# Presidential Faculty/Student Collaboration and Publication Grant

**Deadline February 24th**

Please use this checklist and budget. Include with your completed application. For more information about Presidential Faculty/Student Collaboration and Publication grants, please see https://gustavus.edu/kendallcenter/grant-opportunities/presidential-grant.php.

## Faculty Information

Name: Julie Bartley Email: jbartley@gustavus.edu

Dept: Geology Rank: Associate Professor

## Student Information

Name: Tara Selly Email: tselly@gustavus.edu

Major: Geology & Biology Year: 2013

## Checklist

**Project Details**

- **X** Brief description of the proposed project including its collaborative nature p. 2-3
- **X** Clear statement of anticipated outcomes p. 3
- **X** Likely placement for publication or performances p. 3
- **X** Anticipated research completion date p. 4

**Participant Details**

- **X** Names and brief biographies of all participants p. 5
- **X** Explanation of how this project fits into the career of the faculty p. 5
- **X** Explanation of how this project fits into the educational trajectory of the student p. 5-6
  (include year of graduation; student eligibility is limited to full-time returning students)

**X** **Presidential Budget Proposal Form** p. 7

**X** **If successful, my proposal can be used as an example to assist future applications. Check to give permission. This decision will not influence the application evaluation.**

## PROJECT DESCRIPTION

The early fossil record (3.5 to 0.5 billion years ago, Ga) is dominated by microscopic forms. Many of these are small (<10 microns, μm), unicellular fossils that most likely represent bacteria. Beginning about 1.9 Ga, though, a few more complex, larger forms appear in the fossil record. Cell sizes above 50 μm, complex cell arrangements, ornamentation, and, in some cases, macroscopic size indicate an evolutionary transition. The nature of this evolutionary transition, however, is poorly constrained. Most of these large-celled, unicellular organisms have been interpreted as active or resting stages of algae (Moczydłowska et al., 2011), but there are few specific characteristics tying these unicells to specific groups. By about 0.75 Ga, definite eukaryotes (organisms with cell nuclei) are preserved in the fossil record, but the specific affinity of these organisms is similarly in question. These fossils have been variously interpreted as algae (of various sorts), large bacteria, egg cases of animals, encystment structures, and fungi (Cohen et al., 2009). Resolving the interpretations of these early fossils is crucial to understanding the early evolutionary history of major lineages – bacteria, protists, fungi, animals, and plants – and, in particular, establishing the time that eukaryotes originated would lend insight into the evolutionary origins of multicellularity. Recent approaches to determining the affinity of these fossils include traditional morphological analysis (Moczdłowska et al., 2011; Butterfield, 2000, 2004; Porter, 2004), electron microscopy to evaluate cell wall structure (Javaux et al., 2004; Cohen et al., 2009), and microchemistry (Javaux et al., 2004). These approaches have helped to narrow the range of possibilities for some forms, particularly those appearing later in the fossil record (after 1 billion years ago), but the solution remains incomplete.

In this project, we take a different approach to this question. We will examine the fossilization trajectory (termed *taphonomy*) of modern (living) organisms to determine whether particular groups (e.g., red algae, green algae, fungi) exhibit characteristic changes during the first stages of alteration after death. The way an organism decays can itself be a source of information (Grey and Willman 2009; Manning and Bartley, 2007; Knoll et al., 2006; Bartley 1996). For example, eukaryotes with complex, durable cell wall structures are predicted to be more likely to have their cell walls preserved intact during fossilization (Knoll et al., 2006), compared to bacteria with simpler cell wall structure (Bartley, 1996). Predictions such as these have never been experimentally tested, though there is circumstantial evidence from the fossil record that suggests that different types of organisms undergo different decay pathways, even under the same environmental conditions (Grey and Willman, 2009).

