VOL. 96 • NO. 2 • 1 FEB 2015

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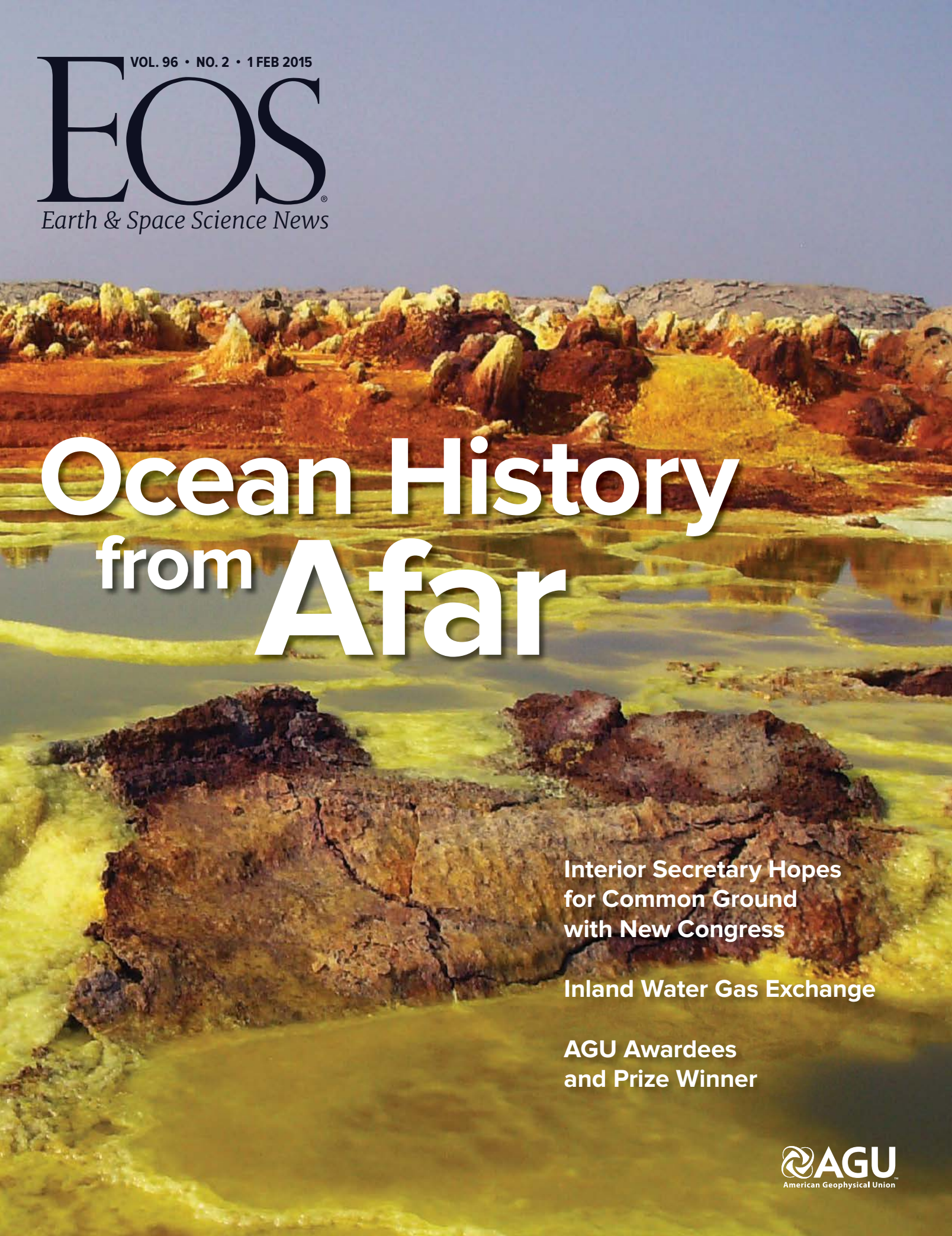

Ocean History from Afar

Interior Secretary Hopes for Common Ground with New Congress

Inland Water Gas Exchange

AGU Awardees and Prize Winner

AGU
American Geophysical Union

1 FEBRUARY 2015
VOLUME 96, ISSUE 2

COVER

Reading History from Afar

A look at the sedimentary record in northern Ethiopia tells the story of oceans past—and maybe future.

FEATURE

Two- and Four-Year Colleges Team Up to Support Science Students

Faculty from community colleges play increasingly important roles in promoting science, technology, engineering, and math. What can faculty from 4-year colleges and universities do to collaborate?

NEWS

3 Common Ground with New Congress Sought by Interior Secretary

At the 2014 AGU Fall Meeting, Sally Jewell called for working constructively with Congress and even with those who hold strong ideological views.

