the thesis

quintessentially Princeton
The faculty’s enthusiasm about their students’ work is precisely what makes Princeton so special…. This level of dedication and exuberance—from both faculty and students— is what makes the thesis experience … so incomparable, so priceless, and so quintessentially Princeton.
More than any other academic experience, the senior thesis embodies the defining characteristics of undergraduate education at Princeton. The thesis gives the student the opportunity to pursue original research and scholarship on a topic of the student’s own devising, with the guidance and supervision of a faculty adviser. What is most important, thesis-writers and faculty members agree, is less the subject matter itself than the contribution of the thesis in developing traits that augur well for future success, no matter what one’s professional and civic commitments. These include mental discipline; independence of mind and judgment; the capacity to focus and pursue a subject in depth; the ability to design and execute a complex project; the skills of analysis, synthesis, and clear writing; and the self-confidence that grows from mastering a difficult challenge. At its best, the thesis enables students to make their own contribution to knowledge in their respective disciplines.

Requiring a thesis of its undergraduates sets Princeton apart from other colleges and universities where the thesis stands as an option that can be elected by seniors, often in the context of an honors program. Generations of Princeton undergraduates have approached the thesis with a mixture of fear and anticipation. Over the years most seniors have taken great pride in their work, sometimes surprising themselves and their professors at what they have been able to accomplish. While some students may take an indifferent attitude toward the project, the more remarkable fact has been the number of students who have caught fire intellectually in the senior year and produced first-rate theses.

I invited some seniors in the Classes of 2002 and 2003 to tell us about their experiences as thesis writers, and I asked their faculty advisers to reflect on their experiences advising those students as well as on the pleasures and challenges of thesis advising more generally. I posed some questions, but I left each of the writers free to decide how to respond.

As you read you will notice some recurring themes, both about the process of thesis writing and about what makes for a successful thesis. Here are some observations that seem to me to be especially well taken:

• Select your thesis topic as early as possible.
• Select a topic you are passionate about.
• Select an adviser who is interested in what you want to write about.
• Begin to write early on even if it is difficult (or even if what you write ultimately proves unusable).
• Good ideas actually come to you in the process of writing.
• Be flexible: don’t be afraid to change direction (or to take a tack different from the one you originally intended) if a better idea (approach) occurs to you as you proceed with your work.
• Keep an open mind to new ideas, to new data, to the relevancy of information you hadn’t thought relevant before.
• Test your ideas in regular conversation with your adviser, with other faculty members, with your friends.
• Leave time to rewrite and revise.
• Set a schedule and keep to it, even if some days are less productive than others.
• Don’t forget to have fun.

You will notice, too, that the seed for a student’s thesis often appears to have been planted in one or more courses taken in the first three years at Princeton. It is a good idea to keep an eye out for possible senior thesis topics as early as the freshman year and certainly during the sophomore and junior years. Junior papers often yield promising leads as well.

Other points worth noting include the following:
• A number of students make use of University funds to do research abroad.
• A number of students use summer internships to launch their theses.
• Some students begin their science research in the summer at Princeton.

You will be struck, too, by the number of times faculty advisers make a key point: at their best, students’ theses turn out to be learning experiences for the faculty, on occasion leading the adviser to say, “Why didn’t I think of that?”

I confess to having chosen strong students who wrote successful theses and who were pleased with what they were able to accomplish. But you should observe that, even in the case of the best students, thesis writing is never linear; there are plenty of challenges, detours, and false starts, and there is often more that could have been accomplished if time had permitted.

The individuals writing here are meant to be illustrative rather than representative. Many fields of study are not included, a function not of my judgment that some departments are more important than others, but rather of which students had the time to respond to my request amidst the competing claims of new jobs, new marriages, and graduate study. For all of the obvious omissions, I am confident that these accounts provide a real and immediate sense of the most distinctive aspect of undergraduate education at Princeton, a tradition of serious engagement in scholarship of which generations of students and faculty are justly proud.

Nancy Weiss Malkiel
Dean of the College
The senior thesis provided me the unique opportunity, and challenge, to become an actual practitioner in my field. The transition from studying physics to being a physicist can be a rather painful process. In physics, and other technical subjects, simultaneously gaining the necessary depth and breadth to do independent research is a difficult task. Fortunately I feel the thesis is well worth the effort and looking back, with several months safely separating me from the experience, I consider it to be one of the defining moments of my Princeton education.

In the spring of my junior year I began to consider possible thesis topics and advisers. That spring I had taken a graduate course in quantum field theory, the formalism that describes how the fundamental particles in the universe, such as quarks and electrons, behave. I had hoped to work with one of the particle theorists in the physics department. Much to my dismay I was repeatedly told that my background was inadequate. However I was urged to speak with Professor Paul Steinhardt, one of the inventors of inflation. The theory of inflation resulted from an application of particle physics to the early universe, which solved many of the unresolved problems of the Big Bang theory. I decided that working with Professor Steinhardt would be a good way to apply what I learned in quantum field theory that spring.

At the start of my thesis work Professor Steinhardt tried to methodically guide me through the basics. As I had so much ground to cover and my time was being split among coursework, graduate school applications, GRE preparation, and the varsity cross-country team, I was largely unsuccessful. Therefore I decided at some point in November to simply immerse myself and try to learn whatever was needed along the way. This approach paid off in the end. Around intersession a few missing pieces fell into place and I started to understand the fundamentals of cosmology. I then steadily worked towards making the relevant calculations and learning necessary techniques as needed. In the end I was able to achieve the goals that were established for me in September.

My thesis focused on the ability of gravitational lensing to constrain properties of the universe. Gravitational lensing, simply stated, is the bending of light by the gravitational effects of matter. The study of this phenomenon predated Einstein’s
theory of general relativity and, for the simplest of situations, the solution in the Newtonian case differed from the general relativistic case by a measly factor of two. During a solar eclipse in 1917 the verification of this factor of two was considered a tremendous triumph for Einstein’s theory. In the following years theorists predicted a variety of gravitational lensing effects, including viewing multiple images of astrophysical objects, such as quasars or supernovae, and viewing slight distortions in shapes of galaxies due to the intervening matter lying along the lines of sight to the galaxies. Unfortunately no observations of these predictions were made for nearly 60 years and gravitational lensing was almost forgotten. Finally in 1979 a multiply lensed quasar was observed and over the next 20 years a surge of theoretical work and observational effort has made gravitational lensing a cornerstone of modern cosmology.

Since the 1990s two major problems in cosmology have become apparent. Both are related to the fact that cosmologists observe vastly different amounts of matter in the universe depending on how the measurements are done. An upper limit on ordinary baryonic matter can be placed at approximately 5 percent of the critical value needed to make space flat. Baryonic matter consists of ordinary protons and neutrons, the kind that makes up the wood in my chair or the skin on my hands. However, when the dynamical effect of the gravity produced by matter is measured, the value is near 30 percent. Researchers call this difference dark matter. It is important to realize that dark matter is not protons and neutrons we simply do not observe, but something fundamentally different in nature. In the mid-1990s Professor Lyman Page of Princeton led a group that observed the properties of the cosmic microwave background and concluded that the universe was very nearly flat. This implied that an additional 70 percent of the universe was missing and was fundamentally different from the already different dark matter. Most cosmologists failed to recognize the significance of this observation until 1998 when one of the greatest shocks in cosmology was announced—the universe’s expansion is accelerating. In our everyday experience with gravity we only observe its attractive effects. However, the observed repulsive effects can occur if the universe was dominated by an energy component with negative internal pressure. This is the mysterious 70 percent of the universe that Professor Page and his colleagues indirectly detected.

In the past four years several models of the true nature of dark energy and methods to observe its properties have been proposed. As several candidates for dark energy can be seen emerging from superstring theory, these observations of the largest scales of the universe (10^{26} m) will have tremendous implications for the smallest scales of the universe (10^{-33} m). My thesis focused on the ability of weak gravitational lensing to constrain the internal properties of dark energy. Similar research had been done in the past, but my work generalized the previous papers by considering time variation of the internal properties of dark energy. The analysis was directed towards a new telescope that was being built, principally designed to perform these surveys. The construction should be done within the next decade so I can envision a time when my thesis will be directly relevant to physics. This made the work special as it addressed a question that simultaneously had ramifications for fundamental physics and observational signatures.
Professor Steinhardt allowed me to pursue ideas on my own. This had both positive and negative effects; however, learning to direct one’s own research is the key ingredient in the transformation from student to practitioner. In any research topic that is near the forefront, the references are typically limited to journal articles written for other researchers who are already well versed in the fundamentals. This made it very difficult to find an appropriate entry point into the field. I finally found a Ph.D. thesis written by Jordi Miralda-Escude *91 and examined it for several weeks. After I understood the basic formalism of weak gravitational lensing, the literature became more accessible and I was able to progress in my own work. This process was part of the transformation that I mentioned earlier; however, completing a relevant course or using the spring JP as a stepping stone to the thesis might be a wiser choice. I recommend that future students who may find themselves in a similar position read review articles and old theses on the subject, as both generally do a fine job in summarizing the fundamentals. Another suggestion is to wait until the foundations are absorbed before jumping into the research literature.

When I walked into Professor Steinhardt’s office I had never taken a relevant class in cosmology or even read much about cosmology and astrophysics in the popular science literature. I strongly discourage anyone else from taking this approach. The senior thesis should be an actual research project and having to learn everything from the very basics does not leave much time to conduct actual research. Having said that, I now feel that being lost was a good experience because it gave me the confidence to work on problems where everyone is lost and these tend to be the most important problems in physics. Looking back, my senior thesis experience was a positive one. It has provided the starting point for much of my research in graduate school and altered the direction of my career. While there were certainly difficult times, the opportunity to become an expert in a particular area of physics was a defining moment in my time at Princeton.

Paul Steinhardt
Albert Einstein Professor in Science

The most important experience for the Princeton undergraduate in physics is involvement in original research. Solving problems in the classroom is important for reinforcing basic principles. However, the problems are carefully crafted so that they can be done using the limited set of techniques presented in lecture. In original research, you do not know if your problem can be solved or what additional knowledge is required or what techniques you may have to learn or invent. The difference is like the contrast between swimming in a narrow, shallow channel with a life-preserver versus being thrown into a dark, swirling ocean. The miracle of the senior thesis is that it takes students who are proficient at the first and shows them that they are capable of the second, all in one brief year.

Exactly how the miracle works is different for every student. In Daniel Babich’s case, I knew from the outset that I was working with a gifted and mature
In original research, you do not know if your problem can be solved or what additional knowledge is required or what techniques you may have to learn or invent.

student. At Princeton, we are blessed with outstandingly bright physics majors, among the very best in the world. Among this elite group, Dan had performed at the top of his class, including in his junior papers, and he seemed very capable of handling a difficult challenge. In his case, instead of leading him gently away from the narrow, shallow channel towards deeper waters, I essentially stripped off his preserver and thrust him headlong into the teeming ocean.

The problem I suggested was to explore a new way of identifying the nature of “dark energy.” Dark energy is a substance with the remarkable property that it is gravitationally self-repulsive, in contrast to matter of our everyday experience, which is gravitationally self-attractive. (Dark matter, which comprises most of the mass in galaxies, is also gravitationally attractive.) Recent cosmological observations suggest that 70 percent or more of the energy in the universe today is some form of dark energy. By pushing itself apart gravitationally, dark energy also speeds up the expansion of the universe, an effect that has been measured by observing the recession speeds of distant supernovae. Although there is so much of it and it has such an important effect on the future evolution of the universe, we know virtually nothing else about the properties of dark energy. Perhaps by measuring the bending of light by the gravitational fields of large clusters of galaxies at various distances, I suggested, we can determine how the repulsive pressure and energy of dark energy have been changing with time, a key to determining its physical origin.

To succeed, Dan had to learn all of the basic cosmological principles that underlie our current cosmological model and all about the various types of observations that can be used to constrain the properties of dark energy. I consciously gave Dan measured advice with the notion that he should have to learn as much as possible on his own, yet, at the same time, making sure he kept on track so that his substantive project could be completed. I knew from experience that the first term would be difficult as he had to figure out how best to learn what he needed to know. At this point, the student typically feels very lost and uncertain about the prospects. I also knew, though, that this is the most valuable period in a senior thesis (or research generally). The student learns that he can work his way out and, ultimately, succeed. Dan was a splendid example. I saw him get lost in the first semester and then, just as I had hoped, he began to gain his bearings and develop confidence as the second semester was underway. In Dan’s case, seeing him through this transition was really all that I had to do. Once he gained confidence, Dan proved to be so talented and independent that he completed his impressive project with relatively little guidance. The result was a beautifully written, thorough, and original contribution that characterizes our current knowledge and future prospects for discovering the nature of dark energy. The work is of publishable quality and of great interest to the cosmology community. More importantly, Dan has matured as a physicist through this experience by leaps and bounds. I am gratified to have played a small role, and I look forward to his future accomplishments.
Perhaps it should be said right off, before I attempt to offer any advice on the thesis-writing process, that until I had, snow-covered and lightly frosted, dripped my soggy way into the English department office on that blizzard-struck Tuesday in April with two plastic-wrapped copies of “Cast in Treen Mould: Arborification and Its Ramifications” tucked under my arm, I truly had no idea just how my thesis was finally going to turn out.

I’d like to say this up front, because there were few things I found more discouraging as I approached the thesis than the belief that everyone else around me had been, without exception, researching furiously, writing diligently, and envisioning clearly since the summer an exact, specific, and certain final product, and every page turned, every binder called, and every printer refilled along the way existed as a link in an inescapably causal chain. In retrospect, I can see how false this impression must have been: the thesis is the process which, incidentally, leads to a submitted product; it is not the submitted product one struggles to reach via a year-long process. Were I a motivational speaker, I would say

Potentially useful thesis tip #1: the thesis is a journey and not a destination

and then probably force all available listeners into an icebreaker activity involving clapping and running around. Since I am, however, not such a speaker, I will say instead that it is my sincere belief that the thesis is most rewarding not when it is turned in, but rather when one is in the throes of wrestling with the material, trying to fit a fascinated mind around the topic.

This brings me to

Potentially useful thesis tip #2a: choose a topic that will fascinate, energize, preoccupy, and absorb you utterly

My thesis attempted to make sense of the moments in literature when characters turn into trees, and then, as trees, speak. It was a topic that had been perched at the back of my mind for about two years—ever since having discovered “The Dream of the Rood” (a poem about a talking tree) in English 201. Talking trees had been popping up ever since then for me, in The Faerie Queene, the Aeneid, the Inferno, and until the thesis gave me the chance to look at them closely, these incidents always ended up on the periphery of my literary consciousness as a marginal phenomenon that was intriguing but unavailable for in-depth study.
The thesis provided an opportunity for me to explore the talking trees that kept appearing tangentially or as footnotes in previous and current coursework. It also provided a semi-legitimate pretext for making all kinds of truly terrible puns about trees in all varieties of social situations, which leads me to

**Potentially useful thesis tip #2b: choose a topic that will make you great fun at parties**

though this is almost certainly less important than #2A, and, it must be said, there is a limit to the number of times you can tell that joke about barking up the wrong tree, going out on a limb, or getting to the root of the problem before you stop getting a laugh, if you ever got one, which I’m not sure I ever did. So let’s return to #2A.

Once I began work on the thesis, I found that one strand of thought led to another, that one poem unlocked the next, that the linkages among my primary texts were as complicated and intricate as the root systems of a hundred-year-old oak. The topic that had waited for so long on the backburner was making up for lost time by infiltrating every other area of study—the trees were everywhere. Additionally, there was not a great deal of critical literature available on the motif of the arborified speaker, which lent a certain thrill to the research: I was striking out into fairly new territory, I was saying something almost new, I was making a contribution, however odd or off-beat, to the body of critical thought. Every day I saw more trees, saw something I had not seen before, read a text slightly differently. Every day I got closer to becoming a tree myself, of surrendering skin and teeth for bark and leaves. When I finally started dreaming about being turned into a tree, I realized I had been possessed by my thesis.

This was not at all a bad thing, as far as obsession goes: I stayed focused, I remained energized, I never once lost interest. And so I say there can be no overstating the importance of choosing a topic that will expand and envelop you over the course of this one year, once-in-a-lifetime opportunity to discover a new species, a new island, a new star.

It must be said, however, that I never would have had the confidence to pursue what at the time seemed to be a pretty half-baked idea had not my adviser reacted so positively to my suggestion in our first meeting. “Talking trees?” Professor Vance Smith said, “That sounds wonderfully interesting!”

**Potentially useful thesis tip #3: use your adviser like there’s no tomorrow**

Over the course of the year, each meeting with Professor Smith yielded a whole new direction for research and writing. Flexible, patient, and enthusiastic, my adviser was able to suggest books, angles, approaches, formats, authors, traditions, all while graciously pretending to be amused by my tree jokes.

In comparing notes with classmates, I have discovered two commonalities among most thesis advisers. First, they tend to be almost unbearably smart and are typically incredibly supportive. Second, advisees tend to hide from them, which is downright silly. Next to you, your adviser will know more about your thesis than any other individual, and is probably more willing than any other individual to help you make your thesis as earth-shatteringly fabulous as possible. So consult with your adviser often—my largest regret about the thesis
is that I did not tap the considerable resource I had in an adviser as often as I might have.

**Potentially useful thesis tip #4: use everyone around you like there’s no tomorrow**

Although there is no substitute for the insight and assistance an adviser can provide, there is no rule stating that inspiration and constructive input cannot be garnered from other sources as well.

In working with the figure of the talking tree, I found myself using a variety of texts: prose and poetry; epic and lyric; classical, medieval, Renaissance; Latin, Italian, English. So I began addressing specific queries to specific professors, both those whose tutelage I had enjoyed and those to whom I had been sent by a kind referral. Their specialized insight was nothing less than invaluable.

My classmates also made some significant contributions to the thesis. I tormented members of my second semester seminars and precepts endlessly with cries of “A-HA! There are trees in the garden of Eden! What do you think Milton means by THAT!?” To which they would indulgently reply with helpful suggestions and piercing insight, while subtly removing sharp objects from my immediate reach.

Additionally, the topic of the thesis comes up almost daily in conversations during one’s senior year, and on several occasions, the most casual discussion can yield some important results. For example, in late winter, I had been comparing notes on the thesis process with a classics major. I mentioned that Virgil’s *Aeneid* was playing a surprisingly large role in the thesis, and my friend asked me if I was using the passage that likens Aeneas to an oak. It was a passage in Book 4 of the *Aeneid* that I had thoroughly overlooked, being so focused on an earlier episode in Book 3. The Book 4 passage turned out to be the perfect complement for the Book 3 passage, and a new chapter of the thesis was born.

Speaking of chapters,

**Potentially useful thesis tip #5: let the thesis go where it needs to go and do what it needs to do**

As it turns out, my thesis didn’t end up having chapters. In the last couple of months before the due date, I realized there was just no way I could manipulate the strands of my argument and the content of the primary texts into any sort of linear chapter scheme and still say everything I had learned as effectively as possible. So I printed out my notes in long form, bought 10 packs of poster mounts, and started tacking pages to my dorm wall. Eventually, the thesis arranged itself into a paper tree on my wall—and I realized that the best and possibly only way I could do the topic justice was to let the thesis mirror a tree itself. So there were no chapters in the thesis: there were Roots, close readings of primary texts; a Trunk, the elucidation of the central claims of the thesis; and Branches, synthetic, thematic analyses across texts.

This arboreal anecdote appears by way of saying that sometimes what is discovered in the process of researching a thesis will demand a formal treatment different from that which is initially envisioned—and this is a precious
...the thesis is most rewarding not when it is turned in, but rather when one is in the throes of wrestling with the material..."epiphany. If the thesis is a process of progressive discovery, those successive revelations will steer the content and format of the thesis in exciting and sometimes novel directions; I believe the important thing to do at that point is to hang on and enjoy the ride.

Fearing that this #5 might be a little too abstract to be of any real help, I would like to suggest a few slightly more concrete and directly applicable tips, including

**Potentially useful thesis tip #6: Don’t skip classes in the last weeks before the thesis is due**

Chances are, as due date looms, you’ll be focused more and more sharply on the thesis. Your mind will adopt the thesis setting as its default, and you will be in a prime position to absorb new facts, information, and ideas into your thesis. It was two days before I brought my thesis to the binder when something was said in a Milton lecture that changed the entire shape of the thesis tree. It obliged me to rewrite chunks of the thesis and generate whole new Branches, because the revelation that dropped in my lap that Thursday afternoon knit the thesis together in an entirely new, unbelievably coherent way. So consider them study breaks or the seeds of new shoots, but go to class.

Furthermore,

**Potentially useful thesis tip #7: In the weeks before due date, eat and sleep like a normal human being**

It may seem, as the weeks and days contract, that there is some advantage to shaving hours and minutes off your schedule by avoiding sleep and/or food with a nutritional value above zero, but this is not so. Your thesis will only get catty with you if you approach it when you’re too tired (my thesis would mock my shoes and call me a ninny if you can believe the nerve!), and ordering pizza for every meal for four days will only leave you looking pasty-skinned, staring at the keyboard trying to use “pizza” as a verb (which, FYI, doesn’t usually meet with great success).

**Potentially useful thesis tip #8: Know all the requirements for binding your thesis and set up your binding plan two weeks before due date**

Each department has its own requirements for thesis submission. In the case of my department, I needed to submit two copies of the thesis, one hard bound and the other unbound—which meant I needed to get my thesis to the binder’s three days in advance in order to be able to have it hard bound by due date. Trouble with the binder can cost you time, so it’s best to sort it out before zero hour.

**Potentially useful thesis tip #9: Proofread over and over until you turn it in to be bound—and then don’t look at it again for a week!**

Proofreading is essential, as anyone who has, like myself, misspelled her/his own name on important papers will attest. So review your thesis as thoroughly as you can, and draft your friends to proof for you as well. Then, once it is safely in the hands of Pequod, Triangle, or Smith-Shattuck, don’t
torture yourself any more. You will not have been able to get rid of every single
typographical error—don’t go looking for them when there’s nothing to be
done about them.

