

Features: Points of View

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Note from the Editors

Points of View (POV) addresses issues faced within life science education. Cell Biology Education has launched the POV feature to present two or more opinions published in tandem on a common topic. We consider POVs to be "Op-Ed" pieces designed to stimulate thought and dialog on significant educational issues. Each author has the opportunity to revise a POV after reading drafts of the other POVs. In this issue, we ask the question, "Should students be encouraged to publish their research in student-run publications?" This question has been debated at institutions and has presented a renewed challenge with the advent of open access publishing as exhibited by the Journal for Young Investigators (<http://www.jyi.org>). Three POVs are presented. Scott Gilbert, Professor of Biology at Swarthmore College, is well-known for his developmental biology textbook. John Jungck, a CBE editorial board member and Professor of Biology at Beloit College, is founding director of BioQUEST. Margaret Harris (Physics, Duke University), Renée Mercuri (Science Journalism, University of Waterloo), and Joshua Tusin (Biology, Beloit College) are staff members of the Journal of Young Investigators. Vivian Siegel is the Executive Director of Public Library of Science (<http://www.plos.org>) and former Editor of the journal Cell. The authors bring a wealth of publishing experience and different points of view to the debate. Readers are encouraged to participate in the online discussion forum hosted by CBE at <http://www.cellbioed.org/discussion/public/main.cfm>.

A Case Against Undergraduate-only Journal Publications

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WHILE there may be several positive arguments for undergraduate research journals, I think that the negatives far outweigh the values they may have.

My first argument is that a journal geared toward the publication of undergraduate research would significantly "up the ante" and increase the pressures on students. Right now, my undergraduates do not need a published paper to get into an excellent graduate school or medical school or to be competitive for a fellowship. What they need is a letter of recommendation, wherein I write that the student has drive, persistence, intellectual curiosity, and that she or he knows how to plan experiments with the appropriate controls. The fact that the student's research has not yet reached the publication stage is not considered a disadvantage. If there were an undergraduate research journal, such a publication might become an expected "credential."

The second argument against an undergraduate research journal is that it would significantly increase the stress on faculty. One of the joys of pursuing research at a primarily undergraduate institution (at least, after one has tenure) has been the ability to do the research without having to have a program with a 100% chance of success. Moreover, I can work on topics that might take years to accomplish (and which would never be assigned to a graduate student). The research that I have done on turtle shell development investigates an organism that has a breeding season of 3 months each year. By the time we know what to look for, we have to wait 9 months for the next experiment. When we publish a paper, there may be 3 years worth of students on it. It takes time to make such a paper, and I would not want to publish pieces of it so that each undergraduate could have a paper published by the time she or he applies for fellowships or graduate degree programs.

Another stress on faculty members may involve competition between those who publish in such journals and those who don't. Would such papers in undergraduate journals count toward tenure and promotion? Are they "real" papers? Should someone who builds a story over a number of years be penalized for not publishing it bit-by-bit and accruing numerous "publications"?



The third argument against a journal specifically for undergraduate research is that it could easily become a journal of not-ready-for-prime-time studies. If the research is good enough, it should be published in a “real” journal. I agree that the standards set by journals are making it progressively more difficult to publish in the mainstream journals. However, many journals have “rapid” publication sections or portions that are designed specifically for small projects such as gene expression patterns. A quick look at Google located undergraduate research journals at Caltech, University of Florida, University of California-Irvine, Stanford, and Berkeley. There is even a U.S. Government-sponsored *Journal of Undergraduate Research*, published by the Department of Energy. It would be interesting to know if any article in these journals has been cited by anyone outside its home institution or whether any of the journals is indexed in searchable databases such as PubMed. In other words, the journals risk being little more than “vanity journals.”

I also see two other problems concerning the quality of such papers. First, if the journal were run solely by undergraduates—including the reviewing process—there might be a question of quality control that might worry others about citing the article or using the data in their own research. Are undergraduates prepared to review articles written by their peers and to comment on them in a constructive way? Do undergraduates have enough time during their undergraduate careers to respond to reviewer criticisms of their own papers? While many undergraduate students become competent at critically discussing the literature, they may not have the perspective and knowledge required to review articles in a way that their judgment is required before publication. Second, once published in a journal of this type, the data would be precluded from publication in another journal. One cannot always have the foresight of knowing what research and information may be interesting at some later date.