MEETING REPORT

Measurements, Modeling, and Scaling of Inland Water Gas Exchange

Two- and Four-Year Colleges

Team Up to Support Science Students

By Janet Hodder, R. Heather Macdonald, and Jude K. Apple

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Much has been written about how the United States faces a shortage of science, technology, engineering, and mathematics (STEM) professionals despite the national goal to provide 1 million additional STEM degrees by 2022 [e.g., *President's Council of Advisors on Science and Technology,* 2012]. What is not immediately clear, however, are the steps educators need to take to overcome the shortage and meet that goal.

The success of several new projects suggests that 2-year colleges, community colleges, technical colleges, and junior colleges (collectively 2YCs)—a group new to the STEM reform movement—can help lead students into career pathways involving science and math [*Boggs,* 2010; *National Academy of Engineering and National Research Council*, 2012]. In turn, these projects have increased awareness among professional societies and staff at 4-year colleges and universities (4YCUs) about the importance of 2YCs in the preparation of students for STEM careers.

Some 4YCU faculty, particularly those who did not attend a 2YC as part of their education, may be unfamiliar with the culture, needs, and realities of the 2YC faculty and their students. Here we provide insights into the community colleges' missions, students, faculty, and curriculum and present specific strategies to promote successful partnerships between 2YC and 4YCU faculty and institutions. In doing so, we hope to assist the growing number of 4YCU faculty who desire to partner with 2YC faculty to improve STEM education and achieve a broader impact for their disciplinary research.

Profile of Community Colleges

1132 public and private community colleges in the United States play a crucial role in undergraduate STEM education. They enroll 12.8 million students annually, approximately 45% of all U.S. undergraduates [*American Association of Community Colleges,* 2014]. (See box on page 10.)

Nearly one half of Americans who receive bachelor's degrees in science and engineering and one third of recipients of science or engineering master's degrees attended a community college at some point in their education [*Tsapogas,* 2004]. Community colleges are also important for teacher preparation, with 40% of the nation's teachers—including those in STEM fields—completing some of their mathematics or science courses at community colleges [*Shkodriani,* 2004].

Community colleges are diverse in size and location, ranging from multicampus districts in large urban settings to small, rural colleges in remote areas. Their departmental and governance structures vary within and among states.

Teaching at a Community College

Teaching is the primary responsibility for 2YC faculty (see box on page 11), and thus their reward structure is often different from those at many 4YCUs. Generally, research in their discipline is not expected; it may even be discouraged because it could interfere with time dedicated to

teaching. Teaching loads are heavy, and 2YC faculty commonly teach four to five courses per term.

In many programs, faculty are expected to teach courses beyond the primary discipline of their academic degrees. For example, a solid Earth geophysicist may be assigned to teach introductory oceanography.

Some faculty teach during the summer, others teach night classes, and some instruct online courses, which are increasingly being taught at 2YCs. The heavy teaching load means that 2YC faculty may find it difficult to engage in activities beyond their instructional duties and to take time away from their courses to participate in professional development. Teaching assistants are almost nonexistent, and laboratory preparatory staff are uncommon; 2YC faculty are generally responsible for teaching all parts of a course.

Many community college faculty have chosen careers focused on teaching and are committed to improving learning opportunities for students. Many have considerable experience with student-centered learning, developing teaching materials, and employing pedagogical innovations. Others participate in educational research such as that associated with student assessment or effective learning strategies.

Many community college faculty may become isolated from their academic discipline and thus may not be involved in disciplinary professional societies. When available, professional development opportunities provided by 2YC institutions focus primarily on teaching and supporting student success, with less emphasis on advances in disciplinary knowledge.

The curriculum at 2YCs focuses on lower-division courses. Some 2YC STEM courses fulfill general education requirements, whereas others meet general education requirements as well as specific degree requirements of 4-year STEM programs. Other courses are specifically designed for the STEM workforce as part of a certificate or applied associate's degree.

State regulations, institutional governance, and curricular demands at individual 2YCs can restrict or limit curricular reforms and new initiatives, creating a barrier to curricular change [*Macdonald et al.,* 2011]. In many cases, the curriculum at 2YCs is constrained because of articulation agreements with 4YCUs.

Partnerships Between 2YCs and 4YCUs

Recognizing that many 2YC students later enroll at 4YCUs, faculty from both 2YCs and 4YCs are working together to instill student interest in science and math. A few joint efforts stand out.

One is the Centers for Ocean Science Education Excellence (COSEE)–Pacific Partnerships program (http://www.coseepacificpartnerships.org). COSEE has provided opportunities for 2YC faculty and students to work with ocean scientists through a series of workshops and research internships. The goals of this project are to increase the quality of ocean science instruction at 2YCs, to improve ocean literacy of both faculty and students, and to develop an increased awareness of potential STEM career pathways (see Figure 1).