**Potentially useful thesis tip #10: relax—it’s really not so bad. And you

can totally do it**

The thesis is an academic and personal experience unique in its intensity
and the freedom it offers. Enjoy it. Besides, depending on your topic, it could
make you great fun at parties.

D. Vance Smith

**Associate Professor of English**

I had the great privilege of advising two brilliant theses last year, one by
John Lurz and the other by Christine Barrett, both of which broke the usual
mold for the thesis, although in very different ways. Christine and I probably
spent almost as much time talking about the form of her thesis as we did the
texts she was going to analyze, but not because she was unduly worried about
tackling a large and somewhat daunting project. Indeed, after every meeting
she accomplished increasingly more daunting tasks—poring over Deleuze and
Guattari’s difficult work *Thousand Plateaus* because I referred to one passage in
a meeting, reading about the strange medieval poem *Piers Plowman* because I
mentioned in passing that its form might be analogous to the form she had in
mind for her thesis. Christine thought seriously and hard about the form of her
thesis because it concerned the larger question of the shape that writing itself
tends to take. Her thesis affirms the important observation recorded by the
early medieval bishop Isidore of Seville that books are like trees because their
Latin name—*codex*—comes from the word for bark, *caudex*, which surrounds
the tree. Christine’s thesis recognizes that books are surrounded by trees in
literary history, in texts from Virgil to Milton and Marvell, brilliantly taking what
most readers—even historians of the book—have dismissed as a casual, almost
accidental, figure—a bad pun, if you will—and turning it into a haunting, almost
lyrical meditation on what the thesis describes as the “unimaginable union of
speaking and being while accepting the inability of literature to escape the
traumatic separation of meaning and representing.” In doing this, Christine
shaped her thesis itself, in fact, like a tree, dividing it into not chapters but
into “roots”—the texts in which trees appear—the “trunk”—the central argu-
ment—and “branches,” the ramifications, so to speak, of both. She did this by
pursuing the deeply literary practice of close reading, by reading of and among
the roots of things, the roots of words, the roots of writing, close readings that
show many of the texts she works on in a new light. In describing what the tree
stands for in these texts she ultimately describes what it means to be a reader.
It means, as she says, to trace “the violence endemic to the movement between
human and tree, speech and text, the problem of fallen representation, of
trying to reconcile utterly not only registers but ways of perceiving the shades
of language.” But even with her tone of philosophical meditation, Christine
Christine thought seriously and hard about the form of her thesis because it concerned the larger question of the shape that writing itself tends to take. keeps the thesis rooted in particular texts and objects, from the laurelled Daphne and the myrtled Polydorus in Ovid and Virgil, to Marvell’s “The Garden,” which emerges as a poem with a surprising and profound prehistory, to what she describes eloquently as “something like a quiet, insistent challenge in the tree, something subtle and relentless about its wreathing, writing, breathing limbs.” In spending almost a year thinking insistently about this quiet challenge, Christine wrote a beautiful, truly independent piece of work.
The Distribution of Native Bees in an Intensive Agricultural Area

Elizabeth Bernier ’02

I majored in ecology and evolutionary biology (EEB) mainly because ecological research can have important effects on policies and perceptions relating to environmental protection. I wanted my senior thesis to deal with an environmental problem because my research could potentially help address that problem. I knew from my departmental courses that many of my professors shared this interest in the environmental implications of their research and, therefore, made environmental issues a central topic of discussion in their lectures and assignments. Accordingly, there were lots of professors with whom I could imagine working on my senior thesis. This fortunate convergence in interests made the decision about a thesis topic and an adviser less stressful than it might have been had my interests differed fundamentally from those of most of my professors.

In my fall junior tutorial, we studied the relationship between biodiversity and ecosystem function. Despite having been studied for decades and investigated in large-scale experiments, this issue remains hotly contentious among ecologists. Because of the importance of this issue to environmental policy, I decided that I wanted it to be the focus of my thesis. I asked Professor Simon Levin, who was one of my professors in the fall of my junior year, to be my adviser because I knew that he was actively involved in research on this issue. This particular debate about the relationship between biodiversity and ecosystem function embodies the nature of ecological research. My advisers during a summer research experience at the University of Michigan Biological Station and later at Princeton emphasized that such research is generally not conclusive enough to satisfy everyone. However, it was not until I had experienced the process of trying to come up with an experiment to address a specific question that I realized the extent to which this uncertainty was a part of research. The later stages of my senior thesis experience, from drawing conclusions about my data to writing about my research, further confirmed this perception.

During our EEB semester abroad in Panama, my classmates and I worked together to design field research projects. Each project lasted anywhere from two days to two weeks and involved anywhere from one person to more than a dozen people. After planning, doing, documenting, and presenting projects for a few months, I realized how difficult it was to find something...
I wanted my senior thesis to deal with an environmental problem because my research could potentially help address that problem. interesting and complete enough to be considered for publication even with such a seemingly large number of resources at our disposal. These experiences helped me become further acquainted with the challenges of field research. The abundance of spatial and temporal variation in natural ecosystems is the reason why nature is so exciting to study, but also a big part of the reason why these endeavors are so difficult.

I discussed potential research topics with my professors in Panama and contemplated expanding upon some of the research to which we were introduced there. Then, after considering other factors, such as where I would like to spend my summer, I decided that I would like to be somewhere in my home state of California to be close to family and friends. My first research project, for the junior high school science fair, had investigated the effects of fire and erosion-control measures on the chaparral-covered hills outside of Los Angeles. I had grown up camping and hiking in those hills, and I had always wanted to study that ecosystem again. Furthermore, I knew that more and more land was being converted to housing and commercial developments, further diminishing the amount of natural habitat available to wildlife. So, I had in mind a study system—the California chaparral—and an environmental problem—habitat destruction and fragmentation. All that was left was to decide how to address the issue.

Professor Stephen Pacala, one of my professors in Panama, suggested that I get in touch with a new conservation biologist coming to Princeton in the fall, Professor Claire Kremen, because one of her research projects deals with the issue of ecosystem services provided by native bees in northern California. Before contacting her, I wanted to have a more specific idea of what and how I wanted to research.

With lots of guidance, I came up with an idea of how to study the effects of habitat fragmentation on native flowering plants by focusing on the potential contamination of their pollen loads by non-native plants growing in developed areas adjacent to natural habitat. I suggested it to Professor Kremen and her research team, only to find that it would be logistically impossible. The most glaring problem was that the flowers I wanted to study would not be blooming until spring. Doing a meaningful piece of research over a summer or even a year requires such a large amount of background knowledge about the focal ecosystem—expertise that Professor Kremen and her team kindly shared with me. My official thesis adviser, Professor Levin, discussed the options with me and facilitated the arrangement between Professor Kremen’s research team and me. The situation worked nicely because Professor Kremen and her team were addressing the questions in which I was interested in a different way and suggested a project that would be more logistically feasible. Not only that, but she also invited me to her lab group’s weekly meetings where graduate students, postdocs, professors, and I discussed and presented research on issues relating to environmental problems.

My thesis research project was modeled after a study done in Germany to try to figure out how native bees are distributed across a landscape where
farms border natural habitat. We repeated the study in northern California to see if we would find a similar pattern to the one that that study found suggesting that native bees nested in natural habitat and flew over the farms daily to forage. Native bee distribution is of particular interest because there is some evidence suggesting that they provide pollination services to commercial crops. As a limited and essential resource for crops, pollination is of great economic interest. The complementary conservation interest in this topic is the preservation of native bee populations and the natural habitat in which they live. If we found that native bees provide services to farmers, then perhaps we could convince people that it is important to preserve natural habitat and start restoring it where possible. In order to build this argument, we needed to find out where most of the bees were nesting and foraging. My research suggests that the bees nest and/or forage in both farms and natural habitat. This result is particularly interesting because it is different from the findings of the study after which my project was modeled. Nonetheless, further research is needed to find out more about the bees’ whereabouts at other times of the year and in other field sites.

Since there are so many exciting professors in EEB, I tried to work with several and solicit the opinions of a number of others, especially while analyzing and writing up my research. I found this aspect of my experience to be extremely valuable. I learned how important it is to approach the design, execution, analysis, and presentation of a research project from various perspectives provided by the different professors with whom I worked. Discussing my project with them as well as with other people, from fellow students in the Environmental Studies Senior Thesis Colloquium to other classmates, helped me work through the issues and learn how to present them to people with different backgrounds. The relationships with my main advisers, Professors Henry Horn, Kremen, and Levin and Professor Kremen’s postdoctoral researcher Neal Williams, will certainly have the most lasting influence on me. Indeed, among the most important aspects of the thesis experience are those that take place when working with the amazing people with whom one has the opportunity to interact.

The purpose of scientific research is to share findings with other scientists. I shared my findings in a number of different ways, from oral presentations to my department to presentations in the Environmental Studies Colloquium to writing it up for the department and outside publications. Like many EEB majors, I finished the field portion of my thesis nine months before the written thesis was due, so I spent the academic year figuring out how to analyze my data and write about my results. I learned a great deal figuring out how to set up my experiment in the field, especially dealing with the inevitable mishaps that plague most field research projects. However, I did not expect that the amount I learned about my project would accelerate as I discussed it with various people.

The part of my senior thesis experience that was most helpful to me in keeping things in perspective was an encounter I had with a group of residents near my field sites. After getting coffee from the gas station (the only place to
get coffee out in the Capay Valley) on a few consecutive mornings, one person asked me what I was doing out there. I explained my project briefly, trying to emphasize the most direct relevance of it to all of our lives—the potential ecosystem service that native bees provide to commercial farmers. The group listened politely, then a short period of silence ensued when I finished. One of them broke the silence with a sigh and declared, “Well, it’s something to do.” I would always think back to that statement when I felt overwhelmed about my thesis because it allowed me to relax and remember that the project in itself, though certainly important, is not nearly as important as the learning process that it makes possible.

The three best pieces of advice I got about my thesis were (1) to choose a main adviser that you think will be interesting to work with and to get to know because it is a wonderful opportunity to do just that; (2) to choose a general topic that is of interest beyond the specific experiment that you will undertake because it needs to hold your interest for a full year; and (3) keep in mind that doing a thesis as an undergraduate is about the learning process and try not to feel too much pressure to come up with something publishable, especially since that outcome is dependent on many factors beyond your control.

Simon Levin
George M. Moffett Professor of Biology

No aspect of undergraduate teaching is as intensive or rewarding for me as senior thesis advising. It is the ultimate formative event for the student, a bridge to independence and the challenges that await outside Princeton. In the period of a year, the student-adviser relationship matures into a more symmetric, collegial one. The best students, like Liz Bernier, learn so much about their problems that they reverse the relationship, becoming teachers and leading their advisers into new territory.

In ecology and evolutionary biology, the senior thesis experience really begins early in the junior year, as students work on smaller problems they hope will grow into theses. This sets the stage for the summer research experience, most often a field project that will mature into a publishable piece of science. I always enjoy the transition. Juniors whom I know only slightly, perhaps through my introductory course, come to talk to see if there is a good fit between our interests. A dialogue ensues, and as the year proceeds, we get to know each other much better and learn from each other. I prefer not to impose my own interests on students, because I regard problem choice as one of the most important parts of the research experience. For most of their undergraduate careers, students are told what is interesting, handed problems, and sent off to solve them. That is a place to start, but provides inadequate preparation for research careers, much less for life. By their junior years, the best students are champing at the bit to stake out their own problems; when they find those problems on their own, they are more motivated, have more of a sense of ownership, and do more interesting work. I also have an ulterior motive—this broadens me, and forces me to think about new problems as well, and gives
me the chance to see these students in their intellectual home territories.

I was fortunate to have four exceptional students in Liz’s year—besides Liz, there were Jamie Mandel, Ginny Pitzer, and Annika Walters. Each was self-propelled and independent, and each received some form of special recognition for his or her work. Liz was already pretty independent when she began to work with me. She had done exceptionally well in my course, and was also a serious and accomplished athlete. She had earlier joined a group of Princeton students who volunteered at St. Margaret’s Village, in Belize, where she hoped to communicate some of what she had learned about conservation biology to the local people responsible for making decisions about managing Five Blue Lakes National Park. It was a terrific experience for her, and helped convince her that she wanted to do more in integrating ecological theory and conservation practice. The thesis, indeed, served as a pathway between her previous experiences and her postgraduate work: she won a prestigious Labouisse Fellowship, which, after graduation, took her to the Peruvian Andes to study traditional organic farming and conservation issues in the local indigenous communities. Again, her goal was to combine research with education, communicating her knowledge and enthusiasm to the native people.

Liz made the most of the Princeton experience. Although I was her adviser, she was motivated initially to work on such topics by a freshman seminar on sustainability, led by Richard Golden. She did research work in Princeton’s Panama program, working under Martin Wikelski and Steve Pacala, and also received much mentoring from Henry Horn. Her initial search for a thesis project led her to explore many themes, before finally settling on pollination biology, where she did field work with Claire Kremen. Princeton faculty are readily accessible to students who want to discuss their work, and I strongly encourage all students to follow her model in exploiting as many faculty as they can.

The pollination biology project was a natural for a conservation biologist. Ecosystems provide humans with many services that we take for granted, and the loss of biodiversity carries with it the risk of the loss of those services. Pollinators, so critical to agriculture and our broader environment, are a case in point. Liz did rigorous fieldwork with Claire, and graduate student Sarah Smith, merged it with old and new theoretical ideas, and produced an outstanding thesis.

Liz will eventually go on to graduate school in conservation. Her thesis, and all that followed, will have been one of the most important experiences for her. For me, every meeting was a delight. I always hate to see my seniors depart, but always feel good when they emerge smiling from this rite of passage.
Completing my thesis was easily the greatest accomplishment of my Princeton career, and (lucky for me) I had a great time doing it. After discussions with my thesis adviser, whom I had talked into advising me late in my junior year, I pinned down my exact thesis topic early in my senior year. The project—a comparative analysis of drug trades in three countries—built on similar work that I had done for my junior paper, which made initial researching slightly easier. Staring down a minimum of 80 pages of writing is difficult to do—especially when the due date is nine months away—but I was acutely interested in my topic so doing the requisite background readings early in the first semester was actually fun for me. (Who doesn’t want to read about the fascinating lives of drug lords?) Also, I split up my thesis into distinct topics, which later translated into chapters, so I was able to attack my thesis in small doses. (This was also facilitated by a thesis schedule that my adviser and I cooked up. It outlined the work I was to accomplish on a week-by-week basis.) Despite this, my first semester of thesis research was still tough because I was taking a heavy course load, applying to graduate school, and working two jobs. However, a few kicks in the pants by my adviser kept me on track with my thesis schedule.

I quickly discovered that, despite my familiarity with the subject, I was walking into uncharted territory in regard to the methodological framework of my thesis: comparative historical analysis. (I had previously been only marginally aware that there was such a field.) This is where my thesis adviser, Professor Paul DiMaggio, began to make a huge difference in my work. Every week I would go to his office to update him on my research progress. Initially, in the organizational stages, I would spout random, unconnected ideas and opinions about the different cases, which Professor DiMaggio would manage to collect and convert into cogent, thematic arguments that were useful equations for structuring my research. After the first few sessions (and a steep learning curve), I learned to rein in my research ideas so that they fit manageably into the scope of the paper. Throughout the entire process, Professor DiMaggio was a constant source of support, encouragement, and direction,
for which I cannot be more grateful. Even though he is not an expert in my field he always knew where to send me to get the information I needed. This was particularly helpful in respect to the theoretical and methodological underpinnings of the paper, which would have suffered greatly without the readings he suggested. In addition, in the second-semester writing stage, his editorial skills proved to be invaluable. I also learned to sacrifice the ornate for the simple, and the complicated for the lucid. I am an exceedingly better academic writer than I was before I met him.

Writing my thesis was different from any other research endeavor that I have ever undertaken. First of all, I never knew I could write 120 pages about anything. As a freshman, I always assumed that I would transfer after my junior year so as to avoid having to write a thesis. The ironic thing is that I felt that I could have written at least a couple more chapters on my thesis topic but time constraints would not allow it. Actually, one of the most difficult aspects of my thesis experience was deciding what to include and what to cut from my paper. I had a tendency to include every single piece of evidence available to me, although the inclusion of fewer examples made a stronger, clearer argument. Pulling all the chapters together in a coherent fashion, after treating them as smaller research projects, was also difficult. I spent the last few days trying to write a conclusion that summarized everything I have ever had to say about the drug trade, and I spent the last few hours tweaking the previous chapters so they would appear to all be parts of the same work. The final touches were also more difficult than I had expected. I spent an inordinate amount of time making sure all the font styles matched, the margins were correct, the headers and footers were consistent throughout, the page numbers matched with the ones in the table of contents, and tying up a page explaining the abbreviations I used. I definitely didn’t leave enough time for these things, although I did finish them in time. (I dropped off my thesis four minutes before Pequod closed. Oops.)

The most rewarding part of writing my thesis was definitely seeing the final product and feeling as though I had accomplished something big. Seeing the title—White Gold, Weed, and Blow: The Drug Trades of Afghanistan, Colombia, and Mexico in Comparative Historical Perspective—stamped in gold on the front of a hardcover book was one of the greatest moments of my life. And knowing that it would forever have a place of pride on my mom’s coffee table was a nice thought too. My thesis received two departmental awards, which were completely unexpected, but nonetheless having my thesis recognized by the outstanding faculty in my department made all the late nights worthwhile.

One of the amazing aspects of writing a thesis is the ability to contribute an original piece of research to the existing literature in one’s field. My field of interest, transnational organized crime, does not have a large academic base, so there were plenty of ways to contribute valuable research to the field. I had noticed a lack of comparative writing about how criminal networks and organizations function across time, space, and culture and used my thesis work.
to partially fill that void. The concluding chapter of my thesis also introduces the idea of carrying out larger comparative studies of drug organizations in more countries to explore how they evolve and behave over time. My thesis research also had a particular emphasis on the manifestation and dynamics of trust relations in criminal organizations, which, despite being crucial to every criminal enterprise, has not been given the attention it deserves from criminologists.

My one major piece of advice to undergraduates would be to start early. Even though I finished right before my thesis deadline, my second semester was exceedingly easier because of the work I accomplished in my first semester. (Choose an adviser and a topic early also.) When choosing a thesis topic, pick something that you are genuinely interested in, because you’ll be stuck with it for nine months. If you are working on a topic you love, the thesis won’t feel like routine schoolwork. Meet with your adviser regularly. I was blessed with having the greatest thesis adviser ever to walk the planet (he won the departmental advising award and not one, but two of his advisees won awards for their work), but most professors are genuinely interested in seeing you and your thesis succeed, so let them help as much as possible. Come up with a great font and style for your cover pages—appearance is everything. The long road to finishing a thesis can be tedious, but trust me, it is definitely worth it in the end.

Paul DiMaggio
Professor of Sociology

Thesis advising is an opportunity to work with brilliant, highly motivated students on issues about which they care deeply. Advising independent work at all levels is the part of teaching I enjoy most. Advising thesis writers is particularly rewarding for three reasons. First, because most of them have never undertaken such a substantial research project before, a little good advice can make a big difference. Second, Princeton students can do extraordinary work—every year some of them produce theses that are, in effect, first drafts of books or publishable scientific articles. The degree of intellectual ambition is gratifying for the adviser. (I often find myself referring to students’ senior theses as “dissertations”—the term for the book-length project that earns graduate students the Ph.D.—and have to remind myself that they are not.) Third, whereas a faculty member’s graduate advising ordinarily is in substantive areas of his or her own specialized expertise, advising undergraduate theses takes one much further afield, into fascinating topics about which one would otherwise learn little (thus enabling one to maintain a thin veneer of broad erudition).

I certainly would not have learned much more about the international drug trade than one could glean from the New York Times had Allison Binns not asked me to be her adviser the summer before her senior year. I first met Allison—whose prize-winning thesis was an innovative and acute comparative study of the politics, economics, and culture of illegal drugs in Mexico, Columbia, and Afghanistan—the previous year, when she was beginning to work on the topic. I got to know her better when she took my graduate theory
course that spring. I didn’t know anything about global crime or drugs, but I was interested in network analysis and theories of social organization, so I thought I could be helpful. Allison prepared for her project during the summer, visiting Mexico and taking an intensive course on network analysis, and came back to Princeton ready to jump into her work.

The mechanics of thesis advising are fairly straightforward. One meets with one’s advisee early in the fall. The first job is to clarify the research problem the student’s thesis will address, which Allison had already done. Then the student identifies the tasks that have to be completed to finish the thesis, and sets out a fairly detailed work schedule, which serves as a yardstick for evaluating his or her progress—and for revising aspirations before reaching the crisis stage if initial expectations are unrealistic. (In Allison’s case, the work schedule proved to be a pretty reliable guide.) I then schedule biweekly appointments—weekly towards the end, or earlier if the student can stand it. The student and I agree on a goal, involving at least some written product, for each meeting—problem statements, schedules, and outlines at the beginning; memos on readings or data sources in the middle; and drafts towards the end of the process. Students vary quite a bit in their ability to keep appointments and stay on track. Many tend to be a bit casual during the first part of the fall, and some disappear so thoroughly that missing person reports must be filed. Students who write the best theses invariably start early and work steadily throughout the year.

In advising Allison, I lucked out. Her commitment, ability, and organization made my job pleasurable and relatively easy. Allison’s thesis topic was risky because it was so original: Studying something that no one has studied before (at least in the way you approach it) and relying on a wide range of text sources rather than a statistical data set, is a bit like tightrope-walking without a safety net—all the more so when one is examining three cases rather than just one. The best theses evince enormous creativity no matter what method the student uses. But with more conventional methods and more well-worn topics, the adviser can provide direction that will pretty much ensure a moderately satisfactory outcome. By contrast, because of the wide-ranging character of her exploration of uncharted terrain, I couldn’t tell Allison what to do: She had to find a diverse range of materials herself, produce thorough accounts of each case, and then develop an original analytic framework to understand differences and similarities among them. Fortunately for both of us, she did all this spectacularly well, though not without one or two vertiginous moments. I was particularly impressed by her ability to penetrate the veil of appearance in order to identify deep structural parallels where these existed, even when systems differed in more superficial respects—an ability that may be the best indicator of the sociological imagination.