The fourth argument against an undergraduate research journal concerns for whom the journal exists. I don’t think the student will gain much from having a paper published in a journal for undergraduate research. As mentioned above, the undergraduate gains from a good letter of recommendation. However, I can see reasons why *faculty members* might want such a journal. It would allow the publication of small research papers so that the faculty member might not get scooped by other laboratories. (This would be possible only if the journal were

recognized by a number of indexers so the article could be found and cited by others in the field.) While there may be some merit to this, I don’t see this as benefiting our students.

My fifth argument concerns the reason for doing research in the first place. If you work at a research institution, publishing in a journal of undergraduate research is not going to garner you many laurels. If you work at a primarily undergraduate school, then such a journal might undermine the major reason for doing research there. Namely, research is the best way of teaching our best students. Research with undergraduates is done in the context of teaching, not publication. I am very happy with this model, because it makes *working* with students more important than *publishing* with students. I am concerned that a journal of undergraduate research, if successful, would undermine this important principle of liberal arts science education.

I think that the future of research at primarily undergraduate institutions is through collaboration with larger laboratories. This has many benefits, including access to new techniques and concepts, the introduction of undergraduates to the joys and frustrations of high-power research, and the possibility for undergraduates to participate in studies that are published in mainstream journals. If I have my own project, I can often bring it into a larger laboratory and work with students there in the summer. And if our goal is to train undergraduates to understand what research science is all about, they should have realistic expectations for publication and authorship and the scientific review process. They should also realize that not all work leads to publication.

Thus, I do not think that an undergraduate research journal provides benefits for the undergraduates that outweigh the costs of time and other resources. I also doubt that such a journal would have articles of significant benefit to science or the scientific community. Moreover, I believe that such a journal would only put more publication pressure on faculty members and weaken one of the fundamental reasons for pursuing research with undergraduates. The risks of publishing an undergraduate research journal outweigh any possible benefit such a journal might have. I think that there are other, more important places where we can put our limited funds and time.

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Undergraduates: Do Research, Publish!

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RESearch is not complete until it is published. A science education is not complete until students fully participate in all aspects of professional scientific culture. This means they have to understand the values of the profession that they are joining. Although undergraduates are provided opportunities to recognize the importance of research, too often they fail to appreciate that research is not complete until it is published. Values of researchers necessarily include publishing, peer review, and priority, but these values are not part of textbook information, traditional labs, and mass lectures or accessible through passive learning. Occasionally, students are listed as co-authors of articles in professional journals, but typically they are credited for their work in the acknowledgments. Rarely are students fully involved in both the writing and peer review process. Full engagement and benefit in undergraduate research will not be realized until peer review and publication are standard expectations of these critical experiences.

Undergraduate research transforms many student lives (Spillich, 1997). The experience is an actualization of dreams, a “professionalizing” experience, and an opportunity to be an active contributor to the production of scientific knowledge. Yet, most students are excluded from three crucial components of research: (1) publication, (2) peer review, and (3) priority. This gap needs to be actively addressed by the membership and leadership of life science professional societies. If we want to be consistent with our initiatives in improving undergraduate education and to recognize the authentic success of those undergraduates who have actively participated in the research experiences we have promoted, support of peer-reviewed journals serving the undergraduate community is a logical extension of that commitment.

While institutional student research journals (such as the *Beloit Biologist* [over 20 years] and the *Caltech Undergraduate Research Journal*) have existed for a long time, there have not been many national opportunities for undergraduates enrolled in the majority of institutions. The most popular forum for students to present their work in a national context has been in student sessions of professional societies such as AAAS and through National Conferences on Undergraduate Research (NCUR) (<http://www.ncur.org/>). NCUR has existed since 1987 and specifically states three objectives relevant to student researchers:



1. Communicate and celebrate the results of mentor-student collaborations
2. Foster a multidisciplinary and multicultural community of researchers, scholars, and artists linked by a common enthusiasm for learning
3. Achieve its goals by sponsorship of an annual conference and by publishing proceedings of its conferences

The 18th annual NCUR meeting will be held at Indiana University–Purdue University, Indianapolis, IN, April 15–17, 2004. The meeting provides an excellent forum for students to meet peers from many other institutions, present posters on their research, and, in roughly 500 out of 2,000 cases, to gain published recognition of their research. Although NCUR is not a research journal per se, the proceedings are published separately after the conference.