In particular, the COSEE–Pacific Partnerships project seeks to move professional development for 2YC faculty beyond learning new teaching methods to updating disciplinary knowledge. Through the program, 2YC faculty work closely with geoscientists to translate current geoscience research and knowledge into course content and other approaches to engaging 2YC students in the practices of science.

Another joint effort is the Supporting and Advancing Geoscience Education in 2YCs (SAGE 2YC) project (http://serc.carleton.edu/sage2yc/index.html). SAGE 2YC has provided 2YC faculty with resources to improve their teaching and support students in their career development through geotechnician preparation programs or by preparing students for college transfer.

Several other projects bring 2YC students to 4YCUs. For example, the Community College at Sea project (http://cascadia.uoregon.edu/ccsea) at the University of Oregon provides 2YC students opportunities to participate in oceanographic research cruises [*Livelybrooks,* 2013]. Chapman University provides summer undergraduate research fellowships for selected 2YC students in Orange County, Calif., who are studying Earth and environmental sciences, with support from the U.S. National Science Foundation's Research Experiences for Undergraduates program.

How to Develop 2YC-4YCU Partnerships

From our experiences as 4YCU faculty working with 2YC STEM faculty on COSEE–Pacific Partnerships and SAGE 2YC, we have developed a broader understanding of issues to consider when developing a 2YC–4YCU partnership for education, research, or faculty professional development. Through our collective projects, we have identified five factors to consider in establishing partnerships.

Include the 2YC faculty in the initial planning of a project.

Successful partnerships include a common understanding of relationships and roles. Performance expectations should be clear, and everyone should benefit from participation. Including 2YC faculty at the beginning of a project makes them more invested in the project's success and

Heavy teaching loads mean that 2-year college faculty may find it difficult to engage in activities beyond their instructional duties

Fig. 1. Community college faculty testing underwater microphones (hydrophones) that they constructed during a Centers for Ocean Science Education Excellence (COSEE) sponsored workshop held at the Oregon Institute of Marine Biology. Credit: Janet Hodder

allows them to contribute to project planning. One perception, based on the experience of many 2YC faculty with whom we have worked, is that they are included in many projects as a token, as an afterthought, or only as a way to boost the possibility of obtaining funding.

Understand the institutional mission, policies, and the true capacity of the partner 2YC.

Some 2YCs do not have a grants office and may have limited support for administrative functions related to external funding. Timing of activities related to the proposed project may need to fit the often more constrained 2YC schedule. Some 2YC faculty will have difficulty leaving their institution during the academic year and may need to provide replacement instruction, sometimes from their own resources, because they cannot cancel classes.

Be aware of the target student's profile and the 2YC's profile.

Projects that involve students need to take into account student needs and constraints (e.g., families; jobs; barriers to moving that prevent, say, participation in off-campus internships), the assets they bring (e.g., life experiences, strong community ties), and the culture of a 2YC.

For example, in developing the COSEE Promoting Research Investigations in the Marine Environment (PRIME) internship program (http://www.coseepacificpartnerships.org/programs/CC/students/), which provides 2YC students with a summer research opportunity at a marine laboratory, we had to work with 2YC faculty to identify students who would benefit from this early-career research internship. Without faculty intervention, 2YC students rarely consider applying for summer research experiences because they do not see themselves as being qualified for these opportunities.

The more diverse nature of the 2YC student body makes it necessary for program developers to think beyond the needs of the 18- to 22-year-old student cohort. For example, projects involving, say, fieldwork may need to provide accommodations for accompanying family members or may need to connect participants with child-care options. Projects could also follow the example of AGU's Unique Research Experiences for

Two-Year College Faculty and Students (URECAS) project, which has instituted virtual poster sessions as a low-cost way for 2YC and other students to present their research at national meetings.

Collaborative projects need to reflect faculty members' individual needs.

In the SAGE 2YC project, which has both 2YC and 4YCU faculty as principal investigators (PIs), buyout from teaching for one of the 2YC PIs enabled full participation in the project during the academic year. However, not all 2YCs allow teaching buyout.

In some instances, faculty will need stipends—for transportation, registration fees, and subsistence—to attend project activities and meetings. For some adjunct faculty, the phrase "free is too expensive" resonates, highlighting the need for additional funding to support hidden costs of participation.

Projects should reflect the realities of 2YC-4YCU course articulation.

For curricular projects to work, they need to mesh with goals of 2YCs and 4YCUs. For example, the COSEE–Pacific Partnerships project completed a comprehensive assessment of curricular needs with STEM faculty from several 2YCs before planning faculty professional development activities.