As I mentioned, a great delight of undergraduate thesis advising is that one learns so much. I was fascinated to find out how deeply the drug trades are built into the fabric of everyday life in both Afghanistan (where poppy cultivation is a major source of foreign currency, and farmers are pillars of their local communi-
ties) and Mexico (where narcotraffickers have built alliances with government and the church, and are portrayed as heroes in popular song). Likewise, the chapter on trust—always an important but elusive commodity in criminal networks—explained how Mexican traffickers rely on family to fill crucial roles, whereas their Columbian counterparts have institutionalized an “honor code” that serves the same purpose. The examples could go on and on.

Independent work is potentially the most rewarding part of a Princeton education. In conclusion (and in compliance with the mandates we faculty authors have been given by this volume’s editors), let me offer seven tips that can help students maximize the benefits they will derive from their experience:

- Pick a thesis topic that you really care about—you will be living with it for a year.
- Choose your topic in the spring of your junior year, so that you can get a head start over the summer. (Waiting until fall won’t help you find the perfect topic.)
- Choose an adviser in the spring of your junior year—the best one for you may be booked up by September.
- Confirm that your adviser is willing to meet with you weekly. (Even if you don’t meet that often, you want someone who will commit to regular interaction.)
- Meet with your adviser the first week of fall term; agree on a problem definition (a description of your proposed research that is broad enough to be interesting but specific enough to be doable) by October 1; and agree on a detailed work schedule (broken down by specific tasks and “deliverables” and with a time-line specified to the week) no later than October 15.
- Meet with your adviser at least once every two weeks; agree on some kind of written product to be submitted in advance of each meeting; and stick to it.
- Review your work schedule at least once every two weeks—if you are falling behind, discuss this with your adviser. If you fall too far behind, revise the work schedule and specify less ambitious objectives that you can keep up with.
The Sorrows of Young Graetz, a Jewish Historian in the Making, from Aufklärung to Wissenschaft

Amos Bitzan ’03

I wrote my senior thesis about a Jewish historian named Heinrich Hirsch Graetz (1817-1891) whose scholarship is most often invoked today in references to obsolete 19th-century Jewish historiography. Indeed, my thesis adviser, Professor Anthony Grafton, is fond of pointing out that anyone who has anything to say about Jewish history begins with the assertion that “Graetz was a nudnik.” Some contemporary scholars even accuse Graetz of consistent and deliberate misrepresentation of his evidence. Others explain his failures more sympathetically as functions of a flawed conception of historical writing and research. But most historians writing today simply believe that Graetz was wrong much of the time. Why then would anyone be interested in writing about this nudnik? Or to take the challenge further, what could possibly be of value in a study of another historian, who lived more than a century ago in a country that no longer exists? There are several answers to that question.

One, for all of Graetz’s shortcomings, he remains the preeminent Jewish historian of the 19th century. Bold and captivating, as well as scientific and learned, he is best remembered today for the grand 11-volume history of the Jews from antiquity to the present that he published between 1853 and 1876. Graetz’s Geschichte der Juden (History of the Jews) was 19th-century German Jewry’s most impassioned and foundational gesture of self-assertion. Graetz appealed to both the popular imagination of his readers as well as their demands for scientific erudition and analysis. In his narratives about the struggles of Jewish heroes from the past and present—for Graetz, the prophets of the Hebrew Bible, the rabbis who compiled the Talmud, and the great medieval Jewish philosophers and poets—he captured the hearts of many German Jews well into the 20th century. At the same time, he was an integral part of a rich culture of philological and historical scholarship called (by its practitioners and 20th-century historians) the Wissenschaft des Judentums (Science or Scholarship of Judaism). Graetz’s goal was to get his readers to know the great and villainous figures in the history of the Jews as individuals in a richly and accurately reconstructed context.

Two, studying Graetz in his context can tell us quite a bit about the larger culture and society to which he belonged. Today, most
Historians, for better or worse, do not loom especially large in the public imagination. But in the German-speaking realm of the 19th century, historical scholarship and philological erudition were the rage. Classicists, Bible scholars, and historians sometimes became prominent personalities, playing significant roles in the political, cultural, and religious developments of their time. Jewish scholars in particular emerged as religious reformers or champions of tradition, as advocates for political emancipation, and—particularly toward the end of the 19th century—as activists against anti-Semitism. Their biographies, works, and cultural contexts provide us with the keys to the intellectual history of both modern Germany and German Jewry from 1800 to the early 20th century.

However, I did not fully understand any of these things until the last month of my thesis work. All along, it was quite difficult to explain to my friends what I found so fascinating about Graetz. At some point, while working on my thesis, this question—what makes Graetz so interesting?—began to bother me so much that I confessed my doubts about the whole business to my adviser. I assumed that I would be able to receive a convincing argument from someone who has spent several decades writing about dead philologists. But Professor Grafton’s answer, at once perplexing and encouraging, was that he himself had great difficulties explaining his research interests to friends and colleagues.

Looking back at my undergraduate experience at Princeton, I realize that I first began to take a serious interest in Jewish history in my sophomore year. Very early on, as part of my coursework in Judaic studies, I became especially curious about how historians writing in different circumstances represent the past. I wanted to understand why certain phenomena or periods mattered more to Jewish historians writing in the 20th century than to 19th-century historians. The more history I learned, the more I wanted to know how past and present historians differed in their interpretations of the past.

Although I continued to be interested in these questions, I ended up working on quite different topics for my junior papers. Both of my independent papers were close textual studies that I could not imagine writing today. One of them dealt with a series of political articles by the German revolutionary Rosa Luxemburg; the other with a travel narrative by Alfred Döblin about his journey to Poland. In my junior papers, I focused almost exclusively on the form of these texts and how they articulated certain political or cultural ideas. Working with Professor Barbara Hahn in the German department, I was able to hone my close reading skills and practice writing longer papers. But history or biography hardly entered the picture. In that sense, my senior thesis was a clear break from this work.

At the beginning of my senior year, however, I was still far from settling on Graetz as my thesis topic. In fact, until several weeks after midterms, I had an entirely different project going about two Marxist social theorists (Max Horkheimer and Theodor Adorno) and their escape from Germany to the United States in the 1930s. Working with Professor Anson Rabinbach, by October I had become quite immersed in their correspondence. But history...
and historiography simply would not leave me alone. As part of a seminar with Professor Grafton, History 448, “An Introduction to the Discipline,” I finally set my vague ideas down on paper. I began with a single chapter from one of Graetz’s 11 volumes—a chapter in which he narrates the origins of Christianity in turn-of-the-millennium Palestine. I do not think that I set out to write about it from the beginning. But somehow, looking over the tables of contents in the various volumes and browsing here and there, I started reading and becoming so engrossed in Graetz’s history that I dropped everything else. It was the first time that I felt as if I had hit upon something serious. I wanted to understand exactly what lay behind this Jewish historian’s provocative and—given the time and context—risky account of the birth of Christianity. I ended up working only on this paper, spending nearly every day of the break reading and rereading the chapter, Graetz’s diary entries and correspondence, as well as some secondary literature, and writing as I had never written before.

At first, I entertained thoughts of continuing further research in this area in graduate school, but soon it became clear that there were still hundreds of unanswered questions about Graetz and the origins of Christianity that I could not abandon. I convinced Professor Rabinbach that my future was in the 19th century rather than the 1930s, and he graciously let me change my topic and emigrate a few doors down in Dickinson Hall in search of a new adviser.

Early on in my work, Professor Grafton encouraged me to present my analysis of Graetz’s historical scholarship in some wider biographical and cultural context. To narrow the scope of my thesis, I decided to focus primarily on Graetz’s early life. I tried to find out as much as possible about the very local conditions as well as the larger historical circumstances in which my subject grew up. For my research, I relied heavily on Graetz’s diary and correspondence, published in different places with minor variations. I tried as often as I could to cross-check personal recollections with local sources from Graetz’s time. My sources thus ranged from 19th-century guidebooks for towns that Graetz visited to letters and notes of rabbis with whom he studied. My goal was to prepare a vivid but accurate reconstruction of Graetz’s personal experiences and his environment that would explain how a young man from a poor, traditional Jewish family transformed himself into a 19th-century Prussian scholar. While researching Graetz’s early life, I also had to study his later historical scholarship and his objects of study. This meant reading his histories, monographs and essays, and becoming acquainted with early Christianity and Judaism in Roman Palestine. I had to keep one eye on the distant past, and another on the 19th century.

My adviser was a crucial part of my thesis work—from the conceptual parts to the finest details. One of my main goals was to finally write something that would engage anyone with an open mind and an appreciation for reading, regardless of specialty or background. Professor Grafton’s books and lectures showed me that this was possible; his tireless attention to the craft of writing helped me do it with my own research. I am still not sure where he found the time, but somehow he read and corrected every single one of my many drafts right until the last hours before the thesis deadline. No matter how bleak things sometimes looked, Professor Grafton always had an encouraging word
and another book or article to help me out. I think that this part of the thesis writing process—the opportunity to work so closely with a faculty member like my adviser—will have the most lasting influence on me. Working with Professor Grafton, I saw up close how one combines a serious commitment to excellence in research, writing, and teaching undergraduates. I hope to be able to do the same with my own scholarship.

Anthony Grafton
Henry Putnam University Professor of History

Teaching at Princeton has brought me much joy since I started doing it in the fall of 1975. And no part of the job has been more fun, or more instructive, than supervising senior theses. Every year, I have the chance to watch three or four or five immensely talented and intelligent individuals carry out an incredibly demanding and intricate task. Every year, my seniors work hard at every aspect of their theses—from finding the right documents and digging through them to thinking hard about the results. Often they combine the insight of an excellent graduate student with the élan and fearlessness of undergraduates. They attack subjects that seem impossible, yet by the end of the year they show that they were right to do so. When they finally stagger into the binder’s shop with the last versions of their theses, they know their big and challenging subjects better, and have written better about them, than anyone in the world. It’s amazing and wonderful to see this all happen year after year.

None of this is easy to achieve, and even the ablest students can run into practical or intellectual difficulties. The schedule, with its firm deadlines in the spring, leaves little room to remedy early errors in choice of topics or research strategies, especially since seniors are fully engaged with heavy course loads and multiple outside activities in the fall. Sources have to be available at the right times; research trips need early, systematic planning; other faculty members may need to be consulted about particular technical matters; writing schedules must be made and then, more or less, adhered to. It’s the supervisor’s job to see to it that each senior realizes all of this, and goes to work in a timely and efficient way. At the same time, supervisors play many roles: you have to be a critical sounding board for questions, ideas, and hypotheses; an enthusiastic supporter when problems arise; and a stern, niggling critic of argument and style as the draft chapters come in. At the same time, the supervisors always have to bear in mind that the student is thinking very hard about other matters as well—like the choice of a profession to follow college. Discussions of sources or chapters often mutate, imperceptibly, into discussions of journalism, banking, or graduate school. It’s a complex, challenging, and immensely enjoyable process—especially when you’re the one holding the rope, rather than the one making the intellectual bungee jump.

Amos Bitzan first consulted me in the summer before his senior year. A German major, he wanted to enrich the more literary methods he had used in departmental courses and junior papers with a more historical approach to sources and argument. He was interested in working on Heinrich Graetz
(1817-1891), the first great modern historian of the Jews. But he had already started working on a 20th-century topic, and in fact spent much time during the summer and early fall on that, before deciding that he really wanted to work on Graetz. We began work a little late, accordingly, and I started out a little worried about the project—especially as it lay in the world of Jewish history, which I know only from the outside.

But student energy—and help from learned colleagues—overcame the obstacles. In the course of the fall and early winter, Amos unearthed a mass of primary material. Susannah Heschel, a visiting professor from Dartmouth who specializes in the efforts of German Jews to write modern histories of their people, helped him find his way through Graetz’s immense corpus of writings. One source in particular—the immensely detailed diary that Graetz kept, in German, Hebrew, French and other languages—offered rich insight into the historian’s emotional and intellectual formation. Amos made the diary his Ariadne’s thread and followed it through Graetz’s labyrinth of a life. With immense energy and ingenuity, he ransacked Princeton’s library system to find materials that could provide a three-dimensional background for his main source. Contemporary maps, city guides, popular novels of the early 19th century and modern studies of the German publishing industry all went into the hopper and all shed light on Graetz’s difficult early life and eventual success. By reading this rich and difficult text critically and setting it into a rich historical context, Amos made sense of Graetz’s evolution from a poor young scholar, supported by charity while he studied traditional Jewish learning, to a skilled practitioner of the new scientific history practiced in German universities.

A fine linguist, a resourceful researcher, and a skillful writer, Amos found his own materials and forged his own interpretations of them. Meanwhile I suggested still more sources to consult, questioned readings of individual passages, and then stayed out of the way, as far as possible, until Amos’s massive draft chapters began to come in. I read each of these closely, two or three times, and suggested ways to prune extraneous material and shape what remained—the one part of the job that had to be done under some time pressure, especially as I was doing the same for three other energetic and dedicated seniors, two of whom, like Amos, emerged with prizes. In the end, Amos produced a learned, insightful and beautifully written study of the making of a historian, almost 200 pages long—a highly original work of intellectual biography, and one that would have done credit to a far more advanced scholar.

Working with Amos yielded rewards of many kinds. His inventive and craftsmanlike ways of doing research gave me new approaches to my own field of study—the history of historical scholarship and writing in early modern Europe. Our regular conversations often turned from the specific problems raised by the thesis to the larger discipline of history, and it came as a delight when Amos—like a number of his earlier colleagues and classmates—decided to undertake graduate work in the field. Above all, working with Amos reminded...
me of something that supervisors can easily forget—especially when, like me, they tend to take the mother hen as their model (the department secretaries are used to chasing me out of the office on our departmental due date, since otherwise I will spend the day there worrying until all of my seniors have brought their theses in). The thesis is the student’s, not the professor’s project. At its best, supervision means suggesting slight course corrections while a very young scholar chooses the goal, plans the route, and makes the journey.
Development, Duality, and Synthesis in the Breton Legend of the City of Ys (Stones that Stay Whole, and the Sea Splits in Two)

Matthieu Boyd ’03

My thesis was in the Department of French and Italian; at the same time I was working on translations and creative writing for the Program in Creative Writing. Though related these were independent projects. Karl Uitti was my thesis adviser; Paul Muldoon and C.K. Williams helped me with my work in creative writing. I am very grateful for these people.

I was writing about Ker-a-Is, the Town Down There or the City of Ys, Atlantis in Brittany. Brittany, or Breizh, is part of France now; it’s the bit that sticks out in the west, pointed at America. My mother was born there.

Reader, you may not have heard this story.

It explains the time when Brittany was baptized.

In the middle of the first millennium after Christ, the pagan Gallo-Romans, who were living in a place they called Armorica, were colonized by Christian Celts from Wales and Cornwall, and by monks from Ireland. Those who came cut crosses in the standing stones and transformed the gods of wood and weather into saints who are not recognized in Rome. They were Britons and they called the country they invaded Little Britain.

Later they would be King Arthur’s people. They would be the knights who cantered through the forest where the fairies have retreated. They would offer medieval literature the ‘matière de Bretagne’ associated with Marie de France and Chrétien de Troyes, and the scholarship of such as Peter Abélard and Bernard of Chartres (something that is far too much neglected). Storytellers and seafarers, they were also always looking at the sea.

What happens to people and things when they are baptized is this: they get wet. Brittany gets wet in the Atlantic Ocean, in that lake of widows’ tears and angels’ piss where the sailors of the Celtic countries have been traveling for centuries. It is a connecting fabric; it goes all the way to China; often it binds tighter than the roads we pave with asphalt. The Atlantic Ocean brought the Britons in the first place, then it brought the Irish missionaries, then it brought the Vikings. The City of Ys is a city that is said to have submerged in the Atlantic.

They are Roman roads that vanish in the beaches at the end of Brittany, aimed at islands once connected to the land.
Archaeologists confirm that the level of the sea has risen in the last two thousand years. Where most of the Roman roads are going is to Roman factories for salting fish. But for centuries to those who had the eye they looked like highways to the origin, to the Other Side of life that is the womb, the tomb, the map and bestiary of the meaning of the world.

My grandfather had a devil that lived in his basement.

That is how my thesis starts: “My grandfather had a devil that lived in his basement.” True. He told me. If he was joking he was only partly joking. Where I followed this was to the inner landscape that exists in Brittany, the surreal universe of artwork and particularly stories that the people have evolved to gloss their physical surroundings. All the ocean is salt and water. But, three points of mythological significance: it’s deep (so deep that the world might have salt water round its heart), it’s wide (so wide that it might be Paradise we glimpse just over the horizon, like the story of Saint Brendan’s Voyage), and it moves. It has waves that come down like the thing is breathing, it has tides that go out halfway to America, and the wonders it uncovers hint at other wonders, so that there are times a person feels that the Other Side comes nearer. I wrote that I thought this was one of the strongest and most curious of the Celtic feelings: a sense of now-you-see-it-now-you-don’t, of having had something, almost having had it, paradise lost, nostalgia. I had it . . . I had it . . . but where did it go? The fishermen who make it down to the City of Ys underwater inevitably get the chance to make it rise again; just as inevitably, though, they let it slip, and only barely manage to escape. Ys is like that, incomplete, a once-and-future story, like King Arthur, like the Bible, and of course it often comes to represent whatever the person who is telling you the story thinks that he once had and now is missing.

Ys is also told like Sodom and Gomorrah, like a wicked city that was punished. The Celtic twist is that what drowns in water does not die, but lives on otherwise, and is translated. You cannot go diving for it. It continues as a story. The City of Ys is an impression of the Breton coast; those who tell the story fill it up with characters who are a gloss on Breton history, who act it out in a symbolic sense (it’s theater):

- there is a Saint or more than one who wears a Wild mask, a Fool mask, a Devil mask, like all the Celtic saints;
- there is a King who loves too much and loses all he loves and goes on living;
- and a horse, who crosses borders;
- and a girl, a Celtic triad, Maiden Mother and Old Woman, giving birth and killing like the sea;
- and she has a son who is a sacred mystery and who may be the son of the legend itself.

Never mind what happens to them. Someday maybe I will tell you. In my thesis I was documenting that. My specific thesis (I did have one—everyone should have one) was to reinterpret and follow a strand of the legend that becomes the only version now told orally (and recorded on CD!). The man who tells it is alive, of course; his name is Alain Le Goff; I went to see him. What people like that will tell you are the things that you don’t know that you don’t
know. That is precious, precious information. Do make sure that you already know whatever books can teach you. Otherwise the people will be very kind, but they will only tell you which books you should read.

There were lots of books about Ys already, bits and pieces put together from the early Middle Ages through the spring before I started writing. The story is one that has grown through imagination and coincidence, accreted like crystal, not one that has fallen from a whole original. The relevant literature spans 10 centuries, fossils of the legend’s evolution in an oral bath of stories told in Latin, French, and Breton. These days Ys is everywhere in Brittany. Restaurants named after it. Bus companies named after it. Swimming pools named after it. If only as a demonstration of how the Atlantic seaboard evolves a story, all this is of interest. Only very few people writing in English seemed to have an interest. That was when I thought that I could do some useful work.

I went to Brittany. I spent a summer. That’s one thing: you have to go. (I should add that I was blessed with an adviser who believed this. That made all the difference.) Choose your topic early so you can.

You will have another understanding of your topic if you go to where it comes from (whatever it is and wherever it comes from). You will understand, if you are lucky, how your topic moves ‘the real world’—or how it could. I mentioned the sea by way of saying that A PLACE is an important kind of inspiration. There it is. It will not look like the books that you were reading. The discrepancies will make you open. Don’t be nervous. Here’s a story. I went to the Bay of Douarnenez, where the sunken city is supposed to be. I met an old woman, the kind of old woman who looks like a queen of the folklore, who looks like she has seen the cauldron where all things past present and future are mixed. I asked her what she knew about Ys, the lost city. She said:

“I’m 80 years old, turned 80 this January, Douarnenez born and bred, and I’ve never heard of it. Sorry, dear.”

Those who ‘own’ a topic often trust to their subconscious, pass it by and never notice. A person sometimes has to come from elsewhere for it to seem new and strange and wonderful again. My aunt, who lives in Brittany, told me this. It is a good gift to give to the people you meet; what comes in exchange makes for very good research. By contrast, reason perfectly alone inside the so-called ‘Princeton bubble’ (which if you are not careful will go places with you) and you will risk being so right, you’re wrong. In fact I think that every culture tolerates, some indeed rely on, seeming contradictions. Some of these are very deeply bedded. They can be intensely fertile, foundational even, the enemy couple making love. Recognize this when it happens; let it. Sometimes, when you ask the thesis question ‘Is this the case or is it that?’ the only acceptable answer is YES. Or, as Professor Uitti once told me (mentioning a U.S. president of whom it was said that he couldn’t do this), maybe it walks and chews gum at the same time.

THESIS is the awkward way that Princeton has of naming and allowing for YOUR WORK. Live your work intensely; live the whole direction of your life. Do more research than you have to. If you’re catching salmon, don’t catch half a salmon. In Ireland they have a story about that, the Salmon of Knowledge.
I’m convinced I ate some with a friend there, Sarah-Jane Murray, she was working on her doctorate at Princeton. We could share what we were doing and so what if she was writing a Ph.D. dissertation and I was writing an undergraduate thesis. That can happen. Know that the people at Princeton don’t need the whole salmon. Some of them won’t want it. It’s for you. You will have to say, This is too much, I must work within convention, this here is relevant and interesting but I must leave it out, but know it, know it anyway, know it for its own sake, it’s the food of the soul and the soul of the world. If that isn’t how you feel about at least something, one of us is lost.

Karl Uitti

John N. Woodhull Professor of Modern Languages

Karl Uitti died unexpectedly in the fall of 2003 before submitting his essay for this book. Instead, we print here the comments he wrote for the Department of French and Italian in the spring of 2003 about Matthieu Boyd’s thesis.

