Research Statements in STEM

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Workshop Objectives

- Understand the function and form of research statements
- Critique examples
- Consider strategies for writing more effectively



What are Research Statements?

a.k.a: "research summary", "statement of research plan," "statement of research interests and plans," etc.

Part of application packet for academic positions

Communicate what you have done, how your research contributes to your field, and in what direction you think your work will progress

Research statements have a specific audience, function, and form



Audience

- Mainly members of a search committee + departmental faculty

Function

- Present your area of research
- Demonstrate the importance of your work
- *Convince* audience of your research ability
- Propose your future research plan

Text: Short (2-3 pages), formatted in a way that enhances readability; Can have a longer version with more specifics

Thinking like the Search Committee: What do they want to know?



- What are your research interests and academic specialities?
- What would you contribute as a faculty member and colleague?
- What is your potential to develop your own research program?
- How would you complement the mission of the department, school, and/or university?



Institutional Considerations







- Content and focus of your statement will differ depending on the institution
 - Research I university
 - Primarily Undergraduate Research Institutes
- Adjust scope of research endeavor, role of students, and importance of service to align with institution







Form of Research Statements



Form #1: Research statement as a description of your research and how it contributes to your field or discipline

Form #2: Research statement as a research proposal

Do you know what type of research statement is expected in your field? If in doubt, ask (your NextProf mentor, your PhD advisor, or the chair of the search committee)

Form #1: Situating your Research

- 1. Explain the relevance of your work (the "so what" question)
- 2. Identify the research problems or gaps in your field (i.e., situate your work how does it fit in?)
- 3. Give context for your work esp. previous research
- 4. Demonstrate your research accomplishments
- 5. Identify your future research directions (next 3-5 years)
- 6. Note how you might engage students in your work (as needed)
- 7. Use Figures and Sources (as needed)

How might you organize Form #1?



Consider a Chronological Order

- Executive Summary/Overview (first paragraph)
 - Address: why is research important, what is approach, what are long-term goals,
- Graduate Research (by project)
- Postdoctoral Research (by project)
- Future Research (by project)

Form #2: Research Statement as Proposal

- 1. Identify the gap or problem that your research will address
 - a. Gap: what remains unknown about your topic
 - b. Problem: issue for which you are developing a solution (more common in engineering, computer science)
- 2. Propose research questions, research aims, or problem statements
- 3. Explain how you will answer these questions



How might you organize Form #2?

Background and Significance of your Research What is known, what is not known

Project Plan

- Objectives/Questions/Hypotheses
- Aims/Questions/Hypotheses
- General Methods

Importance/Impact of Proposed Work

Connection with University/College

Beyond form, Research Statements require you to explain the Relevance of your Work



Give context for why your work is important

Identify problems in your field that your work will address (what motivates it?)

Present some of the key questions or objectives for your work

Demonstrate your research ability, by highlighting your skills as well as key contributions and collaborations

Examples - Research Statement

Dr. Hernán López-Fernández, Associate Professor, EEB - University of Michigan

I am interested in the evolutionary processes that originate "mega-diverse" biotic assemblages and in the role of ecology in shaping the evolution of diversity across large temporal and spatial scales. Different evolutionary processes combine to generate extraordinary but unevenly distributed diversity across the tree of life. Why are some groups of organisms highly diverse, while closely related groups are exceedingly species poor or functionally conserved? How does adaptation affect diversification in highly diverse clades? For instance, many believe that adaptive radiation –the rapid diversification of an ancestor into ecologically and functionally specialized lineages– may explain the origin of large swaths of biodiversity. However, most classic examples of adaptive radiation represent relatively recent diversification events in island-like environments such as the Hawaiian archipelago or the east African Great Lakes. Whether adaptive radiations may explain the origin of widely distributed, comparatively older clades at continental scales remains much less explored. Moreover, if adaptive radiation can explain macroevolutionary divergence at these large scales, how does it happen? How long does it take? How do groups that undergo adaptive radiation differ from those that do not? And ultimately, whatever their pattern of divergence, how do long-coexisting clades coevolve into the hyper diverse continental systems we see in regions like the Amazon or Central Africa?

