

Sowing the Seeds of Knowledge: The Integration of Practical Flow Cytometry into Undergraduate Education

White Paper

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Introduction

Since its invention in the late 1970s, flow cytometry has revolutionized research in many areas of the life sciences, including immunology, cell biology, hematology, and oncology. The applicability of this technique to practically every discipline of biologic research has made the flow cytometer nearly indispensable in the modern research laboratory.

Until recently, flow cytometers have been restricted to larger medical and educational institutions and core laboratory facilities. But the introduction of the BD Accuri™ C6, the first *personal* flow cytometer, has brought this key technology within reach of individual researchers, smaller institutions, and even young scientists at the undergraduate level. This white paper discusses the advantages of integrating flow cytometry into undergraduate education, as reported by researchers and teachers who are doing so.





Figure 1. The BD Accuri C6 flow cytometer system.

The personal flow cytometer

The BD Accuri C6 is a four-color, dual-laser flow cytometer that offers performance, simplicity, and affordability. Easy to learn and use, it is about the size of a microwave oven, allowing it to be set up in even the most limited lab space. It is also rugged enough to be transported, making it usable in undergraduate teaching labs or classroom demonstrations.

Operation is menu-driven and intuitive. Most operators feel at ease with 30 minutes of instruction. The combination of low cost and ease-of-use has made the BD Accuri C6 an attractive option for many research scientists in educational institutions who never thought that they could afford a flow cytometer.

As a result, the BD Accuri C6 flow cytometer is finding a place at a growing number of four-year, undergraduate colleges and universities where classroom instruction is the primary mission. In such a setting, undergraduates can experience laboratory research firsthand.

Benefits across the institution

For these select colleges and universities, an affordable flow cytometer helps recruit and retain talented faculty. Many applicants for junior faculty positions at these institutions are recent PhDs or post-doctoral fellows who performed their graduate or post-graduate research in laboratories that routinely used flow cytometry. To them, a flow cytometer is standard laboratory equipment, as necessary as a light microscope, centrifuge, or plate reader.

Institutions also appreciate the operational simplicity and serviceability of the BD Accuri C6. They do not have to hire a dedicated technician to operate and maintain the instrument or assist researchers in its use.

The BD Accuri C6 helps faculty be productive both as researchers and teachers. While classroom instruction might be the primary mission of these colleges and universities, newly hired faculty members often are expected to establish a laboratory and perform original, publishable research. Access to a flow cytometer means they will not be at a disadvantage compared to their colleagues at larger institutions.

Finally, for undergraduate students, access to a personal flow cytometer helps them understand what it's like to work in a modern research lab. If they decide to pursue a research career, their experience with the BD Accuri C6 makes them more attractive candidates for acceptance into top-tier graduate and professional schools.

Undergraduate project examples

Direct scientific observation and experimentation are widely becoming central to a strong undergraduate education in biology as well as other disciplines. At some institutions, the BD Accuri C6 is used not only by students in biology, but also in chemistry and biochemistry.

Undergraduates are now participating in a wide variety of research projects involving flow cytometry. Topics include cell culture, oxidative stress, calcium flux, metabolism, cell cycle analysis, apoptosis and cell death, and the role of T cells in autoimmunity and aging.

Sources of funding

The funding sources through which faculty members have purchased their BD Accuri C6 cytometers are as diverse as the research projects for which they are using them. Many instruments are funded by large public grant agencies such as the US National Institutes of Health (NIH), the National Science Foundation (NSF), and the Department of Energy, under programs specially oriented toward smaller institutions. For example, the INBRE (IDeA Networks of Biomedical Research Excellence) grant program at NIH was designed to support faculty research and expand undergraduate research opportunities in states traditionally underfunded by NIH grants.

Similarly, the NIH's AREA (Academic Research Enhancement Award) grant program was designed to support biomedical and behavioral science research programs at academic institutions that have not been major NIH grant recipients. The MRI (Major Research Instrumentation) program at NSF supports the acquisition of major state-of-the-art instruments to help equip research environments that integrate research with education.