Matthieu Boyd, himself, says it best. His remarkable thesis constitutes the description and analysis of a set of accreted, crystal-like tales that, together, as well as separately, tell, and create, what he calls “The precious things [recounted about Ys and the many people involved with the submerged, Atlantis-like city. These, he adds,] were never lost, for they may never have existed—until, like the city itself, they were told into being.” The thesis itself is a “telling into being” of these “tellings.” The legend remains alive, generating new elements and versions, in myriad genres, including sculpture and painting, among with poems, plays, comic books, and both oral and written narratives. Apparent contradictions abound, and the various conteurs enter into serious arguments with one another, as well as with their numerous predecessors.

Matthieu Boyd demonstrates on each of his pages that he possesses all this. I have never read a senior thesis that displayed such a thorough scholarly mastery of the relevant texts and artifacts; indeed few Ph.D. theses merit comparison with this one on that count. Yet the immense learning that has gone into the fashioning of this work betrays not a shred of pedantry. In fact, Matthieu Boyd’s reader comes to know the books he cites, and their authors. “Yes,” one finds oneself saying, “Alain LeGoff would say something like that.” And I for one would like to meet his Breton cousin who tells Matthieu that “Ys est une vaste connerie!”

Although he concentrates on Brittany, and, by extension, the Celtic world of the Atlantic Seaboard (about which he knows a very great deal), Matthieu Boyd’s contexts extend to Norse and Germanic myth, an excellent and accurate fund of biblical knowledge, a good awareness of medieval writing (epic, romance, hagiography), and numerous other areas of what might be called “scholarly specialization.” He has clearly read and thought carefully about each item listed in his bibliography, and a good deal more to boot, because his thesis makes many—often unsuspected—pertinent connections and observes

Live your work intensely; live the whole direction of your life.
interesting disjunctions between these many works, or masses of Ys crystal.

The underlying structure of *Development, Duality, and Synthesis* . . . resides in its author’s longtime fascination with Brittany—his mother’s homeland, incidentally—and, by extension, with the Celtic world—its history, its stories, its way(s) of understanding, its complex and profound relationship to the sea—and in his own writerly, as well as theatrical, talents. The thesis conjoins these matters. In so doing, it allows Matthieu to formulate a number of judicious insights and observations; these command the assent of his reader. Brittany helps him to understand Ireland, and the converse is also true. Although many of these observations appear to be almost gratuitous generalizations, this is far from the truth, since they stem from the warp and woof of the thesis’s very articulation. Thus, what Brittany is must be located inside those who see themselves as Bretons (like Matthieu’s grandfather who has a devil in his cellar), but it is no less real for being so located. On the contrary. Place itself is, to a large extent, interior. Thus, Ys by definition, having been swallowed up by the sea, has, as Matthieu Boyd has put it, been *translated* to the “Other Side . . . [to the] inner world.” Because Ys was there—but it isn’t always there,” leads to the conclusion: “That, I think, is one of the strongest and most curious of the Celtic feelings: a sense of now-you-see-it-now-you-don’t, of having had something, almost having had it, paradise lost, nostalgia. I had it . . . I had it . . . but where did it go? . . . Ys is like that, incomplete, a once-and-future story, like King Arthur, like the Bible.”

This wonderful senior thesis is beautifully written, and quite *entraînant*: one doesn’t want to put it down. When one has finished it, one feels that one has learned a great deal and that one has been lucky to read it. With a few revisions here and there it will make a beautiful, and, I believe, important, book.
Super-elastic Gold Conductors on Elastomeric Substrates

Catriona Chambers
Oxford-Princeton Exchange Student, 2002–03

In September 2002, I found myself in Princeton after spending the previous three years in Oxford. My senior thesis was one of the most rewarding aspects of my exchange year. Within the first few weeks of arriving in Princeton I was introduced to my supervisor, Professor Sigurd Wagner, who proposed the thesis topic. His initial description of the project sounded extremely interesting, although at this time, I had little perception about how and where my research would lead.

The aim of my thesis was to produce metal conductors that could eventually be used in flexible and stretchable electronic circuits. Examples of applications where such metal interconnects would be used are rollable LCD display or sensor skin for a robotic arm.

The concept was an exciting and challenging one. Metal typically will break after only a few percent of stretch. Our aim was to produce interconnects at least five times as flexible that would remain electrically conductive under a 10 percent increase in length. The idea was to use a thin strip of gold, about 25 nanometres in thickness, on a layer of rubber-like material. The metal, being so thin, would then stretch with the material underneath it and the material would constrain cracks in the metal. To detect what was happening in the gold metal as it was stretched, we observed the structural change through a microscope and utilized the electrical resistance to further understand the mechanisms and determine whether the prepared samples would be suitable for use.

Although I had no experience in my thesis topic area, the initial groundwork had been done before I arrived. The process to fabricate these tiny interconnects on the rubber material without cracking them had been developed, an initial test set-up constructed, and some preliminary experiments carried out. Getting up to speed with new techniques was my first task and I started by learning clean room techniques. The yield when making these interconnects is relatively low and so I learned how frustrating the research process can be and how perseverance is often a requirement in research.

Although I am an electrical engineering major, my project spanned a range of fields. When testing the samples, I observed an unexpected phenomenon in the way the gold metal layer
buckled and cracked, and the electrical resistance of the metal jumped and decayed. I therefore found myself drawing on the expertise of my mechanical, material, and, of course, electrical engineering peers, and I also learned about these areas through my practical research. I found that my involvement in my thesis work stimulated my interest in engineering subjects outside my major, which was reflected in my subsequent course choices. I chose to take a materials/mechanical course in my second semester that was related closely to my research and this gave me a greater understanding of my research subject.

My previous academic experience had been mainly theoretical and I felt that the more practical work on the thesis helped to consolidate my four years of university education. I found myself drawing on knowledge I had gained previously, which facilitated finding possible reasons for the results which were obtained in my research. Whereas previously in my studies, there was often only one answer to a posed problem, there were, as yet, no definitive answers in the area I was investigating. I found that my colleagues were interested in my ideas, and that my questions could not always be answered by the professors. In the early stages of research on a new topic, I discovered that nothing is set in stone and that further experiments can change everyone’s initial thinking. Being responsible for the research meant that I had an influence on the direction of the project to an extent that I had not experienced before.

One of the surprises in my project was how it was often impossible to set out an exact plan on to how to carry out research as I found that each experiment was revealing new data. Before I arrived, Dr. Stéphanie Lacour already had shown that some samples she had made could be stretched to the desired 10 percent even though there were cracks running across most of the width of the interconnect. In my experiments I found that we actually had two types of sample. One was exceedingly elastic and could be stretched beyond 30 percent. It became apparent that the difference between these two samples was that the flexible set contained tiny cracks on the micron scale. It was hard to trace the difference in technique used to create these two different kinds of samples, but it appears to originate in the surface of the rubber material. The discovery of these super-elastic samples meant that we could test the samples under more strenuous conditions than I would have thought from my experiments at the beginning of the year. It was hard, however, to control which type of sample we produced, and from this I learned that when carrying out a scientific experiment, it is important to be very meticulous in documenting every step that is taken as it is hard to trace back events.

Perhaps the most demanding part of my thesis was deciding the next step that should be taken. So many exciting phenomena were observed in each experiment that it was easy to get caught up in the detail and lose sight of the objective. Although it can be very frustrating to observe something unexpected and not to be able to find the answer, it was also an aspect of research that made the project fun. Asking people in different fields of study would often result in a very different explanation.

For me the most rewarding aspects of working on my thesis was being involved in a research group. I became friends with Professor Wagner’s Ph.D.
students and was aware of the other interesting research subjects they were pursuing. I found their ideas and feedback stimulating and challenging. When I attended a materials research conference, Professor Wagner’s group led the flexible interconnect field, and it was exciting to be a part of it. Another aspect that made my thesis so enjoyable was the interest people took in the subject. People in all areas listen to your opinion and enjoy discussing their opinions with you. I find myself still curious about what is happening in the project and what direction investigations are now taking. It is exciting to think that some of my results may have helped to spark others’ interest in this field.

My work on my thesis and my involvement in the research group have significantly changed my outlook on my future. Although it had never been my intention to go into research, I still find myself itching to be involved in a project and a research group like the one in which I did my senior thesis, and I am seriously considering going back to school to do a Ph.D.

This thesis was the highlight of my university degree. Looking back on my experience, my advice would be to keep your initial objective in sight while having the flexibility to explore other avenues depending on results. Overall I was challenged, stimulated, and encouraged to participate in research in the future.

**Sigurd Wagner**

Professor of Electrical Engineering

“Super-elastic Gold Conductors on Elastomeric Substrates, Catriona Chambers, University College,” reads the title page of a report that describes one of our most interesting research projects in recent years. Catriona is the only student to whom I was freshman, study, and senior project adviser all in one. The “University College” on her reports stands for Oxford University, because Catriona was the first exchange student in engineering under our Oxford-Princeton program. She spent her senior year at Princeton, and her research project had to meet an Oxford graduation requirement.

On September 4, 2002, a week before classes were to start, a tall woman walked into my office and said “Hello, I am Catriona Chambers.” (She said Cat-shona, not Catree-ona as I had imagined from her Latinate name. All year long I didn’t manage to rid myself of my “Latin” pronunciation, but if Catriona was annoyed she didn’t show it.) Because she just had arrived at Princeton, I opted for my function of study adviser and asked for her course selection. She seemed not to understand what I meant. She told me that she had to work for at least 200 hours on a project worth three papers and write a report of approximately 40 pages, and that she must have her project proposal approved by Oxford. And she was very concerned about meeting other, precise, graduation requirements that I didn’t understand. So in our first weeks we together took a crash course on the differences between British and American academic regulations, between the languages that describe them, between the curriculum...
that Oxford and Princeton had negotiated, and engineering reality. We passed this course only by the grace of Catriona’s Oxford adviser, who on September 20 wound up near-daily e-mail exchanges by writing: "... we follow your advice.” My advice had been that Catriona pursue a Princeton program, which meant that she was free to select her courses, and I was free to give her one of my high-risk, not-too-well-defined, thesis projects. I asked Catriona to help us understand super-elastic gold conductors.

I give my undergraduate researchers exploratory, risky, open-ended projects. Seniors are my crack troops. They are smart, open-minded, and motivated. They don’t carry the baggage of experience and don’t know what is impossible. I dispatch them to the frontiers. If they discover something there—perfect; if they don’t—on the march they still learn a way of thinking, a laboratory technique or two, how a lab is run, how a research team works, how to present results. Catriona’s team leader was Stéphanie Lacour, a postdoctoral researcher from France, and her teammate was Joyelle Jones, a Ph.D. student from Louisiana.

Stéphanie had just discovered that films of gold can be made stretchable when placed on a rubbery membrane. This is a remarkable scientific discovery, and also a useful one because it opens the door to making sensitive skin-like surfaces for human prostheses and for robots. These skins will rely on stretchable electronics and wiring as thin as Saran wrap; borrowing a term from integrated-circuit technology we call the wiring stretchable interconnects. Catriona immediately began working in the lab (the key to pulling a good thesis together is to start working on it in September). She learned from Stéphanie how to make gold films on membranes: tricky experiments, these. Stéphanie designed a machine to stretch the skins, measure their electrical conduction, and take micrographs, all to be controlled by computer. Catriona built the machine, installed the software, and set out on her experiments by testing the apparatus on the stretchable interconnects she had learned to make.

Catriona discovered electrical resistance drift in unloaded stretchable interconnects, noticed that they come in two kinds of microstructures, found an electrical cycle at twice the frequency of the mechanical cycle, observed propagation of cracks as they formed, and collected micrographs that simply are beautiful to look at. Catriona turned out to be a first-rate experimenter, imaginative, observant, organized, efficient. At the spring 2003 Meeting of the Materials Research Society in San Francisco she described her work in a talk, and then published her paper in the conference proceedings. Her Princeton project report was accepted at Oxford, where she graduated at the end of June.

Catriona left behind many more ideas for making, understanding, and using stretchable interconnects. And like many seniors before her, she made us catch sight of the ever-expanding frontier of research.
Cinematic Transfigurations of Jesus: A Study of Films by Pasolini and Scorsese

Jessica Collins '02

The Thesis. Call it what you like. There are plenty of creative nicknames a senior can conjure up in an attempt to avoid saying the word. “The big T,” “Mr. T,” “my short paper,” “T-bomb,” “my special friend”… Yes, I actually did hear all of these terms used over the course of the eight months that I was immersed in the senior thesis culture that is so unique to Princeton. A few of my friends even went so far as to set up a policy that required that every time a person uttered the word in their room, he or she was subjected to a fine of 25 cents. Whether you choose to turn it into a capitalist scheme or not, you’ll find that there are innumerable ways to avoid the reality of this endeavor. But do not fear. It can be done. And it is worth it.

Personally, I know that I often find it difficult to take advice from a total stranger, so before I go on I’d like to give you a brief sketch of me as a student so that you know where I am coming from. Generally speaking, I am the kind of student who works up until the very last minute. Regardless of how much time I’ve given myself to work on something, I write and edit until the final hour and typically turn a paper in with less than 15 minutes to spare. And let’s be honest—you may have seen me run across campus once or twice on dean’s date. I also tend to be indecisive and decided to be a religion major sophomore spring after debating between English and religion (and sometimes psychology) for quite a while. (Caveat: I am absolutely confident that I made the best decision and took the maximum number of religion courses allowed.) Junior year I took a wide range of religion courses and focused my independent research in the fall semester on popular religious fiction and my JP in the spring on Paul Ramsey and his Christian ethics of death and dying. To be honest once more, I don’t think my research methodology junior year was very good, and as a result, I found myself a bit over my head when it came to the breadth and depth of the material I was trying to organize and critically evaluate.

I say all of this to specifically encourage those of you who aren’t feeling exactly triumphant or entirely satisfied after your junior year independent work experiences. Trust me, it can and will get better. That was simply the warm-up lap. However, that being said, you should not view the thesis as the race to end all
races. That was my first mistake coming into senior year. First, it’s not a race with your classmates. The senior culture indeed seems to revolve around theses, but I found that I much preferred the moments that I bonded with my classmates in our united effort over the times when we fired our complaints back and forth. The thesis culture can really be a great facilitator of friendship.

That aside, this “race to end all races” misconception manifested itself personally in my initial attitude and expectations in that they revolved entirely around the final product. My goal was to say something important in my thesis. I wanted it to contribute something entirely new to my field. I wanted it to be excellent and virtuous and certainly passable and hopefully more than that—praiseworthy. I was so focused on the product and the intangible idea that my work would be forever bound between two leather covers that I found myself stagnant. I was stuck and bound by my own fear, expectations, and far-sightedness.

I think my adviser, Jeffrey Stout, could see this by the middle of the fall semester, and he called me on it. He reminded me that in approaching the thesis, one should not focus entirely on the product, but rather on the process. This may sound simplistic, and I’m going to mention it several times, but you will see that it is exactly what you need to be reminded of as you attempt to narrow your topic. After having a fairly frustrating experience with my JP, I had decided over the summer to pick a topic that was for one less theoretical and more creative, and second, more interesting to me on a personal level. Thus I thought that it would be great to combine my interest in film (sparked by a freshman seminar in film theory and aesthetics and a religion and cinema seminar) with religion. Junior spring I also realized that I was really interested in theology, and as there was no course offering at that point in time that dealt with theology in depth, I applied for and received a grant to take a graduate theology course in Boston that summer. That experience confirmed that I wanted to add theological elements to my topic. In sum, I decided I would write on theology and film. Hmm.

Does that sound vague? It should. It was at first. But it was generally what I wanted to pursue, and so I did, and as a result, I was actually able to enjoy the pursuit and sustain interest for eight months. (Simple, perhaps obvious advice nugget: pick something you’re curious and/or passionate about.) To return to my initial reason for bringing this up, it was once I believed that the goal of the thesis was in fact the process—not simply the product—that the research itself became purposeful, interesting, and not as stressful. And eventually, through my reading and many conversations with Professor Stout and other film professors, I narrowed down my focus to two films: The Last Temptation of Christ by Martin Scorsese and The Gospel According to Matthew by Pier Paolo Pasolini. (Another advice nugget: do seek out your professors for ideas. Don’t feel like you have to go into every meeting with an answer or a plan. Go instead with questions.) I chose these films because they are the two most sophisticated and, in different ways, controversial films about the life of Christ. Through closely analyzing these films, studying biographical and stylistic details about each filmmaker, and learning more about christological doctrine and debate,
I hoped to draw out and address questions about the ways in which the two films portrayed and challenged orthodox views of Jesus’s nature and identity.

So I’ve talked about the thesis as a process, not a product. I hope that you can embrace that attitude down to the level of instinct. However, you may, as I did, run into a second major freezing point. Writing. For me, starting the writing process was by far the most difficult part. I put it off, I procrastinated, I suddenly (for the first time ever) embraced the concept of the necessity of detailed outlines . . . basically I was scared and overwhelmed. Yet again Professor Stout came to the rescue with these words: “You have to make a mess before you can clean it up.” Like me, some of you may not be accustomed to preparing multiple rough drafts for shorter papers and prefer to spend more time on the front end reading, thinking, and notetaking, and then edit as you go. In January it finally hit home that this would be impossible with the thesis. Simply put, it’s just too long to do that. Be realistic. Expect to make a mess, but leave yourself time to clean it up. I realize now that I had to make a major mess of each chapter for several reasons. First and most obviously, I could then work on expressing things more clearly and eloquently. Second, and more importantly, diving in and starting to write even though I felt unprepared and scared exposed at an early enough stage the roots of some of my basic problems, such as the types of questions I was asking or the poor logic of my answers or arguments. Finally, making a mess is crucial because it helps you see how much you can actually accomplish.

Professor Stout and several of my friends who read my early drafts laugh with me about the contrast between my initial writing and the end result. It is pretty comical. I say that now without any shame (though I definitely felt some of that initially each time I hesitantly placed rough drafts of chapters in Professor Stout’s mailbox), but rather with so much pride.

I think that I initially thought that a great thesis was kind of like the academic version of the MVP award of sports. In retrospect, I think that the award we should be aiming for is the MIP—the most improved. I made some drastic improvements from my junior year in how I asked questions, analyzed, and articulated my answers—and for this I felt most accomplished. Good luck, keep the faith, and enjoy that day in late spring when you do experience the satisfaction that is uniquely and quintessentially Princeton.

Jeffrey Stout
Professor of Religion

I first heard about Jessica Collins from her coaches on the women’s soccer team during her freshman year. They said that despite being too athletically limited to win a starting position on the field, Jess’s strength of character made her one of the most important players on the team. Four years later, one of her coaches told me that she might be the most impressive person to have played...
soccer at Princeton. By then I had taught Jess in one course and advised her senior thesis, so I knew exactly what he meant.

The course was a seminar on “Religion and Cinema,” which P. Adams Sitney, a professor of visual arts, and I taught together during Jess’s junior year. Her first paper for the course was a relatively brief comparative analysis—about five pages, as I recall—of Pier Paolo Pasolini’s *The Gospel According to Matthew* and Martin Scorsese’s *The Last Temptation of Christ*. It would have been hard for anyone to do justice to two films of such aesthetic power and religious depth in such a short paper, but Jess did have a few interesting things to say.

A little less than a year later, Jess proposed the same two movies as her senior thesis topic. And by April, when she handed in her thesis, she realized that she could have written a full-length thesis on either of them. Many students begin afraid that they won’t have enough to say, and discover along the way that they have more than enough to say, that their topics are rich enough to continue demanding more attention, even after the thesis has been handed in.

One thing that Jess had learned from our seminar was that the existing scholarly literature on religion and cinema is not worth a great deal. Most experts in religion who write about the religious dimensions of film don’t know enough about film to get very far. Most scholars specializing in film studies neglect the religious dimensions of cinematic expression altogether. Jess set out in her thesis to raise the scholarly standards that are usually applied in this area. She succeeded handsomely.

In the process of working with Jess, I learned a lot about both of the movies and about their directors. In preparing to teach the seminar with Professor Sitney, I had already studied Pasolini’s handling of the biblical text quite carefully. So I encouraged Jess to discover for herself exactly how Pasolini arranged passages from Matthew and to pay particular attention to what he left out. This turned out to be explicable partly in terms of Pasolini’s Marxism. I also encouraged Jess to figure out what allusions the film contains to Renaissance painting. With help from relevant specialists, she was able to determine which paintings had influenced certain shots in the film. But she also argued, in light of published interviews in which Pasolini discussed the process of making the film, that while he had started out with an elevated style, he quickly abandoned that style in favor of something much more down to earth. This reinforced Jess’s political reading of the movie in terms of Pasolini’s Marxism.

In preparing for a lecture I gave on *The Gospel According to Matthew* a few days before Jess handed in her thesis, I made some discoveries of my own about Pasolini’s handling of the biblical text. The most important of these was that he had inserted the Madonna into the scenes involving Jesus’s last days and crucifixion, in effect conflating the Madonna with the two Marys who are mentioned in the corresponding passages in Matthew. This discovery takes on more significance when one realizes that Pasolini cast his own mother in the role of the Madonna. The psychosexual dimension of the movie became much clearer as a result of this realization, but it was now too late for Jess to take advantage of all this in her thesis. The process of discovery does not always fit neatly into the schedule of deadlines imposed on us by the academic calendar. I think Jess
and I both felt that we would continue learning more even if we extended the process by months or years.

Jess’s analysis of Scorsese’s movie led her in a more theological direction. She argued persuasively that *The Last Temptation* is a serious theological meditation on the doctrine of the Incarnation. What would it actually be like to be wholly human and wholly divine? This is the theological question Scorsese is struggling with. But it brings many other questions along with it. While Scorsese spent time in seminary as a young man, he is no theologian. He is content, as a filmmaker, to leave most of these questions unanswered. Jess made some progress trying to grasp these questions and the leading answers to them, but she also learned how much more she has to learn about this aspect of Christian theology.