Previous work by Bartley and two undergraduate students (Phillip Cole and Ashley Manning) at the University of West Georgia suggests that decomposition trajectories can be observed and quantified by both light (Manning) and electron (Cole, Manning) microscopy, and that different types of algae exhibit markedly different changes during decomposition. These early results, while promising, were pilot studies and lacked sufficient data to draw solid conclusions. Tara Selly, a geology and biology student, has precisely the skill set and interest to both strengthen the earlier work and to examine a sufficient number and diversity of samples to constitute a meaningful and publishable dataset. The experimental design is relatively straightforward: cultures of several candidate groups (red, green, and yellow-brown algae, cyanobacteria, and groups to be determined in the course of the project), will be exposed to biological (bacterial) decomposition and the resultant changes quantified and described. The decomposition trajectories will be compared with each other and with photographs of fossils to determine (1) whether particular groups exhibit specific decay trajectories and (2) whether any of

these trajectories are identifiable in fossil specimens. We have access to a limited number of microfossil samples, which might also be used in comparison, and Susannah Porter (UCSB) has agreed to make her more extensive collection of microfossils available for study.

The work of this project will form the dataset for Tara Selly's senior thesis (required of all geology majors). Tara will thus assume a principal role in *both* data collection and communication of results – an opportunity often elusive for undergraduate researchers, as they typically graduate before the project is complete. The work proposed here is an excellent opportunity for collaboration. Julie Bartley (Bartley, 1996) developed a methodology for quantifying the nature and degree of alteration in a microfossil and has successfully applied it to both modern and fossil (Bartley et al., 2000) microbes. Part of the summer will be spent training Tara to apply this method; in addition, however, Tara will develop new metrics applicable to the particular organisms under study. Both Julie and Tara will make observations – previous experience has shown that replicate measurements are necessary to ensure consistent reporting of observations. Because this will form Tara's thesis project, we expect that by the end of the summer, Tara will have assumed a principal role in determining the scientific direction of the work, and the conclusions drawn from the results will be driven by her interpretations of the data.

**ANTICIPATED OUTCOMES & PUBLICATION PLANS**

*DIRECT OUTCOMES —*

(1) We will amass a substantial dataset on the decomposition trajectories of at least five types of organism.
(2) Tara Selly will use the data collected to write her senior thesis, to be completed during spring semester 2013.
(3) Some or all of the thesis will be published in a journal such as PALAIOS (an internationally-distributed journal published by the Society of Sedimentary Geology)
(4) Tara Selly and/or Julie Bartley will present the results of this research at an appropriate off-campus conference (North-Central section meeting of the Geological Society of America is the most likely venue); Tara will present at on-campus conferences (Fall Research Symposium; Sigma Xi Undergraduate Research Conference; Celebration of Creative Inquiry).

*INDIRECT OUTCOMES —*

(1) Future research trajectories will emerge that focus on particular aspects of modern-fossil microfossil comparison. While it is impossible at this stage to predict what those points of comparison will be, it's impossible to imagine that we will fully answer this question in a single year!
(2) Julie Bartley will, during her sabbatical (2013-2014), build from this project to begin a new dimension of her collaboration with Susannah Porter (UCSB) that will investigate taphonomic patterns in fossil material, with the aim of generating additional experiments that can be conducted at Gustavus.
(3) Tara Selly will gain invaluable research experience that will position her for applications to graduate school next year and/or make her an extremely attractive candidate for professional positions in geology or biology-related fields.

**TIMELINE FOR RESEARCH**

March-April 2012: Using resources available in the department, we will purchase (or request from colleagues) cultures of at least three organisms, so that decomposition can begin prior to the start of summer. We have sufficient laboratory supplies in stock to begin the project.

April-May 2012: Tara Selly will conduct a literature review as part of her junior research seminar and write a prospectus of research (part of the thesis process in geology).

June-August 2012: Tara Selly and Julie Bartley will begin measurements and observations of "phase 1" organisms (decomposition began March). A second set of organisms (phase 2) will be purchased and placed in decomposition conditions. These will be evaluated after a suitable decomposition period. All of the project expenses will be incurred during the summer.

Fall 2012: Tara Selly, with advice from Julie Bartley, will complete data analysis and remaining observations. Tara will present at the Fall Research Symposium. All data collection will be complete by the end of fall semester.

Spring 2013: Tara Selly, with advice from Julie Bartley, will write a senior thesis and manuscript for publication in a journal such as PALAIOS. We expect that Tara will serve as senior author, with Julie Bartley as co-author. At the end of spring semester, we hope that the manuscript will be submitted. Tara will present at the Celebration of Creative Inquiry, Sigma Xi undergraduate research symposium, and North-Central Geological Society of America meeting. By the end of spring, all work on the project will be completed.