Some disciplines other than biology have offered opportunities for undergraduates to publish research. For example, the American Institute of Physics founded the *Journal of Undergraduate Research in Physics* as “the journal” of the Society of Physics Students and its honor society, Sigma Pi Sigma in 1981. It is now available as *The Online Journal of Undergraduate Research in Physics* (<http://www.jurp.org/>). Unfortunately, biology students have not had such a forum or the support from professional societies. However, today, we have two excellent alternatives for direct participation in publishing undergraduate research. The *American Journal of Undergraduate Research* (<http://www.ajur.uni.edu/>) is edited by Cliff Chancey (University of Northern Iowa). In the lead-off article in the current issue (2003), he states:

How should an undergraduate research journal be different? In its investment in helping the student researcher be a full partner in preparing his or her research paper for publication.

Primarily distributed as a hard-copy journal, the *American Journal of Undergraduate Research* also has sample issues available online in downloadable PDF. The editorial board has been drawn primarily from Project Kaleidoscope (<http://www.pkal.org/>) participants.

The *Journal of Young Investigators* (JYI) (<http://www.jyi.org/>) is an online journal that publishes original research, features,

news, and views. It provides a forum for discussion of articles that are curated and archived. JYI is edited by undergraduates with mentoring from faculty and has been published for 7 years. JYI has had NSF funding and the editorial staff receives professional journalist press passes at AAAS annual meetings. Co-founder Andrew Medina-Marino states the need for such an initiative:

While many undergraduates participate in scientific research, too few have the opportunity to communicate their research and results to other students—especially outside their institutions. JYI answers this need by recognizing the significance of publication as an integral component of science and research training.

At the heart of JYI's mission, we hope to provide a forum for us, the undergraduate scientists, to showcase and publish our research, discuss our experiences, and communicate with the scientific community our thoughts, ideas, and concerns. More specifically, JYI aims to provide a forum in which we as young scientists may communicate with each other and form a cohesive community across the traditional barriers of specific scientific disciplines and fields of study.

JYI began with a challenging idea. While doing research at the Lawrence Berkeley National Laboratory, Andrew Medina-Marino—a founding member of JYI and now a member of the Board of Trustees—wondered why undergraduate research was so invisible. Thousands of undergraduates engage in research through independent study projects, senior theses, and summer research programs, but the scientific community rarely sees the fruits of this work. This led Andrew to the age-old question asked by scientists: Why?

There is an irony here. Many researchers have reacted negatively to undergraduate research journals. Negative reactions are prevalent even among those who deeply value mentoring undergraduates in research in their own labs at R01 universities, large government labs, biotechnology companies, and elite research liberal arts colleges and who have added undergraduate researchers as co-authors of primary research journal articles. Reasons for this position have included three principle questions: (1) Shouldn't students seek to publish in "real" research journals, because they will not receive professional credit for these secondary publications? (2) Who will index and track research published in undergraduate research journals? and (3) With the rapid change-over in the undergraduate student population, how can such an endeavor be sustained, especially with consistent high quality? The implication is that student researchers can't be trusted to do the work of peer review and publication. How would these negative mentors respond to Seymour Papert's famous critique: "much of education is designed to infantilize students" (Papert, 1980)?

This "infantilizing" history is completely at odds with contemporary dynamics of undergraduate education. The majority of students enrolled in undergraduate education are adults (that is, 18 and older, with some large institutions having average age of undergraduates in the mid-30s), taxpayers, voters, work off-campus a significant amount, and contribute to our economy in many ways. Students are frequently involved in the governance of institutions of higher education, where participation ranges from service on committees such as curriculum policy and faculty hiring to membership on boards of trustees. However, while engagement in that important activity of scholarship—namely publishing—is encouraged in areas such as creative writing, it has been actively screened off from most

undergraduates in science, mathematics, engineering, and technology education. It is time to develop an adult model of science education that recognizes student creativity and productivity in hypothesis generation, experimentation, observation, analysis of results, publishing, and peer reviewing.