This became especially clear during Jess’s final oral examination. James Wetzel, a highly respected specialist on the thought of Saint Augustine, happened to be visiting Princeton during Jess’s senior year. He got to know Jess when she took his seminar on Plato and Augustine. Finding her impressive and being interested in the movies she was working on, he volunteered to be the second reader of her thesis and to join me as one of the examiners for her orals. The exam lasted for 90 minutes, 45 of which were devoted to thesis, 45 to Jess’s coursework in the department. While questioning Jess for 20 minutes or so on her Scorsese chapter, Professor Wetzel did a splendid job of opening up a path of theological inquiry suggested by her work.

So the story of my work with Jess is one that begins with a modest course paper and leads eventually to an excellent senior thesis. But it doesn’t end there. The thesis itself made us aware not only of how far Jess had come but also of how much both of us had to learn. The moral of the story is that the thesis and the exam that follows it don’t really constitute an ending at all. They just mark the point at which inquiry becomes independent in a fuller sense.
At the beginning of September in my senior year, I approached Professor Scott Soames to ask him to advise a thesis on a problem in the philosophy of language that I’d read about over the summer. The problem is sometimes called “the rule-following paradox.” It was alluded to by Wittgenstein in the 1950s, but was first explicitly raised in a book, *Wittgenstein on Rules and Private Language*, by an emeritus Princeton professor, Saul Kripke. I’d read Kripke’s book the summer before senior year, and I thought the problem would make a fascinating thesis topic. Additionally, choosing a problem in the philosophy of language would allow me to work with Professor Soames as my thesis adviser, since language is his area of specialty. I had already taken two semesters of courses with him, and it was clear to me that of all the philosophy professors, he held undergraduates to the highest standard.

From the first time I met with Professor Soames in September to discuss thesis advising, he had me handing in written work every week. The occasional lapse aside, throughout the year I would e-mail Professor Soames about seven or eight pages of material weekly on whatever specific issue we were working on at the time; he would then e-mail back comments he’d written up on my work, and then we would meet in person for about 40 minutes to discuss. A great deal, if not the majority, of what I wrote did not go into the final thesis. Rather, the main purpose of the weekly writing assignments was for me to master some argument or issue raised in a chapter of a book or an article that Professor Soames asked me to read.

Unlike almost every other major, doing original work in philosophy does not require you to run experiments, collect data, or even spend many hours in the library reading what has been thought historically. I only had to read about 20 to 30 pages a week for my thesis. Most of my time had to be spent re-reading these articles two and three times (sometimes many more times!), thinking about the arguments, and then writing and sometimes rewriting commentaries on them.

For the first half of the year, I don’t think I did any work that was remotely original. My weekly written commentaries just rehashed other people’s arguments. Although this certainly helped me to gain a deep understanding of these important
my thesis opened up a line of thinking that I felt I could pursue and that I thought could contribute to philosophy.

arguments and views, I was worried that I was going to have a hard time doing any original work in the whole thesis. From the start Professor Soames had warned me that enough work had been done on the rule-following paradox that by now there might not be much left to make up an original thesis. However, he agreed that we could start the year working on the rule-following paradox and perhaps go on into some other areas of the philosophy of mind and language later in the year.

Over Christmas break, and into the first few weeks of the spring semester, my work began to depart from its original topic and move into different (but related) areas. According to Kripke’s exposition of Wittgenstein, the rule-following paradox plays a main role in motivating a conception of language that is often characterized by the admittedly vague slogan ‘meaning is use.’ The work I’d done though the fall semester ultimately added up to a rejection of the legitimacy of this motivation for Wittgenstein’s view (largely based on other philosophers’ arguments, especially some arguments of Soames’s). My plan for the rest of the year was to offer an original way of understanding Wittgenstein’s conception of language without relying on Kripke or the rule-following paradox. The idea I came up with to find a motivation for the view involved examining primitive communication in animals.

Aside from trying to analyze meaning in animal communication, I considered how language would change and evolve as humans began to communicate. My hope was to find here a new source of support for Wittgenstein’s theories of meaning. In the end, although I didn’t give Wittgenstein a full vindication, considerations from evolutionary biology were able to lend new insights into Wittgenstein’s views.

I did have to do a little extra reading in the spring to bring myself up to speed on animal behavior and communication. I also met with an ecology and evolutionary biology professor, James Gould, to talk about these topics a little and to get his advice on how to learn more about the area. But actually, many philosophers of language have long been interested in biology and what it can show about meaning and representational content, so I was able to glean most of the best data for my purposes from articles written by philosophers.

Having started with my focus on Kripke’s work and ended up getting more into Wittgenstein’s own views, the chapters of my thesis were less unified than they might have been had I known from the start where my work would take me. Of course, we cannot be certain from the start what views our research will support, else our work would be biased. But the project that is started with the thesis doesn’t need to end when the final paper is handed in. The value of my thesis for me was that it opened up a line of thinking that I felt I could pursue and that I thought could contribute to philosophy. I hope to continue the work I started in my thesis, as well as the method of working, as I continue to study philosophy in graduate school and throughout life.
Sinan Dogramaci had taken two of my undergraduate courses during his junior year, and I knew him as a talented and highly motivated student with a genuine curiosity about philosophical problems. When he said he wanted to work with me on Wittgenstein’s rule-following paradox, I was both pleased and apprehensive—pleased because of his ability and dedication, apprehensive because I wasn’t sure that his enthusiasm for the topic would bear fruit. In simplest form, the paradox goes something like this: whenever we use a word meaningfully, we presume that it has a meaning that provides standards for its correct application—standards that govern, not just the relatively few situations in which we have already used the word, but also the indefinitely many new cases in which we may want to apply it to objects we have never before encountered. What guides us in applying the word to new cases, and what determines the correctness or incorrectness of any such application? A natural answer is that the rules that give the word its meaning, and that one masters when one learns it, do this. But then Wittgenstein asks, “What are these rules anyway?” If, as one naturally supposes, they are instructions for how and when to apply the word, then in order to be effective they must be understood—which presupposes that they too must have meanings which incorporate standards for the correct use of the symbols they contain. Thus, the same questions that were posed about the word we started with, can now be posed about the rules that were supposed to answer those questions—and so on, ad infinitum. At some point, there must be words, or symbols, that are understood in the absence of any meaning-giving rules that govern them. Presumably, for these primitive, un-rule-governed symbols, it is simply a brute causal fact that we happen to apply them in certain ways, and not in others. But surely, the mere fact that we are strongly inclined, or even causally compelled, to apply a given word to a certain object doesn’t make that application correct. As Wittgenstein insists, in order for a word to be meaningful at all, there must be at least a potential difference between one’s application of it being correct, and one’s merely thinking that it is correct. The paradox is that although something independent of our inclinations, and the causal forces that propel us, must determine the correctness or incorrectness of our applications of words, none of the obvious candidates for what this might be seems up to the job. In Wittgenstein’s view, the only way to solve the problem is to recognize that the speaker can’t mean anything on his or her own, in isolation from the larger linguistic community. There is, as he puts it, no private language. Rather, the essence of meaning lies in the interaction of different members of a linguistic community, and to use a word correctly is to use it in a way that agrees with its use by others.

That was the problem Sinan was interested in. What gave me pause was that, as a result of my own study of the issues, I had come to believe that the problem was not really one but two. The paradox can be resolved independently of the Wittgensteinian solution, and the social conception of language he champions requires some compelling motivation over and above its relation to the para-
dox. Where that motivation might be found is quite unclear. What, I wondered, would Sinan’s response be, if, and when, he arrived at this parting of the ways. I need not have worried. After diligently mastering the standard background literature, he reached the point I had envisioned, while retaining his conviction that there was something right about Wittgenstein’s social conception of meaning that stood in need of vindication.

With this in mind, he turned to two independent bodies of literature that he thought might contain clues to what he was looking for—work on animal communication and analyses of social convention (like driving on the right-hand side of the road). The key idea came from the analysis of convention (due to the late Princeton philosopher David Lewis) as a regularity in the behavior of members of a community which (in addition to meeting certain conditions) solves a coordination problem for the community—i.e., a problem of coordinating the behavior of its members in a way that satisfies a substantial group interest. Sinan first applied this idea to animal communication systems, explaining why it is that a certain type of slap of a beaver’s tail can properly be said to mean danger, and why a particular dance of a honeybee is properly described as meaning that a source of food can be found at a certain location. In order to be meaningful, these primitive gestures don’t have to be instances of rule following; they don’t even have to be intentional acts guided by the beliefs and cognitive attitudes of the agents. What they have to be is instances of a regular pattern of behavior which solves a coordination problem for the community. Roughly put, for the slap of the beaver’s tail to mean that there is danger in the area is for slaps of this type to regularly cause a certain pattern of behavior in the other beavers (hiding in their lodges) which satisfies a compelling group interest (survival) in cases in which there is danger in the area. With this idea in place, Sinan explained how something similar could be viewed both as providing an essential foundation for the most elementary parts of human language, and as incorporating significant aspects of Wittgenstein’s social conception of meaning.

The end result was sophisticated, illuminating, and original. More important than that, however, was the way Sinan stayed engaged with the issues. Having had an initial idea, and mastered the relevant background, he reached a point where he had to leave the well-trodden path and strike out on his own.
experience on the senior thesis, Sinan should have a good idea of what we philosophers do and why we do it, as well as of what we expect from ourselves, and of the standards by which we are judged. It is gratifying to know that one has had a hand in bringing a student to this point, and, in Sinan’s case, to know that he shares my fascination with the subject, which he is now pursuing at a leading graduate department.
I have to admit, the idea of writing a senior thesis filled me with dread the summer before my senior year. As a chronic procrastinator, I couldn’t fathom the thought of writing 100-odd pages in a night or two. I would have to think in advance. Plan chapters. Write chapters. Edit chapters. Connect chapters. Like I said, dread.

By that summer, though, I uncharacteristically had already begun my planning. Over the course of my three previous Princeton years, my coursework and summer jobs had sparked a real passion for issues relating to development economics and global poverty reduction: I was appalled when I first learned about the absolutely miserable conditions of huge swaths of the world’s population, and was fascinated by the world’s policies to try to ameliorate those conditions. At the same time, largely through the experience of the Humanities Council’s outstanding “great books sequence,” I developed a love for philosophy and, specifically, ethics. Luckily, the flexibility of the Woodrow Wilson School program allowed me to combine those dual interests in deciding on the topic of my senior thesis.

In a remarkable and wholly unique act of early decision-making during my junior spring, I elected to write my thesis about the ethical underpinnings of American development policy. Next step was to find an adviser. Here I faced a choice: I could ask an economics professor who would direct me towards the most cutting-edge empirical research in development. That would mean I could really probe the economics of the situation, but possibly at the expense of the really fundamental ethical issues. Since I had resolved to look at “underpinnings,” such a trade seemed too costly. The alternative was to ask an ethics professor who could point the way towards the philosophical literature on the subject. I would have to run roughshod—out of ignorance—over some of the fundamental economic issues related to poverty-reduction. But I would be able to delve into serious moral considerations. Choice made. With a year to go, too! Note well, ye who would wait until November of senior fall to decide on a topic. Even I, king of the Wa-hoagie-inspired late-night paper, made this decision early….

I had been extremely impressed a year before, in my “Practical Ethics” precept, with Professor Peter Singer’s skill at explaining complex ethical issues, his extraordinary ability
to raise challenging questions, and his respect for diverse opinions. I also got along well with him personally, and our relationship had continued at the Human Values Forum. Asking him to be my adviser seemed like an easy choice, but I had to find out if he agreed. Luckily, Professor Singer acquiesced when I bounded into his office one spring afternoon to propose my vague topic: “ethics and development!!!”

Thus began my thesis experience.

That summer, working for the Carter Center in Atlanta, I received a great education in how development policy is actually implemented, and was steered towards many excellent economics sources that became the base research for the thesis project. By the time I returned to Princeton in the fall, I had a ton of great thoughts in my head, and nothing on paper except my name and a working title. “THESIS (need clever title).”

Luckily, that’s where Professor Singer became a huge resource. He insisted that I stop outlining and re-outlining, and actually get a chapter down on paper as early as possible. My instinct for procrastination kicked back in, and I didn’t actually turn in a chapter draft until after first semester exams. And what a draft it was. Professor Singer returned it to me, trying gingerly to let me know during our meeting that parts of it were too vague, other parts unnecessary; a lot of bloated sections, a lot of holes in my arguments. I returned home, worried about the feasibility of my ideas. It was only later that I recognized how crucial that meeting was—it made me realize that Professor Singer was taking my writing seriously, and was treating it with enough respect to critique it seriously, too. I had not yet learned, however, to construct a really rigorous ethical argument, and I hadn’t realized the importance of stylistic clarity to aiding such an argument. Over the next several months, as he returned comments on other chapters to me and met with me to discuss my progress, Professor Singer taught me those skills. The thesis experience, then, generated improvements in my analytic ability and my writing skill as well as the actual 125-page behemoth.

Once the writing was really flowing, I was extremely grateful for Professor Singer’s guidance. He lent me books that raised challenging ethical issues to make me approach topics on a more sophisticated level. His comments on my drafts were wonderfully thorough, and his suggestions for improving my arguments were always probing. His insistence that I narrow my scope was essential—my final thesis, narrowed significantly from the original “ethics and development,” was still quite a broad approach, and I can’t imagine what I would have produced without the narrowing (either a totally abstract thesis without any correspondence to actual reality… or 400 pages).

My thesis experience really made my senior spring enjoyable. Sure, it was a lot of work. But it was the sort of work that really exhilarated me. (Take note, again, soon-to-be thesis writers: If you treat the thesis as a hoop to jump through, it’ll sprout flames. If you treat it as an exploration into an issue you care about, it will be the best thing you do at Princeton.) I became entirely nocturnal for the last several months: when I would e-mail Professor Singer a chapter draft at the conclusion of a night of work, he would often respond immediately to let me know he had received it, having just arrived in his office.
for the morning. Those late nights hold some of my fondest academic memories at Princeton: sitting back-to-back with my roommate as we worked at our respective desks; going on brief study breaks to the Wa with friends (I think I must have gained 10 pounds over thesis season! Luckily, I’ve since shed the extra thesis-girth); swapping chapters with buddies to proofread; chatting over meals about our respective topics.

And that’s saying nothing of the intellectual stimulation of grappling with fresh ethical arguments and trying to make convincing, readable, and equally fresh responses to those arguments.

Even at the height of thesis time, when I could feel the deadline press down on me, I found myself marveling at the experience. Of course, I was lucky: I had chosen a topic that not only held my interest the whole time, but excited and motivated me to get back to work every day. And I was graced with an adviser who was equally motivated to help me along—his enthusiasm for the project made a big difference. I was fortunate, too, to have had the summer before senior year to get motivated and begin thinking about what I wanted to write the next year. Now looking back on the entire, long process, the joy and the pride far outweigh the stress and worry that any project as massive as a thesis can bring. See? The dread’s all gone!

Now, shoot, I’d better come up with a master’s thesis topic!

---

Peter Singer
Ira W. DeCamp Professor of Bioethics
in the University Center for Human Values

**When Princeton students first come to see me** for advice on their senior thesis, some of them are nervous. They are intimidated by the thought of writing such a long piece of work (as it seems to them) and wonder whether they really have the capacity to do some worthwhile research. Others are all fired up, full of confidence and eager to get on with a project that in their mind’s eye they can already see as an ironclad defense of one of their favorite ideas.

With the former group, it is rewarding to see their confidence gradually develop, as they find that they do have something to say. Often they switch, in a month or two, from wondering how they can possibly fill all those pages, to making hard decisions about what part of their topic they are going to have to omit, since it is clearly impossible to cover it all in such a short piece of work. Since Princeton undergraduate courses tend to be broad rather than deep, it is good to see students learning what it requires to really understand an issue thoroughly.

With those who start full of confidence, the problem is often to bring a little realism to their ambitions. They want to use their thesis to solve a major problem on which leading scholars have written large books. They need to realize that while the senior thesis gives them more scope than anything else they have written so far, they still must focus quite narrowly if they are going to be able to do more than summarize the work of others.
Matt Frazier was one of the confident ones—and not without cause. I had got to know him in spring 2000, when he took my “Practical Ethics” class, and was in my precept as well. He was obviously a very bright and hardworking student, and did very well. He joined the Human Values Forum, a student-faculty discussion group sponsored by the Center for Human Values, and I saw more of him in those discussions. He also gave me his junior paper to read, on “International Morality and Humanitarian Intervention.” It was a remarkable piece of work, better than some published discussions. So when Matt asked me to supervise his senior thesis, I had no doubt that he could do something good. I was delighted when he said that he wanted to write on one of the great moral issues of our time: the obligations of rich nations like America to the world’s poor. But no matter how bright and hard-working Matt was, there was always the question: How can he write a senior thesis that will make a real contribution to such a huge topic?

Matt didn’t really need a lot of help from me. He knew what he wanted to do, and he had a good idea of how to go about it. I had to push him a little to keep the topic within bounds. Then I gave him some guidance on the literature regarding our ethical obligations to assist the poor. Finally, of course, there was feedback on the draft chapters as he produced them.

What I liked most about the thesis was the blend of factual information and ethical argument. Of course, in applying ethics to the real world, we need to consider the framework of values we will use, and then present the facts we consider relevant. Matt showed how a wide range of possible ethical views—Christian, Kantian, and Utilitarian—all pointed to a duty to assist the world’s poorest people. He did a superb job of probing the relevant arguments. The extent of his reading was astounding, and he marshalled what he had read very well. He looked at all the major problems people see in using foreign aid to reduce poverty. He covered possible philosophical objections from contractarians, realists, and libertarians, as well as economic arguments that trade, not aid, is the most effective way to alleviate poverty. In each case, he gave responses that showed why the objections were not conclusive. The result was a genuinely interdisciplinary thesis that covered ethics, political philosophy, economics, and studies of development and poverty in specific local contexts. This enabled him to conclude with a set of positive suggestions about what should be done to alleviate global poverty.

Advising Matt was a stimulating experience, from our first conversation to his outstanding oral presentation. My only regret is that I have no way of making Matt’s thesis required reading for every member of the United States Congress.
I hope you will find your thesis experience to be as positive as I found mine. Looking back, I never thought I was actually enjoying myself—because I was not—but now that everything is said and done, the cliché holds true for me: my thesis really was my defining academic experience at Princeton.

When I first arrived at Princeton, I had intended to major in chemical engineering (haha!) but it was not long (actually, it was—it took two years) before I realized that I was not interested enough in molecular structures to want to spend four years studying them. So, towards the end of sophomore spring, I enrolled in the Department of Sociology. Having no background in the discipline, and not being a fan of extensive research and writing, the idea of a junior paper and, subsequently, a thesis, led me to have serious misgivings about whether or not I would be able to produce anything of value, or, indeed, anything at all. But I did produce something, and if I can do it, anyone can.

Thanks to the junior seminar conducted by Sara Curran, I was able to get an idea of what was expected in junior independent research, and I was monumentally fortunate to have Robert Wuthnow agree to be my adviser. (I was doubly fortunate to have him advise me again for my thesis.) One of the beauties of the sociology department is that you can pretty much study whatever it is you want to study, and my interest at the time lay in contemporary evangelical worship. I wanted to know, and I will be frank about this, for personal, rather than academic, reasons, what made worship tick in modern evangelicalism.

While my junior independent research, which was a profile of a 24/7 worship and prayer movement in Kansas City and its role in the development of contemporary worship, led me down one very engaging path, my thesis research led me down another. I elected to study a college movement known as Passion, which aimed to foster an attitude of worship among college students. Although initially I had intended to focus on the style, specifically the music and lyrics, of the worship, eventually my thesis turned to the evolution of worship, culminating in the role of the Internet as both a bridge and a divider. This turned out to be of both personal and academic interest to me, and I was excited and pleased with what I had discovered.
In addition to miraculously churning out just over 100 pages of double-spaced text, I learned a lot about research, time management, and even about me. Here are a few things I am thankful for.

1. I HAD AN EXCELLENT ADVISER.

As someone who had no real experience doing research, I was very grateful to find as strong a mentor as I did in Bob Wuthnow. The man is a mine of information and resources, and never ceased to amaze me. Whenever I went to see him, he would throw me names of authors and books, as he put it, “off the top of my head.” He replied to e-mails within a day (two at most), calmed me down when I was panicked, pushed me when I was slacking, and, above all, criticized my work without ever making me feel like he was criticizing me. He truly let me conduct independent research, and I cannot imagine my thesis experience, or my thesis, being what it was without his advice and guidance.

All this is just to point out that even more important than your topic is your adviser. Your topic may change throughout the course of the year, but your adviser will not. Find an adviser who shares your interests, and be flexible about the way your ideas develop. Also, try to find an adviser who is accessible, if not in person, at least over e-mail. One way to do this is to ask around in the department, talk to other majors, recent alumni, or grad students.

2. I MANAGED MY TIME PROPERLY AND MET MY DEADLINES.

Some people might not have been overly thrilled with all the deadlines that the department set for us, but I personally found them very useful. Knowing that I needed an outline, or a chapter, by a certain date, ensured that I was never working at the last minute as April approached. In fact, I had my entire thesis written by the end of March, a month before the final deadline, and spent that last month doing minor revisions while some people I knew had just started writing. I write that not as a boast, or to gloat, but in recognition of the value of deadlines. I am a person who tends to panic (just ask my roommates), and were it not for those deadlines in January and February, I would have spent all of March and April frantically typing with shaky hands while steadily going mad. As it was, I managed to accomplish the latter just fine.

3. I HAD GREAT FRIENDS WHO PROVIDED SUPPORT, ENCOURAGEMENT, AND A KICK IN THE PANTS WHEN NECESSARY.

In addition to your roommates (your pillow if you live in a single) and friends, I highly recommend seeking help and support from people who do not have a thesis to write. Be sure to find those who will be helpful, and not those who will gloat that they can go out and have fun while you spend the weekend locked in your carrel or room. Bounce ideas off them, wake them up at 3 a.m. and tell them you have writer’s block (they are probably still awake, anyway), ask for help proofreading, and if you are lucky, they may bring you freshly baked cookies, or even do your laundry for you.