My program addresses these and related questions by studying the evolution of Neotropical freshwater fishes, the most diverse freshwater fish fauna on earth, with an estimate exceeding 8,000 species in 43 endemic families or subfamilies. Despite representing approximately 10% of vertebrate diversity, our understanding of the evolutionary history of Neotropical freshwater fishes is remarkably limited. I argue that this fauna provides an exceptional system to address fundamental questions about evolutionary processes resulting in megadiverse assemblages at continental scales through deep evolutionary time.

Where does the researcher identify the role and importance of the work he plans to do?

How does he identify his research questions?

Dr. Hernán López-Fernández, Associate Professor, EEB - University of Michigan

Macroevolution of Neotropical cichlids - My lab uses phylogeny-based comparative methods to analyze the patterns and rates of evolution of lineages and phenotypes of cichlids and of Neotropical freshwater fishes. We perform comparative analyses on phenotypic traits including ecologically relevant morphometric characters (ecomorphology), biomechanical and functional morphological measures of performance (feeding and swimming), body size, habitat, diet data and life history traits to understand adaptive diversification along multiple dimensions of cichlid ecology. So far, our analyses have shown that at least two major Neotropical clades originated following patterns compatible with "ancient adaptive radiation" (López-Fernández et al. 2013, Evolution). Diversification in the South American tribe Geophagini resulted in highly disparate lineages spanning a vast portion of total cichlid morphological and functional diversity, while limiting diversification in other coexisting cichlid clades. Subsequent colonization of Central America by the tribe Heroini resulted in a second episode of adaptive divergence largely convergent with that of South American Geophagini (López-Fernández et al. 2013 Evolution, Arbour & López-Fernández 2016 Proc.Rov.Soc.B). Altogether, our work indicates that these radiations occurred along axes of feeding and swimming specialization (López-Fernández et al. 2013 Evolution, Arbour & López-Fernández 2013 Proc. Roy. Soc. B, 2014 J. Evol. Biol., Astudillo-Clavijo et al. 2015 BMC Evol.Biol.). We are also linking measures of ecological performance such as diet and habitat use with functional morphological attributes of cichlids at macroevolutionary scales (Arbour et al. Evolution In Revision, Astudillo-Clavijo et al. In prep.). We have shown that, in Neotropical cichlid radiations, ecological opportunity was associated with accelerated rates of phenotypic divergence (Arbour & López-Fernández 2016 Proc.Roy.Soc.B). In the two subclades of Geophagini, divergence was dominated by substrate sifting (López-Fernández et al. 2014 PLoS ONE) and by innovations for fast jaw movement and predation (Arbour & López-Fernández 2013 Proc. Roy. Soc. B, 2014 J. Evol. Biol.). Other dimensions of adaptive divergence we are analyzing include body size variation (Steele & López-Fernández 2014 PLoS ONE) and structural changes in vision proteins (Schott et al. 2014 Mol.Biol.Evol.; Hauser et al. In prep.). Extensive convergence among clades of Neotropical cichlids occurred along distinct functional axes (e.g. feeding biomechanics, swimming morphology) and resulted in various convergent adaptive optima or peaks (Arbour & López-Fernández 2014; Astudillo-Clavijo et al. 2015). We are currently exploring whether patterns of convergent evolution observed in one dimension (e.g. diet) are correlated with adaptive peaks in other functional dimensions (e.g. swimming). Ultimately, I would like to address the adaptive diversification of cichlids from a perspective of multidimensional adaptive landscapes in which optima for each axis are represented simultaneously. Such an approach would allow integrating major functional axes of divergence into a holistic picture of ecological specialization and trade-offs during adaptive radiations.

What does the applicant establish in this section?

How is this accomplished?

What do you find convincing?