A second paradox of the antistudent research journal argument, especially by those who write about the importance of undergraduate research, is the willing abrogation of responsibility for mentoring students in a fuller spectrum of research that will strongly relate to their students' possibilities for professional success. However, the current landscape for participation in research is no longer limited to well-funded positions at elite institutions. For example, anyone with an Internet connection now has access to the rich data and powerful tools used in the analysis of molecular sequences and structures. The resulting challenge to educators is deciding how to engage students in biological problem solving and original research that makes use of these new resources in meaningful ways. Much of this research will be done at the teaching institutions where few of the mentors are regularly publishing their own work.

Thus, there are two problems faced by those of us who promote undergraduate research publication. First, many mentors of undergraduates involved in research may be reticent in promoting their students' efforts because they are intimidated or embarrassed by their own modest publication records. Second, many undergraduates in science are not confident about their writing. Hence, the arguments against their active publishing serve as another inhibitory factor, even when their own mentor may be encouraging them to submit their work for peer review. By democratizing the participation of research, use of the web, and widespread availability of sophisticated scientific and computational research equipment through miniaturization and mass production, anyone, anytime, anywhere will be able to conduct sophisticated research in short periods that would have taken years and massive resources in the past. We need to invite undergraduates to do research with us as colleagues and full participants in the diversity of scientific knowledge production; this includes publication.

How inviting are we as a professional community? If a student looks at our culture, is this one they will want to join? If we ask them not to publish as undergraduates, are we not sending the message that they are not going to be able to be full participants in our culture for a long time? The research community needs to change its feudal, hierarchical model of postponed adolescence, where you must go through 4 years of undergraduate education, 7 years of graduate school, 3 years of post-doctoral study, and 6 years of assistant professional development before obtaining recognition as a full professional. Furthermore, if a student looks at the structure of our profession, then she will see that a small minority of scientists are authors of most of the scientific literature, while many faculty never publish anything beyond their Ph.D. dissertation work. How might active participation in publishing and peer reviewing at the first stage of their career begin to change our culture? Whose interests are being served by perpetuating the current model?

While many of us await the official publication of the much heralded research of Elaine Seymour (2003) on the value of undergraduate research as seen from the eyes of students who have participated, let us consider two other available sources. First, in interviews of students actually involved in producing, funding, and writing an undergraduate research journal, the following benefits and challenges were identified:

1. Learn better what your peers are doing
2. Community is a crucial hub of common synergism
3. Begin to really know what you are doing
4. Learn the differences between professional and amateur reviews
5. Appreciate double blind processes
6. Make deadlines, organize, collaborate, and be responsible
7. Have a press pass that gives you differential access to pioneers

These students (“all overcommitted overachievers”) have done research with Nobel Laureates (e.g., Carl Wieman, who received the 2001 Nobel Prize for his research in atomic and molecular physics and is a progressive leader in physics education); obtained Marshall and Rhodes Scholarships for study in the U.K.; worked with the Canadian Broadcasting Company; held internships in Cairo, Egypt; taught in courses, workshops, and camps; and enjoyed the professional opportunities of being recognized as serious scholars.

Second, Audrey F. Manley (1998), President of Spellman College, has listed seven “Life Skills” that are gained through undergraduate research:

1. Mentoring that comes close with faculty
2. Experience with team work
3. Increased understanding of methodology
4. Improved study skills
5. Improved skills in time management
6. Increased self-confidence
7. Improved communication skills

As part of their local commitment, Spellman initiated the *Spellman Science and Mathematics Journal* because they saw it as crucial to “not only make students better professionals, but also better citizens.” Could we ask for more?

We urge professional societies in the life sciences to strongly endorse undergraduate student research publication as a normative expectation of the undergraduate research experience.

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Weighing the Pros and Cons of Undergraduate-only Journal Publications

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RESEARCH manuscripts should be considered the final step of a research project and are often the only tangible products of that research. Manuscripts are written to report and to advance discovery, and one measure of the impact of a research project is the use that others make of that project in their own work.