Of course, if I had to relive the experience, there are some things I would have done differently.
1. I would have utilized the breadth and depth of resources available to me.

A library training session during my junior year had introduced me to some of the resources available in Firestone, but since I was writing a qualitative thesis that did not require too much data analysis, I did not really bother with it. Big mistake. From time to time, my adviser, or Joan or Kelly, the graduate students who were conducting the sociology senior thesis workshop, would give me names of people who might be able to help, or books I should look up, most of which inevitably got lost among my notes, or that I just did not bother with. Another big mistake.

Had I made use of those resources, instead of being lazy or assuming that something would have been of no use anyway, I would probably have made a lot more progress a lot faster than I did, not to mention have made a few more friends. On a separate note, here is another tip—apply for thesis funding!

2. I would have relaxed more, instead of worrying so much, and made the most of my last year at Princeton.

Four years at Princeton, and not once did I use up my Tiger Tickets (I know, there is really no excuse for the first three years). Plays, dances, performances came and went, and I missed them because I thought I needed to work on my thesis. Of course, I stayed in and spent the time procrastinating and moping that I was staying in. There were classes I wanted to audit, and lectures that I wanted to attend, simply to hear a certain professor speak, but I was too sleepy in the mornings because I had stayed up half the night staring at a blank Word document, or, even worse, deleting something I had written because I was not happy with it. Four hours of sleep, bad; eight hours of sleep, good.

At the end of the day, no one really remembers the thesis itself, the books we read, or the arguments we made; what we remember is the experience, and how much we had to spend on binding. And what I remember about my experience is that it was good (yes, even the binding). Above all else, have fun with your thesis—it is your opportunity to study what you think is exciting and worthwhile, so run with it!

Find an adviser who shares your interests, and be flexible about the way your ideas develop.

Robert Wuthnow
Gerhard R. Andlinger ’52 Professor of Social Sciences

For many years I have advised students at Princeton to avoid large lecture classes, except where there were overwhelmingly compelling reasons for taking them, and reap the full benefits of being at Princeton by taking small seminars, participating actively in precepts, and doing tutorials with individual faculty members. Junior papers and senior theses are among those opportunities to exploit to the fullest. I have talked with many alumni who cannot remember a single lecture they attended, but not one who doesn’t remember his or her senior thesis.
As a faculty member, I am not embarrassed to say that some senior theses are much more enjoyable to supervise than others. The ones that are most frustrating typically begin with something like, “Hello professor, I was told to come see you. I don’t know what you teach, but could you give me an idea to work on for my thesis?” Then the student toys with one idea after another until sometime in January, panics, and works frantically to catch up. Those are usually the students, too, who have somehow failed during their first three years at Princeton to learn how to use the library. They think the faculty adviser should have an instant bibliography on any topic ready to communicate on a moment’s notice. The more enjoyable theses are usually ones that have started percolating well in advance. The student may be daunted by the prospect of writing such a lengthy document. But he or she is intellectually curious, capable of doing independent research, convinced that the topic is worth pursuing, and dogged enough to pull it off.

I take very seriously the idea that a senior thesis should be independent work. When students come in still struggling to decide among several topics, I try to help them think about the pros and cons of each topic, but refrain from saying which one I think they should choose. During the process, I generally tell them where they can look for information, rather than suggesting exactly what they need to read. I also think of myself as a coach more than as a judge. If a student seems to be doing B work, I try to push them to do A work. If they are clearly doing excellent work, I try to push them a bit harder to think outside the box or wrestle with difficult questions. Independent work also means that it is acceptable for a student to write on something that is of purely personal interest. Over the years, I have worked with students writing about their home town, the store they worked at during high school, the congregation they grew up in, their favorite composer, some illness they had faced, and a career they were thinking about entering. I have had a few students write theses that could have been (and sometimes were) the makings of an article in a professional journal. But there will be plenty of time to write for other people and for other purposes. The senior thesis may be the only time to pursue an interest that has been developing from one’s life and personal experience.

Because my teaching and research areas include sociology of religion, I routinely advise senior theses by students who are personally interested in or committed to one particular faith or another. When I first began teaching (in the 1970s), such students were sometimes faced with faculty who said they couldn’t write about these topics or, if they did, needed to be scientific and therefore skeptical in their approach. I seldom encounter that attitude anymore, either among faculty or students. Many of the students I advise, in fact, go on to study at seminaries, or pursue careers in service or ministry, or engage in volunteer service inspired by their faith.

When Rachel Gong asked me to serve as her senior thesis adviser, I was pleased to say yes because her topic fell generally within the subfield of sociology of religion and I figured I probably knew the literature well enough to be helpful. She struck me as a very serious and intelligent student who would be capable of working largely on her own. I no longer recall some of our initial
conversations about various possible topics, but, if memory serves, Rachel settled fairly early on writing about a new campus religious movement called Passion International. Movements are always good topics for senior theses in sociology because they embody some interesting new social phenomenon that can be described and perhaps explained. Social movements also invite students to think about changes going on in our world and how things may be different than in the past. I encouraged Rachel to read about this movement on the Internet and see if she could track down some of its leaders and some students who had participated.

The difficulty with a thesis of this kind, though, is that it is rather difficult to define in advance and thus hard to think about methodologically. It’s not a matter of securing a survey dataset and running crosstabs or setting out to interview a dozen people in a couple of different categories. Thus, I have to admit in retrospect that I was a bit nervous about how well Rachel would be able to pursue her topic. As it happened, she turned this difficulty into a strength. The methodology turned out largely to be inductive. She learned as much as she could from movement Web sites, then attended some of its events, and interviewed leaders to learn about some of its less visible operations.

What made this a superior thesis was Rachel’s ability to frame the movement in larger terms. I no longer have the thesis in front of me, but as I recall it posed the interesting question of why this campus religious movement emphasized *worship*—and, indeed, a fairly emotional form of worship—whereas most other campus religious movements have emphasized small group interaction, study, and prayer. Rachel then did quite a bit of historical reading about periods in the past when changes in religious emphasis took place and linked her research with studies describing shifts in American culture and religion more generally.

Every senior thesis adviser worries as much as the student does (well, maybe not quite as much) about what the second reader’s reaction will be. Professor Mario Small was the second reader on this one. And I was almost as delighted as Rachel was when Professor Small found all sorts of interesting connections in the thesis among religion, music, and ethnicity, as well as with some of his own personal experiences. We both suggested some ways that Rachel might be able to shorten the thesis and publish parts of it as a journal article. But whether that happens or not, I am happy with the fact that Rachel pursued a topic that was of personal interest, found ways to associate that interest with the literature in sociology, and learned a great deal about research and writing.
Many people today routinely save all their e-mail and chat messages, and the cost of storing such data is falling by almost 50 percent every year. At this rate, in the not-so-distant future, we will be able to save everything we see and hear our entire lives. When recordings cost almost nothing to make, there will be an incentive to store everything that might possibly be valuable later, and people could carry around portable audio or video recorders to give them a complete record of their experiences. These developments will have many beneficial uses as an electronic extension of human memory, but they also pose serious threats to privacy. If you record your own life, you run the risk that your recordings will someday be used against you. Even if you don’t record anything yourself, you will be recorded by many of the people with whom you interact as digital recording technologies become increasingly ubiquitous.

Professor Edward Felten and I discussed this dire outlook in his office at the Computer Science Building in September of my senior year. Having taken Professor Felten’s information security course as a sophomore, I knew he was an engaging teacher and a renowned expert in the computer security field. He shared my concern about technological threats to privacy and agreed to be my adviser as I worked to develop measures for protecting privacy claims in digital recordings.

This project was an ideal subject for my senior thesis because I had already acquired a strong interest in computer security research from my coursework and junior independent research. To solve the problem, I would need to overcome technical and social hurdles. It is generally much easier to disseminate information than to keep it secret, so protecting privacy is naturally difficult. Furthermore, researchers at Princeton and elsewhere who were developing recording technologies needed to be convinced to include privacy protection as part of their designs. Despite these challenges, I knew my research would be rewarding because it dealt with an important practical problem and gave me an opportunity to make a positive contribution.

I spent much of the fall learning about systems for protecting privacy in related problems and thinking about how best to focus my work. I needed to narrow down my subject from a broad question to a more specific problem that could be addressed using the methodology of computer security. In these early months, the various thesis “checkpoints” established by
my department were quite helpful. I was required to give a short presentation or submit a written report on my progress about every six weeks. Although these milestones seemed like a hassle at the time, they forced me to stay on track, keep my project goals in sight, and improve my organization.

By winter break I had a clear view of the goals for my privacy protection system. To ensure privacy, it would need to require the permission of the people who had been recorded before any recording would be replayed. Additionally, it had to allow these individuals to choose not to grant permission without letting others know for certain that they denied it. This would protect the participants from being coerced into allowing playback. My most intense research efforts took place in January and February, when I worked closely with Professor Felten and graduate student Brent Waters. In a series of long discussions, the three of us specified the problem in precise mathematical terms and invented a cryptographic protocol that would be the core of the solution. For me, this experience was a crash course in security design, but I came away with much greater confidence in my research abilities.

I began the actual writing for my thesis in mid-March in preparation for an early May deadline. Future thesis writers take note: careful organization and extensive outlining are essential to the process. Prior to my thesis, I had never written a paper as long or over such an extended period of time, and my normal writing habits, which involved less planning, couldn’t scale to the task. You should also remember to spend most of the paper writing about your original ideas rather than dwelling on background material. I learned much in my research, and it was tempting to put everything in, but I had to work to get readers up to speed quickly so I would have enough space for my own ideas. Finally, make sure you have friends with good eyes to help proofread. I enlisted my roommates, parents, and grandfather for typo spotting.

During spring break, I put pen to paper from the beach in Bermuda. For months I had expected the writing to be a daunting task, but almost immediately I realized that I would have no trouble filling the pages. On the contrary, it would be a challenge to say everything I had to say in the space allowed. I started with some background about future threats to privacy and technologies for protecting privacy, then wrote about the security protocol and gave proofs that it worked. I also discussed how it would be used as the basis for building a privacy protection architecture, including details of a proof-of-concept implementation. In the last chapter, I considered how technical measures like mine would need to be combined with advances in policy and shifts in social norms to guarantee protections for privacy in the long term. When all the work was done, I felt the exhilaration of finishing one of the most important achievements of my college years, but I knew it wouldn’t be the last time I’d work on the problem of privacy protection.

My senior thesis was the culmination of my maturation from a student to a student-researcher. I wanted to pursue computer science research in graduate school even before the thesis, but writing it convinced me that computer
security would be the focus of my ongoing studies. One of the most important experiences I had during the thesis process was the opportunity to work with Professor Felten and his graduate students. This gave me a sense of what life was like in the computer science department and helped me decide that I wanted to remain at Princeton for my graduate work.

Now, as a first-year grad student at Princeton, I am continuing my work on the problem of privacy protection with Professor Felten and others in the department. Felten, Brent Waters, and I are preparing a research paper based on my thesis that we hope will be published in the spring of 2004, and I’m working closely with researchers who are designing new recording technologies to make sure security and privacy concerns are addressed from the outset. Using the skills I learned as an undergraduate, I hope to continue to conduct sound, socially beneficial research.

Edward Felten
Professor of Computer Science

Alex had done a wonderful junior paper, and we were all expecting great things from his thesis. I was thrilled when he chose me as his adviser.

A great thesis starts with a great topic, and effort spent on weighing or refining candidate topics is seldom wasted. My first meeting with Alex was a long and winding dialogue about possible topic areas, looking for a match between his interests, my interests, and our joint vision of what is important in computer science. We found a topic that excited us both and touched on an important social issue: the privacy implications of personal recording devices.

We could see that recording devices, such as cameras and audio recorders, were getting small enough and cheap enough that people could carry them around and use them all the time. Ordinary people might soon record most of what happened around them. Cheap recording technology has many benefits (ask any camcorder-wielding parent!), especially if the recordings can be stored, processed, classified, and searched with the help of a computer. But if this technology is adopted universally, public places will become zones of surveillance, recorded not by Big Brother but by the collective actions of ordinary people. Alex’s task was to decide what, if anything, could be done technologically to mitigate this threat, to restore the zone of privacy that technology trends were threatening to erode.

One of the many differences between a thesis and ordinary homework is that in a thesis, the professor doesn’t know the answers in advance. To me, that’s one of the main attractions of supervising theses. Although I sometimes learn from students’ homework answers, I have never failed to learn something new and valuable from supervising a thesis. And Alex had chosen a topic I would have loved to address myself. I couldn’t wait to see what he discovered.

Having chosen a topic, it was time to get started. For many students, this is the hardest stage of the thesis. The task is so large and so open-ended that it’s hard to figure out how to get started. The obvious first steps all seem inadequate, so paralysis can easily set in. Usually, the obvious first steps are inadequate, but
you need to try them to find out why. A few nudges from the adviser are almost always enough to get things moving.

The early stages were especially important in Alex’s case. We knew he was going to design a technology, but we weren’t sure what exactly that technology was supposed to do. We knew it should protect privacy, but what did that mean in concrete terms? Privacy is a notoriously slippery concept. Alex had to convert an amorphous desire for privacy into a set of specific technological requirements. Those requirements had to be achievable by a real system that Alex himself could design, in a few short months. And the system had to be easy enough to use that ordinary people might be willing to adopt it.

Alex ended up settling on two technical requirements: (1) any release of a recording after it is made requires the consent of all who were present when it was made, and (2) the entire process must be anonymous, so that parties never reveal their identities to each other. This is not easy—you must be able to verify that everyone in the group has consented, but you’re not allowed to know who is in the group, and some members may be trying to cheat!

How to do this was the trickiest technical problem Alex faced. The solution lay in cryptography (“crypto”), the mathematical theory of how to communicate secretly and reliably in the face of hostile adversaries. Alex’s guide through the thickets of crypto theory was Brent Waters, a graduate student who specializes in advanced applications of crypto. Alex and Brent spent many hours together at the whiteboard just outside my office, and ultimately, they found a satisfactory method. Alex’s design was complete, at least in theory.

It was time for theory to meet practice: Alex had to take his theoretical design and implement it in a real system. This is a crucial step, because building a prototype is the only real way to know that you have thought of all the practical problems a technology will face. Alex devised a clever way to try out his design by putting a thin “wrapper” around AOL Instant Messenger, a popular online chat service. Online chat involves multiparty conversations, with parties entering and leaving during a conversation. There are real privacy concerns about the recording of chat sessions. Alex’s prototype was a privacy-enhanced version of Instant Messenger chat that allowed recording of sessions, subject to the safeguards he had devised. After a brief shakedown period, the prototype worked quite nicely.

Now that the technical work was done, it was time for Alex to write, to turn his outline into fully formed chapters. This is another point at which many students are paralyzed by the size of the task before them. I gave Alex my usual advice: if you can’t figure out how to start, just pick a chapter and fill it with text. Don’t worry much about grammar, spelling, or structure—plan to delete the text at the end of the week. I’m not sure why this works, but it does. You might expect the resulting text to be awful, but invariably it’s pretty good. At the end of the week you have plenty of text, and almost all of it is first-draft quality.
I don’t know whether Alex needed to use this trick, but I know that in the end he produced a clear, well-written thesis. It was a complete package: an interesting and important topic, a clear link between technology and its social impact, a subtle and elegant theoretical design, and a working prototype, all wrapped up in an engaging document. It sits on my shelf as a reminder of Alex’s accomplishment and of my own vicarious role in his intellectual adventure.

The end of Alex’s thesis is not the end of this story, for the technology he designed has since been adapted and extended, by Alex and others, to work with wireless portable audio recorders. Soon, if you visit the Computer Science Building, you may see people walking around with microphones pinned to their lapels and wireless audio recorders in their pockets. Don’t worry; the recorders will safeguard your privacy—thanks to Alex and his thesis.
The senior thesis didn’t really offer me any unprecedented challenges—but it’s also fair to say that I’d never before confronted anything like it. That is, I consider my thesis above all a distillation of all my previous academic work into a single cohesive product. And I do mean “distillation”: not everything I had done over the course of three years at Princeton played into a single paper, clearly. However, those ingredients that most strongly defined the development of my critical faculty for independent thought from the beginning—from an odd class on the Bible I took sophomore year, to research directly related to my topic that I had done for a junior paper—all figured notably in the concoction of my senior thesis.

Indeed, I do think that the thesis is ultimately about forging a mode of critical thought rather than producing a particular substantive breakthrough. Reading through my thesis now many months after its completion, I’m not surprised to discover in it minor insights I had long since forgotten. Rather, I’m surprised to discover a strong voice of my own. By spring of my senior year, I’d read thousands upon thousands of pages of literature and criticism from some of the finest minds of recent centuries. In response, I’d belched out a couple hundred pages of essays for various courses and requirements. Yet the thesis forced me to set all that aside, and to simply speak for myself. The thesis meant it was no longer time to respond, but to provoke. However, in so doing, I felt most rewarded not by meeting that new challenge. Quite the opposite, I felt rewarded by discovering that I had already met the challenge. The past three years had not been for naught! Embedded in all that previous work was a readiness to take on an original critical project of my own. So, to those about to begin a Princeton thesis, I recommend to you some confidence in what you’ve already done. Chances are you’ll find that you’ve already done the hardest part of the job before you even start.

I suppose there’s one exception to my “the-hardest-part-is-over” suggestion: finding a topic. For all the enthusiasm I’d worked up for Latin American literature (as you will hopefully have done for your chosen field), it was daunting to find something of just the right scope and depth to take on for a
year-long assignment. I took an odd tack: I first defined my thesis in the nega-
tive. I decided that, no matter what, I was not going to write my thesis on the
author Jorge Luis Borges. Dominating figure that he was in 20th-century letters,
I’d done extensive work on his writings throughout my time at Princeton. By
that point, it was time for something new. I began by defining a loose corpus
of novels from the Río de la Plata region that provoked debates quite distinct
from what my junior papers, at least, had covered. As I considered questions
of history, politics, aesthetics, and genre present in the texts, I became quite
overwhelmed by the breadth of what I could do. Ultimately, I settled on looking
at certain structural questions of narrative that had resonances, but no direct
parallels, with some of my past seminar and independent work. As time went
on, my adviser and I agreed that it would be best to concentrate meticulously on
one novel especially rich in the problems posed by my analysis. Thus, starting
from a merely negative proposition, I had found an intensely focused zone for
research. Once I had so concentrated myself, rigor demanded that I no longer
“toy” with the topic. I did maintain a certain playfulness with my thesis until the
end, but it did inevitably become a task to complete. The key is to start early
enough that you have this sort of time to play with your question while it is still,
in fact, purely “play.” Finally, I must admit that part of me was dismayed to hear
my adviser’s first comment on a nearly final draft I submitted in late March:
“Your thesis has turned out to be a creatively indirect commentary on certain
key ideas postulated by Jorge Luis Borges.” Great. I had managed to do the one
thing that I had set out to avoid! In retrospect, however, that’s the whole point,
and I ultimately took it as a compliment to my work. That is to say, even to the
extent that my thesis charted new territory, it drew its greatest strength from
my past studies. As I said before, the building blocks of the thesis are already
with the writer before he even begins to assemble it. It is the assembly process
itself that makes the senior thesis a project without precedent.

My emphasis on the “method” aspects of the thesis stems largely from the
singular experience I had with my adviser, Professor Ricardo Piglia. We did
discuss in great depth the literary and philosophical approaches I was develop-
ing. All the same, we spent far more time discussing how to draw from literature
and philosophy in ways that were stimulating, not limiting. My thesis was surely
a research project, but at best it found the boundaries of research. Professor
Piglia consistently encouraged exercising this sort of discretion about when
and where to reject the very thinkers upon whom my study depended. Learn-
ing to make these hard choices implicit in original scholarship was the most
valuable overall reward of writing a thesis. I don’t mean to suggest that all
thesis experiences will follow this specific path; I certainly think it was unique
to the dynamic that developed among my topic, Professor Piglia, and myself.
Indeed, some theses could be defined by exhausting the limits of a particular
line of research. However, I do think that any thesis writer will be able to benefit
from such great payoffs in the same way I did: through exposure to the unique
academic persuasions of his adviser.

In that regard, I had singularly good fortune. Professor Piglia occupies the
dual position of the author-scholar, acclaimed for both his literary works and his
The thesis meant it was no longer time to respond, but to provoke. Certainly discussing literature with someone invested in the actual production of literature itself is a unique privilege, one perhaps more commonly found in creative thesis experiences. Even more important, though, was the unusual scholarly bent his background brought to our ongoing conversations. Professor Piglia’s style opened me to putting the novel itself before any analytical tools that I might find useful to impose on it. I came to understand the novel itself as a critical and scholarly tool, an instrument that opened broader questions of a theory of narrative. That, in its own way, also became the key substantive turn of my thesis: I turned the novel back onto itself as a way to read conceptions of fiction to be found in the intellectual milieu of its era. (Therein did Jorge Luis Borges rear his unexpected head.) Thus, Professor Piglia’s personal style had a decisive influence on my ultimate findings, although the findings themselves were entirely the product of my work. For that reason, I echo the traditional axiom to “find an adviser that fits your style.” I’d qualify it in that I’d pay less attention to working style (e.g., attitudes toward deadlines) than I would to intellectual persuasions. It was necessary to find someone who would challenge me, to be certain, but it was equally necessary that they be the sort of challenges I needed to face in order to sharpen my investigation.

In the end, the thesis was everything I expected and everything I did not. Remember: I did not end up writing about what I thought I would write about, nor did my thesis even end up being about (explicitly or implicitly) what I thought it would end up being about when I was writing it! However, with a willingness to allow the thesis to surprise me, and with a topic and adviser that would accommodate and encourage such surprises, I believe I was virtually guaranteed the satisfying result that I found.