The Need for More Partnerships

Four-year institutions and faculty have only just started to play a significant role in partnering with community colleges to increase the capacity of both types of institution to support undergraduate engagement in STEM. In the geosciences, we have only just begun to see if these efforts will pay off.

Qualitatively, 2YC faculty who have participated in partnership projects reported increased student learning gains and engagement in their geoscience courses, although very few studies have measured whether interest in STEM persists through the students' lives. Nonetheless, an evaluation of 2YC students who participated in the COSEE internship program supports the idea that undergraduate research attracts and retains talented students to careers in science [*Lopatto,* 2007]: Compared with the "average" community college student who transferred to a 4-year institution, the interns

Who Are Community College Students and Faculty?

Developing successful partnerships between 2-year colleges (2YCs) and 4-year colleges and universities (4YCUs) to promote science, technology, engineering, and math (STEM) requires that 4YCU faculty have a working knowledge of the 2YC students and faculty whom they hope to serve. Below are general profiles of these groups.

Students

Thirty-six percent of 2YC students are first-generation college students [*American Association of Community Colleges,* 2014], many of whom have limited knowledge of what is required for success in higher education. Open admission policies mean that some students need developmental courses to prepare for college-level work. Many 2YC students have constraints on participation in extracurricular activities because they may be place bound or juggling employment and childcare.

The open admission policy at most 2YCs results in a student body that is generally more diverse, in many measures, than that of a 4YCU. A higher percentage of minorities underrepresented in the STEM fields attend 2YCs than 4YCUs. Nationally, 59% of Native American, 56% of Hispanic, and 48% of black undergraduates are enrolled in 2YCs.

The average 2YC student is a 28-year-old woman in a class that is 57% female; she is attending college part time, along with 60% of her classmates, and is working full or part time, along with 68% of her fellow students. Her tuition is considerably lower than that at most 4-year institutions, and she, along with 58% of her classmates, is receiving some type of financial aid [*American Association of Community Colleges,* 2014].

The average 2YC student, along with many of her classmates, is unlikely to be thinking of a career in the geosciences. In 2010, only 20% of all U.S. bachelor's degrees were awarded to underrepresented minorities, and fewer than 7% of bachelor's degrees in geoscience were awarded to underrepresented minorities (see raw National Center for Education Statistics data, https://webcaspar.nsf.gov/). Of all of the STEM fields, the geosciences remains some of the least diverse.

demonstrated a high persistence and success in STEM postsecondary education.

The most transformative projects will likely be those that specifically offer professional development for 2YC faculty, improve STEM education of 2YC students, provide research opportunities for 2YC faculty and students, and increase 2YC student transfer success rates to 4YCUs. More projects that focus on 2YC faculty and students should provide us with information on successful strategies for broadening the diversity of the geoscience workforce and recruiting more students into STEM careers.

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Faculty

One distinctive feature of 2YCs is the makeup of the faculty. Nationally, 68% of faculty members in the 976 public community colleges in the United States are part time [*Knapp et al.,* 2012].

From 2003 to 2009, the number of part-time faculty increased by about 10%, whereas the number of full-time faculty grew by only 2% [*Knapp et al.,* 2010]. The number of permanent full-time faculty who teach STEM subjects at 2YCs varies by institution. Some are tenured or tenure eligible; however, some states (e.g., Texas) have no tenure system, and permanent, full-time faculty are employed on multiyear contracts.

Faculty titles at 2YCs are not always consistent with those at 4YCUs. Although some systems have assistant, associate, and full professors, others use terms such as "lecturer" for full-time permanent faculty. In STEM fields, 22% of full-time 2YC faculty have doctorates and 62% have master's degrees, compared with 12% and 51% of part-time faculty, respectively [*American Association of Community Colleges,* 2014].

Some faculty members at 2YCs are nonacademic professionals who teach specialized courses associated with certificate or applied associate degree programs. At many institutions, adjunct or contingent faculty who are commonly employed on a year-to-year or term-to-term basis do the majority of the teaching.

These full-time or part-time adjunct faculty members are diverse and include graduate students who want to gain teaching experience, people attempting to secure permanent positions in academia who may teach several courses each term at multiple institutions, and people with specific technical knowledge who teach a single course at one institution. Some 2YC faculty members, whether by choice or circumstances, spend their entire career in adjunct positions.

One notable feature of having regular and adjunct faculty is the disparity in pay and benefits between the two. Many adjuncts are paid by the course. The median pay for a three-credit course taught by a 2YC adjunct faculty member in fall 2010 was US$2235 [*Coalition on the Academic Workforce,* 2012]. In addition, adjuncts do not typically have access to professional development opportunities or discretionary funds, rarely participate in institutional governance, and may not even be listed on the college website.