Anyone who is considering a career in research should experience this final step, which includes writing, reviewing, and editing research manuscripts. Yet these important aspects of research are often omitted from the undergraduate research experience. The *Journal of Young Investigators* (JYI), as well as many other undergraduate-only research publications, aims “to introduce students to the exercise of communicating their research, reviewing and being reviewed by peers, and the other aspects of publishing and disseminating scientific information. When these JYI authors and editors become professionals, they will be informed and experienced in issues concerning scientific publishing and will be effective communicators and reviewers” (from the JYI Mission Statement [<http://www.jyi.org/aboutJYI/mission.html>]). This is certainly a laudable mission, and I have no doubt that working with JYI as an author or staff member is a remarkable learning experience for the student, offering an unusual opportunity for undergraduates to learn (with mentoring from their faculty advisors) how to assess a research manuscript and how to offer constructive advice to their peers. That said, I question the need to segregate undergraduate research into undergraduate-only journals. With 6,000 journals in science, technology, and medicine—and 24,000 peer reviewed journals overall—the advantage to the reader of a journal devoted to undergraduate research is not obvious.

Research submissions in JYI “are judged according to several criteria having to do with the quality and originality of the research and the manuscript’s presentation and communication style” (from JYI submissions FAQ [<http://www.jyi.org/submissions/faq.html>]). Thus, the standard for publication does not seem distinct from many other peer-reviewed journals. Indeed, in reading some of the articles published by JYI, I came to the conclusion that most if not all of these articles could have been published in more standard publications, and indeed many are superior to some of the articles I have read in journals I have assessed as part of my work as a member of the Literature Selection Committee of the National Library of Medicine, the group that recommends which journals are to be indexed by Medline. So I couldn’t help wondering what the inducement would be for these authors to publish in an undergraduate-only publication. Perhaps there is the sense that if the work is tagged “done by an undergraduate,” it would be looked at with a more generous eye than it might be otherwise. But perhaps the work will never be read, because readers might make the assumption that the work isn’t worth reading, as it would otherwise be found in one of the more traditional journals.

Many standard peer-reviewed journals appear in indices used by the relevant fields (e.g., PubMed for biomedical re-

search), making it easy for other researchers to find and use the research manuscript. JYI, on the other hand, is not indexed (by PubMed at least), greatly decreasing the possibility that other researchers working on similar problems will access and use the research published in JYI.

Reviewing papers for JYI limits the experience of undergraduates to work done by their peer group. This renders the experience somewhat artificial, as one important experience young investigators surely need is how to be critical of work done by their seniors.

Often, work done by undergraduates is a piece of a larger project done by another more senior person in the lab. As such, that work might be included in a more substantial paper that could be published in a journal with a higher perceived quality than JYI, but the undergraduate would be left as a middle author in a piece recognized to belong primarily to someone else. Which should the undergraduate do? Should she publish her own piece in JYI (or another journal) or take middle authorship in a more substantial piece? Might editors also look with a kind eye on undergraduate-only research and allow her to do both?

The answer to that final question is an unqualified “no.” Certainly researchers of all ages are placed in that predicament regularly, and must choose between a relatively minor contribution that is hers alone and a more major contribution that is shared with others. Once a researcher chooses that first option, be it in JYI or BBRC, she can’t then go and publish it as part of another work and pretend that the work has not been published before. If undergraduates choose to publish their work in an undergraduate-only journal, they need to treat that paper as a “real” publication. Thus, even though the result is not highly

accessible (although I am thrilled that access to JYI is free), publishing in JYI will limit the abilities to republish that work again as part of a larger story in a more standard journal. Publishing is publishing, and most journals set the standard that they will only consider work that has not previously been published. By all means, the larger work can and should cite the undergraduate’s JYI paper, but cannot republish the data in that paper as if it is original and offer authorship to the undergraduate of the larger piece.

One of the wonderful things about research is that it is remarkably nonagist. Great discoveries can be made by a researcher just starting her or his career, while others are made by those late in life. Can you imagine Francis Crick or Sydney Brenner publishing their work in the *Journal of Old Investigators*? Should those papers only be reviewed by other “old investigators?”

My advice to undergraduates is therefore this: make JYI a journal of issues relevant to undergraduate researchers. Fill it with essays about lab etiquette, the art of reviewing, how to choose a graduate school, news, and features. But publish articles that detail your undergraduate research in the standard literature—there are many homes available for you to do this, many of them indexed by Medline and available for the scientific community through PubMed. Your work will be cited by the larger papers published by other people in your lab, demonstrating that your work had an impact. And ask your mentor for experience reviewing research manuscripts, not just of other undergraduates but of all your colleagues.

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