Other faculty members have purchased their BD Accuri C6 with internal university research grants, departmental discretionary funds, or private foundation grants.

BD Accuri C6 in the Biology Department at Randolph-Macon College in Ashland, VA



Dr. Melanie Gubbels Bupp is an immunologist who received her PhD from the University of Colorado in 2005, and performed post-doctoral work at both UCSF and Roche Pharmaceuticals. In 2009, Dr. Gubbels Bupp joined the faculty at Randolph-Macon College in Ashland, Virginia, as an Assistant Professor in the department of biology. Randolph-Macon College is a private liberal arts and sciences college with an enrollment of 1,200 undergraduate students. Like many select colleges of this size, Randolph-Macon prides itself on its low student-to-faculty ratio (11:1) and its small average class size (15). The biology department at Randolph-Macon College believes that direct observation and experimentation are fundamental to a strong biology education, and thus requires all of its students to take a one- or two semester research course, during which they complete a laboratory or library research project under the supervision of a faculty member. Dr. Gubbels Bupp's research focuses on the role of T cells in autoimmunity and aging, and for her, flow cytometry is critical. Thus, Dr. Gubbels Bupp negotiated with Randolph-Macon to purchase a BD Accuri C6 flow cytometer as part of the lab start-up package normally provided to new faculty members, with the money coming entirely from departmental discretionary funds. The BD Accuri C6 will be used by a student in Dr. Gubbels Bupp's lab as part of an undergraduate research project, and will also be used by multiple students in the lab section of an upper-level biology class.

Dr. Gubbels Bupp states that she is pleased with the service she has received from BD Accuri, is happy with the results she has generated using the BD Accuri C6, and appreciates the convenience and "low hassle" of her cytometer.



BD Accuri C6 in the Chemistry Department at Hendrix College in Conway, Arkansas

Dr. Andres Caro is an Assistant Professor of Chemistry at Hendrix College in Conway, Arkansas, a liberal arts college with an enrollment of 1,500 students. Hendrix College stresses the philosophy of active learning, or “you learn more when you do more.” Thus, Hendrix proudly promotes its Odyssey Program, which includes a focus on undergraduate research. Students perform a year-long research project under the direct supervision of a Hendrix faculty member, and then report the results of their research in a public forum. Current research areas include cell culture, the study of oxidative stress in cells, calcium flux, and metabolism, all of which can be monitored by flow cytometry. In the past, Dr. Caro would load up his car with five or six students and drive the 30 miles to Little Rock to use the flow cytometry core facility at the University of Arkansas. Dr. Caro was unhappy with this arrangement because a technician at the core facility performed all of the analyses, and the students did not learn to do flow cytometry themselves, contrary to the goals of the Odyssey Program.

Dr. Caro obtained the funds to purchase a BD Accuri C6 flow cytometer with an INBRE (IDeA Networks of Biomedical Research Excellence) grant from the NIH. The INBRE program was designed to enhance the caliber of faculty research and expand undergraduate research opportunities in states traditionally underfunded by NIH grants, including Alaska, Arkansas, Delaware, Kansas, Kentucky, Idaho, Louisiana, Maine, Mississippi, Montana, Nebraska, North Dakota, Nevada, New Hampshire, Oklahoma, Rhode Island, South Carolina, South Dakota, Vermont, West Virginia, and Wyoming.

Dr. Caro wanted to purchase a new cytometer, and the low price of the BD Accuri C6 allowed him to do that with the funds obtained from the INBRE grant. He reports that the BD Accuri C6 is dependable, the service reliable, and the software “just so intuitive.” The cytometer is used by students from multiple departments, including biology, chemistry, and biochemistry. Dr. Caro performs all of the maintenance of the cytometer, which is housed in the college’s core cell culture facility. According to Dr. Caro, the BD Accuri C6 has changed his ability to do research in this constrained-budget environment. And, it allows his students to be more competitive to graduate school admissions committees by being able to say that they have had first-hand experience performing flow cytometry.