Post- May 2013: Revisions, if necessary, to the manuscript will be made by Julie Bartley, with participation from Tara Selly, if she is in a position to work on these revisions after graduation.

**BUDGET DETAIL**

| | |
|---|---|
| *Equipment* | |
| No new equipment will be required for this project | $0 |
| *Materials* | |
| Cultures of organisms, growth media, glassware, microscope slides, etc. | $600 |
| Funds to pay for time on the electron microscope at Macalester College | $200 |
| *We have a good relationship with this facility and they are willing to help us gather the necessary data within limited budget constraints. Electron microscopy serves as an important secondary tool to supplement light microscopy.* | |
| *Travel* | |
| Mileage for two trips to Macalester College | $154 |
| Lunch during each trip | $30 |
| *Stipends* | |
| 10 week stipend for faculty member, Julie Bartley | $3000 |
| 10 week stipend for student, Tara Selly | $4000 |
| Tara is not requesting housing, as she lives off-campus | $0 |
| ***Total*** | ***$7,984*** |

## BIOGRAPHIES

**Julie Bartley** is an associate professor and chair of geology. She earned her A.B. degree in chemistry at Bryn Mawr College and M.S. (chemistry) and Ph.D. (geology) degrees from UCLA. After postdoctoral fellowships at NASA-Ames Research Center (with Lynn Rothschild) and Harvard University (with Andrew Knoll), she joined the geosciences faculty at the University of West Georgia, where she worked for 12 years. While at West Georgia, Julie served as the director of the West Georgia Microscopy Center (2003-2009), director of First Year Programs (2006-2009), and director of the Center for Teaching and Learning (1999-2001). She has supervised more than 35 undergraduate research projects at West Georgia and Gustavus, has published 19 peer-reviewed journal articles (4 with undergraduate students) and has had nearly all her undergraduate collaborators present the results of their work at regional or national conferences.

**Tara Selly ('13)** is currently a junior attending Gustavus Adolphus College. She is studying to major in both biology and geology. She is particularly interested in paleontological studies and examining how organisms interacted with environments in the past. After graduation, Tara intends to continue her education by attending graduate school at the University of Minnesota. This summer, she completed research for the Gustavus geology department. Tara worked with two other students to create a display for both Gustavus and the Nicollet County Historical Society that describes Nicollet County's geologic history; this project was one of the campus projects that commemorate the school's Sesquicentennial Anniversary.

## EXPLANATION OF HOW THIS PROJECT FITS INTO THE CAREER OF THE FACULTY MEMBER

I hope that this project will support three key, near-term career goals. First, although I have been involved with many collaborative projects with students, I am just getting settled with a student-faculty research program here at Gustavus. This year is the first year that I will have graduates whose work I have supervised (Sam Hines, Joe Curran-Jung). I expect to have three or more students from our graduating class of '13. The proposed work with Tara is the most complex of the three and has the best chance of producing high-impact, publishable results. I hope that this project will inspire additional student interest in the early fossil record, and motivate students in the classes of '14 and '15 to an interest in early life-environment interactions. Second, I plan a sabbatical leave for 2013-14 and plan to continue work on determining the nature of these enigmatic early fossils. My colleague Susannah Porter (UCSB) and I plan to examine a variety of fossil and modern organisms during this year, building on results that this project with Tara will generate. Susannah is very excited about the possibility of adding an additional dimension of data to our arsenal of tools for interpreting these early fossils. Third, Susannah and I hope to submit a proposal to the March 2013 NASA Astrobiology/Exobiology program that will take a multidisciplinary approach to studying the fossil record of early eukaryotes. These data on the taphonomic behavior of modern microbes, combined with work that Susannah's group is currently doing on fossils, will be key to demonstrating the feasibility of our approach.