Research Statement

The metabolic consumption and byproducts of microscopic and macroscopic organisms has continually changed the chemistry of our planet, which in turn has both stimulated and limited the adaptive landscape that life can explore. This intimate relationship between geology, chemistry, and biology also forms a powerful tool that we can harness to understand the history of life and environments on Earth—as life impacts the geochemistry around it, organisms are leaving enigmatic clues of their presence and activity. Therefore, my research is driven by one of the fundamental questions in Geobiology: <u>how can we identify and interpret the record of life and its impact on the environment, preserved in sediments and rocks?</u>

I argue that a multi-faceted approach is required to understand the complexities of the interface between geology and biology. A critical problem in studying ancient sediments, especially preserved in deep-time Archean and Proterozoic basins, is distinguishing between primary signals and secondary overprints acquired from late-stage diagenesis, hydrothermal fluids and metamorphism. I use microscale and nanoscale techniques to extract original information from Precambrian rocks. Then to decipher the primary clues left by early life, it is necessary to study modern biogeochemical processes, especially the preservable mineral precipitates generated as a result of specific microbial activities. This is best accomplished by combining laboratory experiments to understand processes on a mechanistic level and modern field analogues to probe similar natural and complex environments.

I apply these integrated approaches using a variety of spectroscopic and microscale imaging tools including scanning electron microscopy and energy dispersive spectrometry, synchrotron X-ray spectroscopy and spectroscopic mapping, Raman spectroscopy, and X-ray diffraction. I intend to lead a question-motivated, collaborative lab that links modern microbe-mineral interactions to the ancient mineral record, focusing in particular on two key elements in geobiological cycles throughout Earth history: iron and manganese. Both of these elements are essential cofactors for crucial biological processes such as electron transport and photosynthesis, and redox transitions of iron and manganese lead to sequestration or release of toxins and trace metals. These redox reactions are often mediated by microbes, tying the Fe and Mn cycles to the carbon and oxygen cycles, and there is much to explore about how these elements cycle under different environmental conditions and how and when branches of these elemental cycles evolved. Not only will understanding the redox cycling of iron and manganese better constrain our current environmental system, but Fe and Mn also were also more prevalent in Earth's Precambrian oceans and likely critical electron donors and acceptors for early life.

Previous Research

Manganese: Minerals, Microbes, and the Evolution of Oxygenic Photosynthesis

My PhD thesis centered on the interactions between manganese minerals and unraveling ancient microbial activity. Deep-time manganese deposits can elucidate paleo-environmental aqueous chemistry and oxidizing potential. Manganese oxidation today only occurs using oxygen or related species like reactive oxygen species, except in cyanobacteria, algae, and plants, where Mn²⁺ is oxidized prior to water oxidation. This exception forms the basis of an evolutionary hypothesis that predicts Mn²⁺ was an electron donor for phototrophs before oxygenic photosynthesis. In the first portion of my thesis, I examined ancient manganese-enriched marine sediments from 2.42 billion years ago (Ga), just prior to the appearance of atmospheric oxygen (around 2.3 Ga). I used microscale spectroscopic measurements and imaging to show that the manganese was deposited as part of the original sediments – although it had been reduced during early diagenesis (Johnson et al, 2013). I also tested proxies for oxygen [multiple sulfur isotope fractionation and redox-sensitive detrital pyrite and uraninite grains] and confirmed that no significant environmental oxygen was present (Johnson et al, 2013; Johnson et al, 2014). Therefore, the manganese deposition at 2.42 Ga is evidence for the hypothesized transitional photosystem between early anaerobic phototrophs and oxygen-producing cyanobacteria.

Dr. Jena Johnson, Assistant Professor EES - University of Michigan

Read first two pages

Where does the researcher identify the role and importance of the work she plans to do?

How does she identify her research questions?

What details does she include to convince you of her ability to do this work?

What is one thing that might improve this part of the research statement?



Dr. Jena Johnson

jena.johnson@colorado.edu

Research Statement

The metabolic consumption and byproducts of microscopic and macroscopic organisms has continually changed the chemistry of our planet, which in turn has both stimulated and limited the adaptive landscape that life can explore. This intimate relationship between geology, chemistry, and biology also forms a powerful tool that we can harness to understand the history of life and environments on Earth—as life impacts the geochemistry around it, organisms are leaving enigmatic clues of their presence and activity. Therefore, my research is driven by one of the fundamental questions in Geobiology: <u>how can we identify</u> and interpret the record of life and its impact on the environment, preserved in sediments and rocks?

