts remain as a grim reminder of parts of Bonaire’s repressive past. The entire northern end of the island is [Slagbaai National Park](#), a preservation that protects the island’s native genetic and biodiversity, and boasts a sanctuary for wild flamingos, a wide variety of birds, reptiles and other animals, as well as caves and unique rock formations that, although remote, remain popular tourist attractions. In the southern part of the island is a large, protected mangrove forest where guided tours can be arranged through the [Mangrove Information Center Bonaire](#).

Students enrolled in the course will receive instruction, training at the [CIEE Research Station Bonaire](#), headed by Director, Dr. Rita Peachy. Students will stay at the research station quarters, and receive selected lectures from the CIEE Instructional Staff on topics such as *Coral Reef Ecology*, *Marine Conservation*, and *Field Research Methods* and *Cultural and Environmental History of Bonaire*. In addition, students will receive introductory training in *Scientific Diving*. Together, this instruction will provide an introduction to many new aspects of the underwater world and of Bonaire that students would otherwise never get the chance to experience.

In addition, several field trips will be organized to allow students a diversity of experiences. Anticipated activities will include: 1) day trip to [Slagbaai National Park](#), 2) guided tour through the mangrove forest through the [Mangrove Information Center Bonaire](#), 3) guided sailing/snorkel trip to Klein Bonaire with [Woodwind](#) guided snorkel tours, 4) visit to the [Donkey Sanctuary Bonaire](#), and 5) day trip to Lac Bay, location of pristine beaches, turtle breeding grounds, and renowned for world-class wind-surfing and kite-surfing. The diving and ecotourism culture on the island is such that there are always a myriad of public talks given by scientists, naturalists, and photographers that would be open for students to attend as a group.

And of course, SCUBA diving will be a regular activity. The main island of Bonaire has 63 marked dive sites, over 40 of which are easily accessible by shore. Additionally, there are 26 marked dive sites off of the nearby island of Klein Bonaire that are accessible by boat. As part of the course, students will be expected to gain experience in open water dives in the calm, clear waters and shallow reef system of the shores of Bonaire and Klein Bonaire. It is anticipated that most students will engage in 7-14 dives during the 2-week trip, and thus accumulate a wealth of experience in a truly transformative, pristine aquatic environment. It is during these experiences that students develop a deep appreciation of the rich diversity of life that exists below the water’s surface, and hopefully begin a transformation in how they perceive the natural world and the fragile ecosystems that it is a home.

Prerequisites:

The only prerequisites for the class include: 1) successful completion of Chem 161 (General Chemistry), and 2) the ability to swim and have proper health and fitness required for [SCUBA certification](#).

Faculty:

The faculty instructor, developer and leader for the course is Prof. Darrin York (Department of Chemistry and Chemical Biology, and BioMaPS Institute for Quantitative Biology). Prof. York is theoretical chemist that is heavily invested in both graduate and undergraduate education. At the graduate level, Prof. York has developed new courses at Rutgers, including "Chemical Dynamics", as well as spearheading interdisciplinary training efforts including serving as PI for the most recently submitted NSF Integrative Graduate Education and Research training (IGERT) grant entitled "Computational Science and Engineering Interfaces with Quantitative Biology". Prof. York is heavily invested in research, heading a group of 12 graduate students, postdocs and advanced scientists in the development and application of quantum simulation methods to study complex biological processes. Prof. York is also heavily involved in undergraduate education, and has served on the Rutgers's School of Arts and Sciences Committee for Undergraduate Education. Additionally, Prof. York currently serves as the General Chemistry Coordinator and Instructor in Chemistry 161 (General Chemistry) for which serves almost 2000 students annually at Rutgers. Prof. York, having had post-graduate research training at Duke University, Harvard and University of Strasbourg, as well as tenured faculty positions at University of Minnesota and Rutgers University, believes in bringing to the classroom both a research and a global perspective, as well as demonstrations that illustrate concepts that are taught in lectures. Very recently, Prof. York has spearheaded the initiation of a new Chemistry Lecture Demonstration Facility with the mission of bringing chemistry into the classroom. In this way, Prof. York has been proactive in helping to enhance gateway classes in Science, Technology, Engineering and Mathematics (STEM).

Prof. York is also a PADI Divemaster with *Ocean Explorers* and it is anticipated by the time of initiation of this course, will be certified SCUBA instructor (although this is in no way a contingency for the course). Prof. York has an intimate knowledge of Bonaire, having made numerous visits to the island from 2000-2010, and has visited and maintained contact with the CIEE Research Station in Bonaire, including close correspondence with Director, Dr. Rita Peachy.

Recruiting:

A key element of this faculty-led study abroad program is recruiting. Of course, this class will be advertised through Study Abroad web site, but additionally, it will be advertised an opportunity to general chemistry students. As general chemistry coordinator, Prof. York already has integrated research examples into the classroom, including having research active colleagues give short, invited talks on their research in class. These 15-minute talks, which are usually augmented with a chemical demonstration, have sparked a wealth of interest in students wanting to pursue undergraduate research opportunities in chemistry. Prof. York discusses in class opportunities available to Rutgers students to engage in undergraduate research, for example, through directed research, and programs such as Aresty and RiSE, as well as other opportunities for summer research outside of Rutgers and abroad, such as at various CIEE Programs. Calling attention to the Chemistry and the Marine Environment faculty-led study abroad course would be a natural extension of what is already in place. Given the close connection between chemistry, SCUBA diving and the marine environment, it is highly anticipated that

there will be a wealth of interest in this course. Currently, there are around 2000 general chemistry students at Rutgers each year, and next year, Prof. York is scheduled to teach (Fall 2012) two large lecture sections, each with approximately 400 students. This creates not only a mechanism to advertise for this particular faculty-led study abroad course, but perhaps more importantly, on a larger scale, a great opportunity to encourage the best students to pursue majors in related areas of basic science, and ultimately to engage in undergraduate research opportunities.

Significance of the Proposed Faculty-led Study Abroad Course. The proposed faculty-led study abroad course will provide a fundamental knowledge base that ties together basic chemistry with the marine environment, SCUBA diving experience, including an introduction to field research methods and scientific diving. Finally, students will engage in the exploration and study of a fragile and diverse coral reef ecosystem on an island that is a model for marine conservation, in an international setting that gives them a global view through study abroad and will shape their perception of the world. The hope is to provide a truly unique, and in many cases a once in a lifetime opportunity, for students to engage in a novel faculty-led study abroad program that ties together fundamental basic sciences with important, tangible environmental issues.

Innovation of the Proposed Faculty-led Study Abroad Course. A unique feature of this faculty-led study abroad course is to target students taking General Chemistry, a gateway STEM class with almost 2000 students enrolled annually at Rutgers. By targeting General Chemistry students who are learning the fundamental laws of *Nature* that impact the marine environment, this course will establish a pipeline to recruit students to major in STEM fields, and in particular, chemistry, marine sciences and environmental sciences. Further, it is the hope that this course will not only attract interest in and complement courses required by these majors, but also facilitate greater interactions between faculty in various departments and institutes, including Chemistry & Chemical Biology, Marine, Earth & Planetary Sciences, and Environmental Sciences.