## EXPLANATION OF HOW THIS PROJECT FITS INTO THE STUDENT'S EDUCATIONAL TRAJECTORY

This project would be a wonderful opportunity for me, and it is well suited for my academic career. In the geology department, all majors must complete research and write a thesis. I will be able to use the data from my research on this project to complete this requirement, allowing

me to graduate in 2013. While this research is primarily in geology, I would be able to bring a different perspective with my interest in and knowledge of biological processes, and my great passion for paleontological studies. I will have a great deal of independence in this project and it will prepare me for work in graduate school, where I will definitely need to apply the research skills I will learn in this project. If this project is funded, I will be able to work on the project for the entire summer, which will allow me to gather data on more kinds of organisms, over a longer time interval than I would if I had to work only in the fall semester. If the project is successful, I will be able to participate in writing a paper for publication.

**REFERENCES CITED**


Bartley, J.K., 1996, Actualistic taphonomy of Cyanobacteria: Implications for the Precambrian fossil record: PALAIOS v. 11, p. 571-586.

Butterfield, N.J., 2000, *Bangiomorpha pubescens* n. gen., n. sp.: implications for the evolution of sex, multicellularity and the Mesoproterozoic/Neoproterozoic radiation of eukaryotes: *Paleobiology* v. 26, p. 386-404.

Cohen, P.A., Knoll, A.H., and Kodner, R.B., 2009, Large spinose microfossils in Ediacaran rocks as resting stages of early animals: *PNAS* v. 106, p. 6519-6524.

Grey, K., and Willman, S., 2009, Taphonomy of Ediacaran acritarchs from Australia: Significance for taxonomy and biostratigraphy: PALAIOS v. 24, p. 176-193.

Knoll, A.H., Javaux, E.J., Hewitt, D., and Cohen, P., 2006, Eukaryotic organisms in Proterozoic oceans: *Phil. Trans. R. Soc. B* v. 361, p. 1023-1038.

Manning, A.R., and Bartley, J.K., 2007, Investigating the taphonomy of microbes by light and electron microscopy: *Geological Society of America Abstracts with Programs* v. 39(6), p. 325.

Moczydłowska, M., Landing, E., Zang, W., and Palacios, T., 2011, Proterozoic phytoplankton and timing of chlorophyte algae origins: *Palaeontology* p.1-30.

Porter, S., 2004, The fossil record of early eukaryotic diversification: *Paleontological Society Paper* v. 10, p. 35-50.

# Presidential Faculty/Student Collaboration Grant
# BUDGET INFORMATION

**Faculty Stipend** ($300 per week, up to $3,000 for a maximum of 10 weeks)

**Student Summer Stipend** ($400 per week, up to $4,000 for a maximum of 10 weeks)

**Student Summer Campus Housing** ($60 per week, for a maximum of 10 weeks)

**Total Budget Maximum** ($8,100 for all categories)

| **ITEM** | | **AMOUNT** |
|---|---|---|
| **Equipment (e.g., transcription machine, camera, cassette recorder – but not to include computer hardware)** | | **$ 0** |
| 1: | Cost: | |
| 2: | Cost: | |
| 3: | Cost: | |
| **Materials (e.g., books, printing, software, lab supplies)** | | **$ 800** |
| 1: media, lab supplies, cultures | Cost: 600 | |
| 2: electron microscope time | Cost: 200 | |
| 3: | Cost: | |
| **Travel Costs (cannot include conference travel, see http://gustavus.edu/finance/travel.php for allowable travel expenses)** | | **$ 184** |
| Airfare: | | |
| Mileage: Number of miles 280 @ $0.55/mile $154 (two trips to St. Paul) | | |
| Lodging: | | |
| Meals: 2 lunches while traveling $30 | | |
| **Stipends & Housing** | | **$ 7,000** |
| Faculty Stipend $3000 | $300 per week, up to $3,000 for a maximum of 10 weeks | |
| Student Summer Stipend $4000 | $400 per week, up to $4,000 for a maximum of 10 weeks | |
| Student Summer Campus Housing | $60 per week, up to 10 weeks | |
| **TOTAL EXPENSES** | | **$ 7,984** |
| | | |
| **AMOUNT REQUESTED** | | **$ 7,984** |

*Tara will be living off campus this summer and is not requesting summer housing support

**Have you applied for, or received funding from, another source to help support this project? No**

**Funding Source:**

**Amount:**

**Please explain how the Presidential will be used in addition to the other funding.**