I argue that a multi-faceted approach is required to understand the complexities of the interface between geology and biology. A critical problem in studying ancient sediments, especially preserved in deep-time Archean and Proterozoic basins, is <u>distinguishing between primary signals and secondary overprints</u> acquired from late-stage diagenesis, hydrothermal fluids and metamorphism. I use microscale and nanoscale techniques to extract original information from Precambrian rocks. Then to decipher the primary clues left by early life, it is necessary to study modern biogeochemical processes, especially the preservable mineral precipitates generated as a result of specific microbial activities. This is best accomplished by combining laboratory experiments to understand processes on a mechanistic level and modern field analogues to probe similar natural and complex environments.

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Dr. Jena Johnson, Assistant Professor EES - University of Michigan



Paragraph 1: Identifies big issue in the field, presents question (@ power position)

Paragraph 2: Presents details for how she will tackle the big issues identified in paragraph 1

Paragraph 3: Demonstrates analytical tools she has to generate data to answer problems

Paragraph 4: Reviews previous research, PhD

Notes: use of first person ("I argue", "I apply", "I intend"); analytical techniques; MI specific section

Form #2: Research Statement as Research Proposal

Bilbo Baggins 9/2015

Research Statement: Immune-mediated regulation of disease B.

Disease CD (DCD) is a lethal childhood disease, which is caused by mutations of the legolas gene¹. Legolas deficiency renders the cell type a membrane susceptible to contraction-induced injury², leads to loss of ambulation by adolescence and death by the 2nd-3rd decade of life. Currently, no cure exists for DCD and therapies are limited to corticosteroids that broadly suppress the immune response to injured tissue type a, implicating chronic inflammation as an important determinant of disease severity. Perturbations of the immune system in abc mice, a mouse model of DCD, have shown that the immune system contributes to the pathogenesis of DCD by exacerbating tissue type adamage³. However, the inflammatory response to injury is also critical in mediating tissue type a regeneration⁴. This dichotomous role for the immune system can be partly explained by distinct subsets of immune cells that either exacerbate tissue injury or promote repair. For instance, Cell type b (CTB) that are induced by pro-inflammatory cytokines such as Cytokine 1 and Cytokine 2 promote cell type e injury⁵. In contrast, other type cytokines such CYTOKINE 3, CYT 4 and CYT 5 induce Cell type c (CTC), which antagonize the action of Cell type b via an arginase-dependent mechanism⁵. Recent studies indicate that Cell type F and Cell type G (CTG) both have the capacity to modulate the activation status of Cell type d^{6, 7}. Moreover, we found that modulation of these lymphoid populations in abc mice regulates the severity of disease B. However, whether these populations directly regulate tissue type a injury and repair, or indirectly through the modulation of tissue type a cell type d activation during disease d remains to be addressed.

Research strategy: During the first 3-5 years of operation, my lab we will focus on investigating the functional role of Cell type F and Cell type G during disease d using a combined expertise in immunology and tissue type a physiology. We will use mouse genetics, histological assays, cellular and molecular techniques, gene expression profiling methods, single cell analysis using various flow cytometry platforms, and tissue type a performance tests to study Cell type F and Cell type G in tissue type a disease. We will modulate Cell type F and CTG numbers or functionality at various stages of disease using mouse genetics and pharmacological approaches to test the hypothesis that Cell type F and CTG function cooperatively to suppress the pro-inflammatory response to injured tissue type a, decrease cell type e injury and promote tissue type a biopsies using histological and biochemical assays to examine the activation and functional state of tissue type a Cell type F and Cell type G in DCD and healthy patients. In later years my lab will begin to address whether the preliminary observations regarding Cell type F and CTG function in DCD are specific to this disease or are a generalized inflammatory response to injured tissue type a diseases. This would allow us to assess whether the therapeutic implications of our work are applicable to a broader class of tissue type a disease. We will define the direct and indirect mechanisms by which Cell type F and Cell type G regulate tissue type a injury and repair during tissue type a diseases by addressing the following specific aims:

Example: Modified Research Statement <u>BioMedical UCSF</u>

What are the different sections of this statement?

Where is the research gap identified?

What questions does the researcher seek to answer?

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Figure 1 here

Aim 1. To test the hypothesis that Cell type F-derived CYT 5 suppresses tissue type a inflammation.

Why might you use Figures or Graphs?





Figure 5. Step-wise spliceosome assembly. Adapted from Reference 18.