BD Accuri C6 in the Biological Sciences Department at the University of Northern Colorado

Dr. Gregory DeKrey is an Associate Professor of Biological Sciences at the University of Northern Colorado. With an enrollment of 10,000 undergraduates and 2,200 graduate students, UNC is larger than the schools profiled previously, and yet not as large as most universities that currently own flow cytometers. Dr. DeKrey applied for an internal Research Enhancement Award Grant at the University of Northern Colorado to pay for his BD Accuri C6, with additional funding coming from individual users and departmental funds. The BD Accuri C6 is routinely used by five investigators for research purposes, and is used as part of a teaching lab in cell physiology. The BD Accuri C6 flow cytometer is not associated with a traditional core facility at the university, although a general instrument technician was hired by the university to service multiple pieces of equipment, including performing routine maintenance on the BD Accuri C6. According to Dr. DeKrey, the BD Accuri C6 “works the way it is advertised,” the software is straightforward and “sets itself up.”



BD Accuri C6 in the Biology Department at Cal State Northridge

The California State University is the largest system of higher education in the United States, consisting of 23 campuses and more than 400,000 students. Its mission is undergraduate education, with limited masters-level degree programs, and no doctoral programs. This is in contrast to the University of California system. With 10 campuses and 220,000 students, the UC system is the other branch of higher education in California, with a better known focus on research, as well as graduate and professional education.

Dr. Rheem Medh is an Associate Professor in Biology at Cal State Northridge, a school with 36,000 undergraduate students and more than 30 biology faculty members. Despite the overwhelming size of the Cal State system, Dr. Medh believes that she has purchased the first BD Accuri C6 flow cytometer among its 23 campuses. She accomplished this feat using an NIH Score SC3 grant. Another principal investigator at Cal State Northridge, a colleague of Dr. Medh, purchased a BD FACSCalibur™ system in the constrained-budget Cal State system by applying for a National Science Foundation Major Research Instrumentation (MRI) grant.

Dr. Medh uses the BD Accuri C6 for her own research in cell death, and to train her students in cell cycle analysis and apoptosis. She indicates that the BD Accuri C6 “doesn’t need a lot of space or a technician to operate, and that the tech support is very good.”

The BD Accuri C6 at other educational institutions

Other sources of funding were used to purchase BD Accuri flow cytometers by faculty at other institutions. Dr. Sharon Stranford at Mount Holyoke College (2,200 students) used an Academic Research Enhancement Award (AREA/R15) from the NIH to purchase her BD Accuri C6. The AREA grants are designed to support small research projects in the biomedical and behavioral sciences conducted by faculty and students at academic institutions that have not been major recipients of NIH research grant funds. Dr. Shere Byrd at Fort Lewis College (3,685 students) used a Department of Education grant to purchase her BD Accuri C6 flow cytometer and to hire a dedicated lab technician to maintain the machine and run the samples for the three main users in a shared lab space. Santa Clara University (5,200 students) obtained a grant from the private Fletcher Jones Foundation to support the establishment of an undergraduate degree program in bioengineering. The funds from this award allowed Santa Clara University to hire Dr. Unyoung (Ashley) Kim, and to purchase a BD Accuri C6 flow cytometer. Dr. Kim is using microfluidics technology to develop a novel magnetic-activated cell sorter. Dr. Kim uses the BD Accuri C6 to assess the purity of the cells that have been isolated using her magnetic sorting device.

Summary

The affordable BD Accuri C6 has opened the world of flow cytometry to a new set of enthusiastic users at select four-year undergraduate colleges and universities, thereby enriching the research experience for scores of students and preparing them for a more productive graduate and post-graduate research career.

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