Ricardo Piglia
Walter S. Carpenter Professor of Language, Literature, and Civilization of Spain

Daniel Hantman is certainly one of the best undergraduate students I have worked with since I have been teaching at Princeton. It was a pleasure and a great intellectual experience for me to work with him. I met Daniel in an undergraduate course on Borges I taught in spring 2000. He immediately revealed his acute intelligence and capacity for hard work. In spring 2002 as a junior, Daniel attended a very demanding graduate seminar I was teaching on the “Detective Novel and Paranoid Fiction.” Among a group of 12 excellent graduate students, his participation as well as his papers and his final essay, were again remarkable. He wrote fluently and clearly about theoretical issues, and had a special talent for literary analysis. I also directed his first junior paper. While his junior work was under process, he frequently came to my office to discuss and comment on the bibliography I suggested to him to read. His interest and steady commitment were clear virtues throughout.
Daniel Hantman’s senior thesis, “Maquinaciones narrativas: Plot, Desire, and the Machine in Adolfo Bioy Casares’s *La invención de Morel,*” is one of the best analyses of Bioy Casares’s novel that I have read. Lucid and very well written, this work renovates the reading of this classic of Argentine contemporary literature, and suggests several original hypotheses about its narrative construction. In my conversations with Daniel, as well as when reading his drafts, I appreciated the way he deciphered the double causality system, thus making possible the extreme concentration effect produced by Bioy’s novel. On the one hand, Daniel clarified the elaborate technological diagram that explains Morel’s fantastic invention, and, on the other hand, the force of desire and passion that motivate and define the plot. This “double causality,” and its relations, was one of Daniel’s original findings. Through his analysis, its interweavings and interferences, Daniel perceived the true knot of this novel and its double plot. On the one hand, the novel is a complex construction deriving from science fiction and its topical evil scientist who manipulates human beings; on the other, it is a sentimental novel, both sinister and kitsch, following the logic of desire, its fluctuations, and its machinations.

The examination of this double movement of the plot allowed for Daniel’s most remarkable contribution. I have to say that what Daniel found is a way to discuss, criticize, and refute one of the central, and often quoted hypotheses of Borges’s narrative poetics. Borges’s conception is clearly present in the prologue to *La invención de Morel,* written in 1940. With its defense of a plot deprived of psychology and of the mathematical construction of the intrigue, this prologue was to become the historical framework defining the reading of this novel. The fundamental critical lesson I learned from this senior thesis was precisely that, contrary to Borges, Daniel does not define *La invención de Morel* as a novel of bizarre adventures to be deciphered through a scientific postulate, but as a novel where drives and webs of desire weave a mad plot, linked to hidden and extreme passions. The entire period I spent working closely with Daniel was for me a truly remarkable intellectual experience.
Genomic Identification of Yeast Mutants Defective in Stationary Phase Exit

Peggy Hsu '03

Anyone who passed by the third floor conference room in Lewis Thomas at 4 a.m. during those final days before the dreaded due date would have found me getting my night's beauty rest. Pajamas (worn for 150 hours straight). Black conference room chair (fetal position). Lab timer (set for 90 minutes).

My thesis project in Jim Broach’s lab was a genome-wide screen to identify mutants defective in exit from stationary phase. When nutrient conditions are poor, yeast can become quiescent in stationary phase and remain dormant for extended periods of time. When the environment becomes favorable for growth again, yeast sense the improved conditions, exit stationary phase, and resume cell division. Many cells in the human body are also in a state of quiescence, and an aberrant exit from this dormancy could potentially result in cancer. Since many of the same pathways are conserved from yeast to humans, the hope was that a greater understanding of how yeast cells exit dormancy could shed some light into cancer progression. To identify genes necessary for exit from stationary phase by screening for mutants defective in this process, I used some new genomic tools: a library of bar-coded yeast deletion mutants and DNA microarrays. The project involved two independent phases of data collection and analysis and then subsequent verification and characterization of the genes identified.

During the course of my research, I encountered several challenges. First, there were the inherent difficulties of molecular biology research. I had to develop patience, a character trait that did not come naturally to me. Experiments took time, usually on the order of hours or days but sometimes weeks or even months. They also had to be repeated before they worked, especially at the beginning. The seasoned lab veterans often told me to take the time I was estimating for an experiment, and multiply it by three—at least. I found that I needed to try several methods to increase my chances for success and above all to be relentlessly persistent. In addition, my specific project had its own challenges. I was really on the cutting edge, using a brand new technology. However, it was not yet perfected and few people, including those in Jim’s lab, were familiar with it. Moreover, I had generated a lot of data, which proved to be a major bioinformatics problem for which my previous academic and lab experiences had not prepared me.
The ultimate goal of my thesis was ambitious, and it required a cooperative effort among several people in order to finish all the required steps of the project. The key to scientific work is collaboration, and I truly learned its value while working on my thesis. The most important collaboration was the one I had with my adviser. Jim’s pedagogic methods coincided with my own learning style because he gave me a lot of freedom and flexibility while simultaneously being there whenever I needed his advice. I was granted independence and complete responsibility over my project, but at the same time I could pretty much wander into Jim’s office whenever I had a major question. Especially with the data analysis, this proved to be invaluable. Talking about my work and its hitches with people who were really interested was an enormous benefit. For the initial technical details, I was guided in the lab by an experienced and unbelievably friendly post-doc. Jonathan Hoffman, the other senior in the lab, was working on some characterization of initial genes identified by the screen. We discussed our work (during those late night/early morning sessions) and bounced ideas off each other. For the computational aspects of my project, I knew I needed to find someone comfortable with data analysis, so I talked to Saeed Tavazoie in the molecular biology department. I also had to consult computer scientists who helped me write a program that I designed to manipulate my data. Finally, I made important contacts with researchers at various other institutions who provided me with advice and even DNA microarrays. Especially because the technology was new, I realized that I had to learn from other people’s experiences with it. I was amazed that other scientists took my questions very seriously and treated me as an equal colleague. As molecular biology research accelerates and becomes more interdisciplinary, collaboration and cross-talk will become more essential than they already are. Science is a living entity. It moves forward by collective work, and each scientist contributes to a shared body of knowledge. I learned how incredibly important it was to be able to communicate my work, and by talking about my work with other scientists, I also more clearly saw how my research fit into the larger research scheme.

Ultimately, the thesis was an incredible growth experience. The molecular biology department does a fantastic job in allowing each student to have their own project, comparable to any of the projects of the graduate students and postdocs. I developed a sense of ownership of my project and discovered that being entirely and deeply engrossed in intellectual pursuit was exhilarating. The thesis was also very different from most classwork because the outcome, as is the case for all true scholarship, was completely unknown. And it was up to ME to determine the outcome. The responsibility was at times daunting. However, there were always supportive people around to help me work through the knots. Except for the length of the project, the thesis was entirely comparable to the kind of work and intellectual stimulation that I will encounter in graduate school and beyond.

For students working on molecular biology theses, I would recommend above all being proactive. With research, there were some factors under my
control and others that were not. The key was to do the best with what I had and then hope that luck came my way. I had to tackle each experiment with multiple, parallel methods, and I sought advice when things did not work. Keeping in touch with the departmental representatives was also enormously helpful when I got stuck. And finally, with regard to the actual writing, I recommend avoiding my painful mistake. Instead, write as you go! Since communication is so crucial in science, writing is often just as important as the experiment itself. I underestimated the amount of time it would take to really explain my findings in written text. Hence, the last minute nights/mornings spent in the lab. However, even those could be fun.

Anyone who passed by the Broach Lab in Lewis Thomas at 6 a.m. during those final days before the dreaded due date would have found me bopping around the lab benches, infused with Diet Coke, dancing to the hits from the early and late '90s in between data calculations.

James Broach
Professor of Molecular Biology

Last year, Peggy Hsu and her classmate Jonathan Hoffman became my 34th and 35th senior thesis advisees since I arrived at Princeton 20 years ago. Each of the 35 students I’ve mentored has brought a different set of skills to my lab and each has faced a unique set of problems in his or her research project. Some of them have made substantial contributions to my research program and a few have become co-authors on published papers. All of the students have enriched my experience as a teacher in ways quite different than that obtained through formal teaching in front of a class or in a seminar. Each student becomes a member of the extended family of graduate students, postdocs, and technicians that comprises my research group. During the long hours working side-by-side in the lab, all of us in the group get to know each of these students and the students get to know us. We teach them what research science feels like and what the experimental basis of what we know in science actually is. In turn, these articulate, thoughtful, and multifaceted Princeton undergraduates provide us with a colorful window on undergraduate life on campus. The students bring a naïve but enthusiastic approach to research that occasionally leads to novel insights into our research program. Like all the other students, Peggy's senior thesis experience was a unique confrontation with a scientific problem but the process she went through mirrors that of many of her predecessors.

In molecular biology, a senior thesis most always involves one or more years of hands-on research in a laboratory in the department. A few students conduct what we refer to as a library thesis, in which the student addresses a research problem solely by sifting through the scientific literature. Occasionally, a student might produce a thesis at an unusual intersection between molecular biology and another discipline, as was the case for one student who wrote a fictional novel set in a molecular biology laboratory as her senior thesis and for one of my students who choreographed a modern dance piece in homage
to molecular biology as an appendix to his research thesis (the dance turned out better than the research).

The majority of senior theses begin in the second semester of the junior year with the selection of the thesis adviser, the identification of a specific research topic, and a literature search by the student on the topic of interest. Each student then spends 10 weeks during the summer between the junior and senior year actively engaged in full time research (60–80 hrs/week in the laboratory), usually under the direct supervision of graduate student or post-doctoral fellow. With the onset of senior year, the amount of time a student devotes to the thesis drops precipitously. For reasons we as research advisers never understand, the students feel they have to spend time on other classes. Moreover, their presence on campus is frequently punctuated with trips for interviews for medical or graduate school. Thus, the sustained research effort for the senior thesis begun during the summer becomes intermittent during the fall semester only to be resumed at an increasingly frantic pace as the deadline for completing the thesis approaches in the spring.

Peggy’s thesis research followed the standard outline with some notable differences. First, Peggy was a precocious molecular biology student and joined my laboratory during her sophomore year after convincing me that she had a genuine interest in pursuing research and would actually show up in the lab. As a result, well before her junior year Peggy became well versed in the research literature on the control of cell proliferation, the focus of our effort in the lab. Peggy also benefited from the advent of new genomic technologies we had just imported into the laboratory and the efforts of a visiting graduate student, Maike Gravert, who had initiated a genomic project on how cells begin growing again after exiting the normal growth cycle. The organism we study is bakers’ or brewers’ yeast, a microbe with many of the properties of human cells. Several years earlier, the complete genome of this yeast was sequenced, allowing identification of every gene within the organism. Subsequently, a consortium of my colleagues created a set of yeast strains each of which was engineered to lack one of its six thousand genes. Accordingly, about the time Peggy arrived in the lab we obtained a set of 63 microtiter plates, each plate containing 96 different strains, each with a different gene disruption. With the aid of a robot assistant, Maike performed the Herculean task of examining all 6,000 mutant stains individually to determine which of these mutants were defective in their ability to resume growth after a period of quiescence. Peggy’s and Jonathan’s first task during their junior year was to look at the list of 300 or so mutants Maike found to be defective and determine from the existing literature what they had in common and whether (in those cases in which the function of the mutant gene was known) the function explained the behavior.

As is often the case in research, this analysis of Maike’s data suggested that we needed to follow up her experiments with some additional experiments. While Jonathan began to examine individual mutants, Peggy and I decided she should redo Maike’s experiment in a slightly different way, both to substantiate the data and to try out a new genomic trick we had heard about. Each of the mutant strains in the collection was designed to carry a molecular ID tag.
Peggy broke the ice with a new experimental protocol and got it up and running in the lab. Inserted into its genome. This ID tag would let us know whether any particular mutant was present in a mixture of cells and, if so, at what proportion it was represented in the population. Accordingly, rather than examine each mutant strain individually as Maike did, we figured that Peggy could mix all the mutant strains together in one culture, perform the experiment (i.e., restart growth after a period of quiescence), and then use the ID tags in a molecular “roll call” to test which mutants that had been present at the beginning of the experiment were absent at the end. These AWOL mutants would be the ones lacking a gene necessary for the process of restarting growth (i.e., heeding the bugle call to wake up), and their identity, we anticipated, would tell us what physiological processes were required for restarting growth.

Since this was a brand new technology with which no one in the lab had any experience, Peggy had to work out all the technical details to make the protocol work and then acquire and analyze the data. The technical details proved quite demanding and a bit harrowing, especially since each nanofabricated chip required to perform each “roll call” cost $250. However, even more demanding was making sense of the reams of data that the experiment generated. Peggy particularly rose to the challenge at this stage of the research. First, she drafted several of her fellow students with exceptional computer skills to develop software that would allow her to collate and sift through not only her data but also Maike’s original data set. Second, she contacted one of the inventors of the technique at Johns Hopkins to query him about the method. She spent a significant portion of her medical school interview at Hopkins quizzing him and his collaborators on how best to tease meaningful information out of the data. (She was sufficiently impressive in this dialogue that my colleagues from Hopkins dangled a potential collaboration in return for her agreeing to accept their offer to medical school.) When she convinced herself and me that the Johns Hopkins folk were no better versed in analyzing the data than we were, she marshaled her computer savvy colleagues again and explored several different ways of organizing the data to extract meaningful data. During the days leading up to the deadline for the thesis, Peggy would pop into my office several times a day to float yet another method and to solicit my opinion as to whether it was better than the others. In the end, she used several different methods of analysis with an accompanying critique of the relative merits of each.

What did we learn from Peggy’s thesis work? We are still in the process of sorting through the data sets from both Peggy’s and Maike’s experiments. Their work highlighted a number of potential genes that may well be involved in this very important but little studied process in eukaryotic biology. Max Reback, Peggy’s and Jonathan’s successor in the lab, has been testing potential candidate genes individually to see if their behavior is as predicted by the earlier experiments. We have high hopes that a few of these mutants will prove informative. More important, though, Peggy broke the ice with a new experimental protocol and got it up and running in the lab. Since her initial foray, our colleagues
have created a second generation of mutant strains and nanofabricated chips for conducting “roll call.” We also have a better idea about how to configure the experiment to pinpoint the mutants we would like to see. So, we anticipate this year that we will see much further into this biological problem because, to paraphrase Isaac Newton, we will be standing on Peggy’s shoulders.

My advice to next year’s senior thesis writers (at least in molecular biology) is twofold. First, get excited about your work. One of the most exhilarating experiences I have known (a feeling experienced by most of my scientific colleagues and the more successful undergraduates) is to open an incubator door in the morning to pull out the experiment from the previous day and see the results of that experiment. For a short while, you know something about an important problem that no one else in the world knows. This feeling is the opiate that keeps scientists coming to the lab in the morning, despite ambiguous prospects for future jobs or worries about grants. Second, bug your thesis adviser. We (appear to) have lots of activities competing for our attention—committee meetings to convene, lectures to attend or give, grants and manuscripts to write, etc. However, most of us take a great deal of pleasure in talking about science and about your project. Don’t worry that your questions may seem trivial—if you don’t understand something, you may need more information. Alternatively, we may not understand the issue as well as we think we do and having to explain it to you may make that clear to us. So, consider yourself new eyes for old guys.
Conducting a functional magnetic resonance imaging (fMRI) experiment was a unique thesis experience. I never locked myself in a carrel in Firestone, and I did not spend months writing—instead, I was getting hands-on experience with fMRI design, running subjects, and learning the methods necessary to take numerical data from the scanner and convert them to meaningful statistics and figures. The applied, rather than classroom, nature of this project challenged me in ways my previous undergraduate work had not, and as a result of this experience, I have decided to pursue fMRI research in graduate school.

My thesis experiment was a comparison of differences in neural processing when participants looked at static emotional faces, like photos, versus dynamic emotional faces, like video clips. The reason I chose this project was because processing of emotional faces is a popular topic in researching both normal functioning and clinical disorders. Past studies relied on pictures of emotional faces to elicit neural response, but when we see emotional faces in everyday life, we see them in action. Accordingly, current experiments have begun to employ video stimuli, but this methodological change has occurred without a direct fMRI comparison of the two types of stimuli. The question I sought to answer was: Are dynamic stimuli really more realistic, and therefore better for research purposes? In asking that question, I had to look at whether or not dynamic stimuli activated the same brain areas established in studies using static stimuli, and whether they did so to a greater extent.

To do this experiment, I filmed actors making emotional faces and created sets of static and dynamic stimuli. With the help of my adviser, Professor James Haxby, I designed an fMRI task, ran subjects, and analyzed the data. What I found was that dynamic stimuli activated the same areas as static stimuli, and caused greater activation in areas associated with the perception of biological motion and with the specific emotions anger and fear, suggesting that dynamic stimuli are more effective for fMRI research. Finding a positive result was rewarding, especially because through a simple task, I lent support to the current trend of dynamic stimuli use in researching facial emotion.

No internship or course could have given me the valuable research experience that I gained from my thesis. Not only did
I have the opportunity to learn how to design, run, and analyze an experiment, but I was able to be part of a supportive research lab where professors and graduate students worked to give me a solid knowledge base in fMRI experimentation as they guided my progress on one specific project. The great responsibility I had in running this experiment gave me confidence in my ability to contribute to science, and the exciting, collaborative nature of the lab convinced me to spend my first year after graduation as a research assistant for Professor Haxby. This year, I will expand my thesis project and apply the findings to project ideas for graduate school, where I hope to study emotional face processing in children with behavior disorders.

My advice to upcoming seniors would be to consider an experimental thesis. Almost nowhere else would you have an opportunity to do fMRI research as an undergraduate. The work on this type of project is difficult—at times you may have to completely change an idea or redo an analysis that you thought was perfect, and you still may not get the results you wanted—but the one-on-one training with a professor who is excited about research is invaluable.

James Haxby
Professor of Psychology

Jessica Kirkland was my introduction to undergraduate teaching at Princeton. Before arriving at Princeton, I had worked for 20 years as a research scientist at the National Institutes of Health where there are no undergraduate students and only a few graduate students. The young scientists in my laboratory whose training I oversaw were postdoctoral fellows. With this background, I had only a vague understanding of what to expect from undergraduates.

With no courses to teach in my first semester, Jessica Kirkland somehow found me and asked if I would be her senior thesis adviser. She had worked over the summer at NIH with friends of mine and had heard rumors of my existence at Princeton. The laboratory that she had worked in conducted research on mood and anxiety disorders in children and, in particular, used functional brain imaging to study human brain mechanisms for face perception, which is the main topic of my research. I was flattered and delighted to have a student who wanted to work on topics in my area of research and actually had some experience. But how much could be expected in a project that had to be completed and written in eight months? Realistic timelines are a chronic problem in research. With postdoctoral fellows, if the project takes a few extra months, its not a big problem. With a senior thesis, a delay of a few extra months would delay graduation and be a disaster for the student.

Jessica came with some great ideas, but they involved making experimental materials with software that I didn’t have and was not familiar with and studying children with diagnosed disorders. The full scope of her ambitions could see her through a full five years of graduate school. So we started talking about what the first step in such a research program might be. Clearly, a clinical study was not an option with the short and unforgiving timeline. We did, however,
have a rare and precious resource, a state-of-the-art magnetic resonance imaging device in the basement of Green Hall that can be used for undergraduate projects. With a few meetings and some further reading, Jessica quickly distilled her plans into a brain imaging project that would use undergraduates as subjects, which we have in abundant supply, and stimuli that she could make with standard digital video editing equipment. The project would also answer a critical question that had to be answered for designing future research studies on brain mechanisms for perceiving and understanding facial expressions. This was still not a small project. It was conceivable that it could be accomplished in less than a year, but could Jessica do it? What if a piece of equipment failed or preliminary results suggested the study needed to be redesigned? I took a deep breath, quietly made some disaster contingency plans, and encouraged her to forge ahead.

Jessica wasted no time. Her confidence and energy were awe-inspiring. She needed to make videos of actors making facial expressions. She recruited friends with some acting experience. The videos needed to be edited into clips, arranged into a specific and precisely-timed sequence, and burned onto DVDs. Then she had to recruit experimental subjects to watch the videos while their brains were scanned. She had to learn how to conduct a brain scanning session and oversee each scanning procedure. Then she had to learn how to analyze the brain scan data, complete the analysis, try to figure out what the results meant, make tables and figures of the results, and, finally, write the thesis. Accomplishing all of this in less than eight months would have been difficult for a research fellow with nothing else to do. For an undergraduate with a normal course load, it seemed excessive. I worried that I had not exercised good judgment in encouraging her to try. Then, about a third of the way into this process, Jessica told me that she was actually writing two senior theses. She informed me that Princeton allowed students to complete a creative thesis in addition to a scholarly thesis. Jessica was writing a novel in her spare time. That revelation broke me. I couldn’t figure out how she found time to sleep, much less found time to write a novel.

Needless to say, Jessica did finish her brain imaging study and thesis, along with her novel, on time. She did not sleep very much. In the acknowledgments for her thesis she gave Starbucks a special mention. She hit many snags making the DVDs, analyzing the data, clarifying her interpretation, and all in a state of partial sleep deprivation. Nonetheless, she solved all of the problems and completed a superb thesis. Jessica became a member of my laboratory and was deeply admired for her intelligence, insight, energy, and unflappable positive outlook. My future senior thesis advisees may not appreciate how Jessica reshaped my expectations of undergraduates at Princeton. I now feel that almost any project is feasible, if the student has the ambition and energy. Maybe with my expectations set so high, I will be lucky enough to have more students like Jessica.
Providing Uncompensated Care and Community Benefits: Challenges Facing Hospitals in New York City and Philadelphia

Elizabeth Lapetina '02

Spending months of senior year tucked away in a dark carrel in Firestone Library poring over journals that laid out academics’ thoughts on my chosen thesis topic, the future of American hospitals, had little appeal to me. Instead, I wanted my thesis experience to provide me with the chance to meet individuals directly involved in charting the course for hospitals in the coming years.

In the spring of my junior year, thesis funding applications were due for students who wanted funds to conduct research over the summer. I knew my schedule for the fall semester would be busy, so I decided to devote a few weeks of my summer to thesis work and apply for funding to travel and conduct interviews. The application for the funding required you to have a solid idea of the research you wish to conduct, so I realized I needed to come up with an idea quickly! After bouncing ideas around with my fall junior paper adviser, Professor Elizabeth Armstrong, I chose to write about the challenges that would likely face hospitals in coming years.