Figure 7. (A) Schematic of 3-color FRel Instrument. A heating laser is used to initiate a Tjump inside a single, adhered cell on a microscope stage. The 3-color FRET labeled protein's donor is excited inside the cell with a white LED and a camera is used to simultaneously detect changes in donor, D, and acceptor, A, fluorescence averaged over the entire cell as they respond to temperature perturbation. (B) Thermodynamics and kinetics extracted from temperature induced dissociation of U170K-SL1



First paragraph - hardest + most important

"Power positions" - beginning of piece and end of piece; start of sentence

If having a hard time starting, then move to other sections of your piece

Revisit your introduction again and again and determine if or how it frames your research statement and research approach





Creating Strong Sentences

- Sentence length: shorter ones are often easier to read
- Pay attention to the subject of a sentence: these establish what the sentence (+ even paragraph) is about
- Subject-verb separation: avoid too much distance between the subject and the verb of the main clause
- Connections look for ways to connect sentences, i.e., how are they related, how do they build on each other?

I am interested in the evolutionary processes that originate "mega-diverse" biotic assemblages and in the role of ecology in shaping the evolution of diversity across large temporal and spatial scales. Different evolutionary processes combine to generate extraordinary but unevenly distributed diversity across the tree of life. Why are some groups of organisms highly diverse, while closely related groups are exceedingly species poor or functionally conserved? How does adaptation affect diversification in highly diverse clades? For instance, many believe that adaptive radiation -the rapid diversification of an ancestor into ecologically and functionally specialized lineages- may explain the origin of large swaths of biodiversity. However, most classic examples of adaptive radiation represent relatively recent diversification events in island-like environments such as the Hawaiian archipelago or the east African Great Lakes. Whether adaptive radiations may explain the origin of widely distributed, comparatively older clades at continental scales remains much less explored. Moreover, if adaptive radiation can explain macroevolutionary divergence at these large scales, how does it happen? How long does it take? How do groups that undergo adaptive radiation differ from those that do not? And ultimately, whatever their pattern of divergence, how do long-coexisting clades coevolve into the hyper diverse continental systems we see in regions like the Amazon or Central Africa?

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Writing clearly and concisely

Don't say in 3,000 words what could have been said in

Robin Henry

- Too many words distract from those that really matter
- Eliminate filler words (actually, quite, essentially, much, very, several, really, etc.)
 - Use active verbs
- Pay attention to word choice, use a thesaurus
- Remove unnecessary words and phrases (there are many papers stating.... It was observed that.... It has been found that....)



Getting Feedback about your Statement

You will need *at least* one outside perspective about your statement (you are too close to it!)

Use NextProf Mentors to get advice about content and how well material "engages" them

Ask adviser (or someone equivalent) for feedback on content such as presentation of research problems, driving questions, contribution, etc.

Ask peers for feedback on readability, prose, etc.





Proofread carefully



Print out a hard copy (essential)

Read each sentence out loud

Check for typos, grammatical errors, long sentences

Have a peer or colleague also read the final draft

Punctuation Saves Lives - Poster by tetitator

Zazzle



Pulling it all together: Final Checklist

Content

- Is the research described important? Is it new? Will it produce important contributions to its field?
- Is the research program "just right" in scope? Not too narrow? Not too broad?
- Are there enough details about the research plan to be convincing?
- Is there a balance of individual work plus potential for collaboration?

Form

- 2-3 pages in length, a useful figure as needed, references as needed
- Clear and logical in layout, includes sections focused on themes
- Is there flow within and between paragraphs? Are sentences easy to read?
- Did you get feedback on the content and form?

Helpful Resources

University of Pennsylvania Career Services

Carleton College Career Preparation

University of Washington Academic Careers Research Statements

UCSF Office of Career Development



Gopen, G.D., and J.A. Swan. 1990. The Science of Scientific Writing. *American Scientist*. <u>http://stat.wharton.upenn.edu/~buja/sci.pdf</u>

Hofmann, A.H. 2014. Scientific Writing and Communication. 2nd Edition. Oxford University Press.

Schimel, J. 2012. Writing Science: How to write papers that get cited and proposals that get funded. Oxford University Press.

Vick, J.M., J.A. Furlong, and R. Lurie. 2016. The academic job search handbook. University of Pennsylvania Press.