I think it is worth noting that while my original topic was “the future of hospitals,” my final topic was narrowed to examine the problems confronting community hospitals in New York City and Philadelphia, with a special emphasis on factors challenging hospitals’ abilities to provide community benefits (services like Meals on Wheels, health fairs, disease management programs, etc.), which are often valuable to the community the hospital serves, but generate little to no revenue for cash-strapped hospitals. As I conducted research and began outlining chapters, I refined my topic into something that could fit into 120 pages of text. It would have been impossible to write a thesis on “the future of hospitals,” but it also would have been impossible for me to develop an extremely focused topic without delving into the research and writing process and developing an understanding for the myriad of problems faced by urban hospitals.

To gain an understanding of the issues confronting today’s hospital administrators, I interviewed nine individuals in the New York and Philadelphia area who are involved in the health care industry. One was a professor of health economics and another was the president of a regional health association.
The rest were hospital and health system CFOs, CEOs, and chief medical officers. The experience of speaking with these individuals was intimidating, and required a great deal of persistence on my part, but was ultimately the most rewarding part of my thesis experience.

Conducting interviews was a great experience for me and made my thesis research process interesting and even enjoyable. But that doesn’t mean that everything went smoothly! You must be prepared to be flexible and accommodating and leave plenty of time for the unexpected. I originally had a meeting scheduled for September 13, 2001 with the chief medical officer of a hospital in New York’s Lower East Side. We rescheduled the meeting for November 1. The day before the meeting, his secretary called and said that the administrator, a neurosurgeon, had to perform surgery that day, so we rescheduled the interview for November 12. On the way to New York that morning on New Jersey Transit, we were told that the train would not be making the Newark Airport station stop and that all New York airports were closed, which sent all of us passengers into a panic. When I arrived for my meeting, the physician told me that a plane had crashed into a neighborhood in Queens, right near one of the hospitals within his system. He apologized for keeping CNN on in the background while we conducted our interview, but explained that because the satellite hospital would likely be inundated with injured individuals, his hospital was bracing for a large number of transfers to its facility. Was the interview worth the hassle? Absolutely. The insights that this physician and every other individual I interviewed were able to give me were valuable and helped me present a paper that focused on issues of importance to those in the medical community.

A few points of advice that helped me in writing my thesis:

• Start everything early. This means thinking of potential topics early, gathering materials early, scheduling interviews with experts early, writing early, and editing early. I highly recommend devoting some time over the summer before senior year to your thesis. I was able to read two books about the history of hospitals and American health policy which helped me focus my initial ideas and gave me background information and questions for my interviews. Having lived through a Princeton senior’s fall semester, I can tell you that there is no way I would have had time to read those books if I had not tackled them over the summer.

• Talk to people about your thesis topic. You never know who may be able to provide you with helpful materials or interview contacts. After telling a friend of mine from another college about my thesis topic, she told me that her father had worked with a managed care company in Philadelphia for many years and had a number of friends who worked at the hospital systems in the area. I was able to schedule four interviews as a result of the contacts her father gave me.

• Don’t be afraid to start writing. I spent most of my fall break at home, wading through books and articles I had brought back with me. I found that writing an introduction that described what I hoped to accomplish...
in my thesis was incredibly helpful as I tried to organize my ideas. Moving from the “researching stage” to the “writing stage” is one of the most difficult things to do, but writing is one of the best ways to realize what information you still need to gather and what you still do not understand about your topic.

- Choose an adviser you know will challenge you, meet with you, and encourage you. Professor Armstrong was my fall task force leader, so I was already comfortable working with her. She was responsive to e-mails, available to meet with me, and happy to review edits I sent her. I think that seniors sometimes worry about finding the expert on their topic within their department. While it is important to have an adviser who is interested in the topic, I think it is most important to have an adviser who is interested in you and who you can work with effectively.

- Remember that like every Princeton student who came before you, you will finish your thesis. You may spend your entire spring break at school, fortified by Frist candy and caffeinated beverages, and you may need to pull a few all-nighters right before your deadline, but you will get through it!! At the end of the process, you will be the proud author of a book you conceptualized, researched, and wrote!

Elizabeth Armstrong
Assistant Professor of Sociology and Public Affairs

Every so often, I have the opportunity to teach a student who, I hope, will end up asking me to advise his or her senior thesis. Liz Lapetina was such a student, every professor’s dream. I met her during my very first semester teaching at Princeton, when she enrolled in a Woodrow Wilson School policy task force that I taught on “Error in Medicine.” Liz quickly distinguished herself in that class as one of the most conscientious, diligent, disciplined, and self-motivated students I have known. I should note that these qualities—from the adviser’s perspective—are all highly desirable in a senior thesis writer, so I was delighted when Liz asked me to advise her senior thesis. I knew her and her working style and I knew we would be able to work well together—and that the experience would be rewarding for both of us. We began talking seriously about her thesis in the late spring of her junior year, when she applied for funding, and continued to correspond over the summer as she began her research on the effect of hospital mergers on the provision of charity care in two historically very different health care “markets,” Philadelphia and New York City.

At the same time that Liz and I worked through her senior thesis, we also collaborated to publish the junior paper she had written under my supervision the year before. Helping Liz to publish her exemplary paper on medical mistakes in the outpatient setting in the prestigious health policy journal Health Affairs was one of the most rewarding mentoring tasks I have ever undertaken. Working this closely with an undergraduate—in the guise of preparing a paper for publication, or advising a senior thesis—offers rare rewards for a professor. First, I have the chance to witness a student’s intellectual growth up close.
and even more thrilling, is the chance to watch the student’s sense of mastery, her appreciation of her own skills and talents, and her sense of herself as a fellow scholar grow and blossom. By the end of her senior year, Liz had mastered the incredibly complex “system” of charity care in the U.S. and was able to offer an insightful set of policy recommendations that followed neatly from the problem she defined at the outset of her thesis. It is wonderful to watch a novice become an expert! And last but not least, in senior thesis advising, I have the opportunity to deepen my own knowledge of a particular area as I learn from my student’s work. In Liz’s case, I learned a good deal about the history of uncompensated care and about how local institutions, customs, and past policies powerfully shape policy options today.

I always spend a lot of time with my students in the early phases of the senior research process sorting out just what their research question is. The best advice I can give senior thesis writers is not to give this phase of their work short shrift. If you don’t sort out precisely what your question is, you can never hope to answer it! And finding a good question to ask is not as easy as it seems. So meet early and meet often with your adviser to focus your research question. You want to tackle a question that is unanswered, important theoretically and/or empirically, and significant in some substantive way. Most importantly, you want to find a question that you feel passionate about; after all, it is your thesis, not your adviser’s, and in the end you will spend close to a year of your life deeply embroiled in this question. It’s worth taking time early in the process to find your passion—you will need it to sustain you through the long months ahead. Once you have a good question, you’ll find that everything else just falls into place!

Finally, remember that just about everything worth doing in life is also hard to do. There’s no arguing that the senior thesis is “hard to do,” particularly from the student’s perspective, but often no less so from the adviser’s. (That may seem surprising to students, but it’s not easy to guide someone on the path to knowledge without leading on that journey. But our job is to help you chart your own way, not to find the path for you.) It’s a time-honored truism that what you get out of an experience depends on what you put into it—that is equally true for both the student and the adviser on the senior thesis.
Out of all the many pieces of thesis advice you’re sure to hear, not many people will tell you what I believe to be the most important and most overlooked: Be careful how you choose your carrel mate. Do not choose your best friend. Do not choose your roommate. Do not choose your significant other. Do not choose anyone addicted to anti-depressants or other drugs. The carrel should be a place of refuge and relative isolation from the world, where thesis is your only food, thesis your only thought, thesis your only existence. It’s difficult enough to find places on campus where you can shut everything out and focus. Don’t make it harder by contaminating the sacred confines of the carrel with your best friend who can only work while singing showtunes, chewing gum, and popping shiny pills. Remember that geek in Economics 101 who studied quietly in a corner of Frist, always had his work done in advance, and aced every test he took? It might be time to facebook him (and to apologize for calling him a geek and not “carrel godsend”). If, furthermore, in your weaker moments, you actually begin to converse with your carrel, don’t worry about it. My carrel—Carol—and I had some great thesis times together, didn’t we, Carol?

Now that that’s out of the way…

My thesis focused on the role of the Trojan hero Hektor in Homer’s epic war poem, the *Iliad.* I researched the history of Homeric scholarship concerning Hektor as a figure in an evolving oral mythology, as an object of cult worship, and, most importantly, as an unforgettable hero of ancient Greek literature. Ultimately, by analyzing the symbolic structures, architecture, and poetics of the *Iliad* with respect to Hektor’s name, lineage, and social status, I learned to read the poem as a whole in terms of the tensions and polarities that are inherent in Hektor’s own characterization. In other words, within Hektor we see the struggles that define much of the conflict of the *Iliad*: the domestic world within the walls of Troy and the world of heroes without; the responsibilities one owes family and allies and those owed to oneself; the divine and the mortal; the all-too fleeting moments of life and the (potential) glory in death.

To all those juniors mired in JP purgatory, the neatness and clarity of my thesis summary, I can assure you, has only been obtained now, as I write to you months after having completed
the entire process. In fact, if you’re anything like me, you won’t really know exactly what you’ve accomplished even after you’ve turned in the thesis, been graded, been graduated, and have moved on with your life—until you are asked to reflect on the entire process for the benefit of “those to come” or, as the Greeks would say, “essomenoi.”

So, right off the bat, here’s my first helpful way of looking at the process: The thesis is not a paper, but it’s a collection of chapters the size of long-ish papers, all related historically/thematically/theoretically. Not so daunting, right? My thesis had three chapters. Each focused on different aspects of Hektor: first, his name, its etymology, and the significance of the semantics of his name in the *Iliad*; second, his relationship to rivers, in particular the Skamandros River that cuts through the Trojan plain; and third, Hektor’s relationship with fire and the connotations of fire within the poem. For each chapter, I read as many relevant contemporary books as possible, while also seeking out the primary sources that informed those opinions. (By the way, an excellent way to get started is by flipping to the end of a good book and stealing the bibliography—don’t worry, it’s not a federal offense.) Most of my “research,” however, was done by reading and re-reading my primary text—the *Iliad*—in English and Greek until my own opinions took shape. You’ll find that in the end, all three methods reinforce each other.

The second thing to realize is that the thesis does not have to be something one encounters exclusively during senior year. Hopefully, you’ll choose a topic that will interest you long after you’ve left Princeton’s ivy walls and eating clubs. Particularly helpful, however, would be to begin to think about what interests you *before* you get to senior year. What I mean to say is that junior year—as you write your JP(s)—is an excellent time to probe the limits of your fascination with ________ [fill in the blank yourself]. So it was for me. My second JP was about a little-known and even lesser-studied work called the *Latin Iliad*, a 1,000-line Latin epitome of the *Iliad* written in the first century, A.D. (almost one millennium after Homer), by Baebius Italicus. What I found, in particular, was that Italicus made Hektor a hero in a way that Homer chose to leave ambiguous (one major change among many other ones). Forget about the specifics. The point is that my experience with Italicus’s text led me to wonder about the dynamics of Hektor’s treatment in Homer. My thesis topic followed. Your JP can very easily become part of your thesis, or at least the authors you treat and the sources you research may prove to be relevant and helpful. So why make more work for yourself? Start thinking about a topic right now. But…

Be prepared for your topic to change. For example, I began thinking that I would research (in detail) Hektor’s hero-cult and its relationship to Homer’s text. But, finding very little about his cult, I chose to focus more exclusively on the poem. It seems like a small change, but at the time I felt as though the world had become devoid of all flowers, sunlight, and happiness. Once you invest so much time in one direction, it’s difficult to pull yourself back and start off in another. But sometimes it’s exactly what you need because it gives you perspective. So be flexible.

Once you have an idea of what you want to write about, it’s incredibly helpful to discuss it with someone, say, someone like your adviser. Some people say
that you should never choose classes, but rather you should choose teachers. Nowhere is that advice more applicable than in choosing a thesis adviser. (My adviser was the professor who had introduced me to the world of Homeric scholarship and who had opened my eyes to epic nuances and fresh perspectives, so choosing her was logical.) And, after you choose your adviser, talk to him or her, frequently—which doesn’t mean you must simply obey what he or she says. Your adviser most likely wants nothing more than for you to follow your own impulses, which, granted, sometimes need serious reshaping. I did not schedule weekly sessions with my adviser—choosing instead to meet when I felt that I had enough to talk about—but I would highly recommend setting up such a schedule. If you keep your adviser updated on how things are going, she or he will be able to help you the most when you feel completely lost (which happens from time to time). N.B. It is ALWAYS better to talk to your adviser when you’re lost than to curl up into a ball on C-floor in the library. Setting specific dates for when you want to have finished research/chapters/books is an excellent way to stay on track.

Let’s say you have a topic, and your adviser likes it; it can still be hard to motivate yourself. So here’s some advice on getting started.

First, just start reading. Set aside certain periods of time—yes, even in the fall—just to read a book that is in your general field of interest. It is as helpful to eliminate what you’re not interested in as it is to decide precisely what interests you—and easier, too. The more you fill your head with other people’s (intelligent) ideas, the more likely you’ll find the contradictions, vagaries, incoherence, and general incompleteness that you can exploit. (Be careful, though, that you’re always critically evaluating what you’re reading as well, because other people’s ideas begin to sound better and better when you think you have none of your own).

Second, just start writing. It is most likely the case that you’ll never really know what you’re saying as you write and that you’ll change your opinion on what you think and on what you think you said as you continue to research. It is infinitely more helpful to get something down on paper that is imperfect and flawed than it is to wait until everything calibrates in your head. If you plan right, you should have plenty of time to edit later on (including, of course, those delicious pre- and post-dawn hours on the day your thesis is due).

Third, be kind to yourself. Schedule serious working time so you can schedule time to relax. It’s really awful how the thesis can consume you . . . if you let it. Your year-long engagement with Mr. T will be benefited as much by a clear head and time away as it will by hours in Firestone and all-nighters. Also, if you’re anything like me (which is to say, human), not every day will be the right day for working on the thesis. Exploit the moments of inspiration by pushing through—into the morning, into Thursday and Saturday nights, into vacation time. Exploit the moments of serious confusion by letting it all go and frolicking in Prospect garden.

requirements, like, like . . . Yale?" If you get to that point, I hope someone is around to get you to snap out of it. It’s all right to feel completely lost and to flip out. Such scenes are amusing to your friends, but are MUCH more valuable earlier on in the process. Here’s a foolproof stress schedule for thesis success: panic in November, flip out in December, tear your hair in January, regain your composure in February, succeed in March, conquer in April, (party in May, June, July, August…).

In the end, you’ll emerge from Firestone sometime in the spring—a little paler, a little thinner, in need of a haircut—but aglow because you’ve done . . . IT. And then you’ll spend the next year (the rest of your life?) trying to figure out exactly what IT was. As I look back on my thesis, I don’t think of it as a culmination either of my Princeton experience or of my time in the world of classics, nor can I say I contributed anything much to the field (not, at least, as much as I got in return). But I think I settled something within myself. I think I came closer to “understanding”—or, perhaps, how to go about understanding something. I think I realized that I care more about something—a book, a character, antiquity—than I thought. I think I dealt with issues that I will continue to contemplate for many years to come. I think I proved to myself that I am capable of independent thought and expression. And I made some great friends along the way. Isn’t that right, Carol?

Froma Zeitlin
Ewing Professor of Greek Language and Literature

It will come as no surprise that senior thesis advising can sometimes be a painful and frustrating chore. Missed deadlines, confused ideas, and general misery for both student and professor in getting the finished product in shape as the last and sometimes traumatic hurdle to attain the coveted undergraduate degree. But then there are the rewards in the form of interactive work that makes the heart soar like an eagle and the professor to her great joy is delighted by the new paths of perception that open up before her through the brilliant originality of a piece of work. Such was my experience in working with Jesse Liebman in spring 2003. I confess that I was very pleased that he chose me as his adviser. He was a member of an upper-level Greek course I taught on Homer’s *Odyssey* in spring 2001 when he was a sophomore. Jesse already stood out in what was a remarkable group of lively, opinionated students, who under the spell of that perennially favorite epic, conducted some of the most exhilarating discussions I have encountered in any class, due in particular to the students’ fierce determination to defend their quite various points of view. I knew for sure when I read his term paper on one of the most enigmatic sections of the poem that has puzzled critics since antiquity. The essay, “A Gate of Ivory: Dreams, God, and Truth in the *Odyssey*,” offered a startling new reading of Penelope’s dream of the geese in her courtyard and the eagle who kills them, which comes to her (in Book 19) at a time when Odysseus is already home, although not yet recognized. I knew too that in the face of some preliminary
skepticism on my part about his Freudian (and I thought, anachronistic) approach, that he was willing to stick to his guns (and his vision). What I did not realize then, however, was the depth of his fascination with Homer that continued to haunt him throughout the rest of his student career. This involvement, even infatuation, culminated in the marvelous senior thesis he wrote, this time on the other epic, the *Iliad*.

When one thinks of ancient Greece, one often thinks first of Homer, the great epic bard, whose two majestic poems were and remain twin cornerstones of literary achievement and cultural influence, down to our own day. So, what could a mere mortal student like Jesse Liebman hope to contribute to the vast bibliography on these epics? What could he do to alter and enrich our perceptions? He himself was keenly aware of this apparent dilemma and yet just as determined to continue to cultivate the profound engagement he felt with Homeric poetry. “Why write about Homer,” he says in the preface, “who is so well written”? In asking “what does it all mean,” he defends his choice by claiming that “instead of searching for the answers, we must... create our own answers.” In this way, he concludes, “the act of investigation is in itself the highest form of admiration.” Modest, yet self-assured, keenly aware of the difficulty of the task he was undertaking but refusing to be daunted by it, Jesse characteristically maintained this balance between his profound respect for those who preceded him and his own vision that led him along the way he had chosen. I quoted the above bit just to give some small idea of the passion and commitment that invigorated Jesse’s thesis and gave it such depth and value.

Now, I’d like to take a good deal of credit for his achievement. We did have frequent discussions; I did read several drafts; I wrote lengthy e-mails of comments and suggestions. But if the end result turned out as it did, it was because he didn’t listen to me, because at some point when he was writing the first chapter, he realized that the way we had agreed upon was not his way. Unlike other heroes, Greek or Trojan, Hektor seems to have no prehistory, in myth or cult, and no afterlife that is not dependent on Homer’s rendering of his character, function, and roles. This seemed to me a terrific project—to trace out the clues through myth, ritual, geography, and alternate traditions—to assess the place of Hektor in the long-lived culture of ancient Greece. But Jesse finally said, no, that wasn’t what really tugged at his heart and mind. He wanted to work with the epic itself and only from within the epic—through the ambiguities of diction, imagery, symbolism, etymology, and repetitive themes—to produce “a semantic and semiotic literary biography of Hektor’s life.” In Jesse’s readings these ambiguities that characterize Hektor are relevant not just to the hero himself as a figure of the flawed leader and would-be protector of his city, but also to the conduct and ideology of the poem as a whole. From this perspective, Hektor stands as a paradigm of the *Iliad*’s uneasy tensions and ambiguities—the dialectic of its seemingly irreconcilable polarities that oppose the domestic sphere of Troy within to the military world without. Another dialectic informs the conflict between “return” (that is “life”) and “glory,” or *kleos*, which is on through untimely death, as it does the innate contrasts between Achilles, born of an immortal mother, and Hektor, who belongs fully
in the human realm. Above all, the etymology of Hektor’s own name contains within itself opposing meanings that come into conflict with one another.

Countless others have written of Hektor, but the originality of this thesis was quite remarkable. I have studied and taught this great Homeric poem throughout my academic career, but Jesse opened my eyes to concepts and nuances I had never considered before. With a combination of close textual analysis, conceptual sophistication, and what seemed to me a quite creative approach, Jesse brilliantly demonstrated the unusual aspects of this ambivalently characterized hero, his function as a function of the epic itself. Additionally, the thesis was beautifully written and argued; the research into secondary sources went far beyond what we would expect from undergraduate work. Jesse may have been expressing his admiration for Homer through his “act of investigation.” I, in turn, reading chapter by chapter, could only express my admiration at Jesse’s own achievement.

So how can this one experience prove of value to all those students who will come after him, all those who will read an essay such as mine in this little book? Jesse hasn’t been the only student through all my years of teaching at Princeton whose work far surpassed the usual expectations. There have been a few others, like him, over these many years, with whom I’ve been privileged to work on their magnum opus. Yet, even at a lesser level, the key, in my opinion, for the student is the depth of engagement in—even love of—a topic. Ideally, there should be a burning question, one that haunts you and keeps returning at odd moments to occupy your thoughts. It is entirely possible that you won’t even find the answers you’ve been seeking or that you’ll be satisfied with what you have found. But the journey is the thing. As the great modern Greek poet, C. P. Cavafy, writes in his poem, “Ithaka,”

As you set out for Ithaka
hope the voyage is a long one,
full of adventure, full of discovery.
Laistrygonians and Cyclops,
angry Poseidon—don’t be afraid of them:
you’ll never find things like that on your way
as long as you keep your thoughts raised high,
as long as a rare excitement
stirs your spirit and your body.
Laistrygonians and Cyclops,
wild Poseidon—you won’t encounter them
unless you bring them along inside your soul,
unless your soul sets them up in front of you.

[Translation by Edmund Keeley]
“Hey Abbie, making progress on your dam(n) thesis?” My friends thought this play-on-words about my thesis on Bonneville Dam was very clever. Amidst the rigors of the culminating academic experience of my Princeton career, I smiled.

I chose to write my thesis about Bonneville Dam because it is a topic about which I care deeply. I grew up in the Pacific Northwest, where Bonneville blocks the Columbia River’s flow to provide power to both Oregon and Washington. The topic fit well with my major in civil engineering and my certificate in the Woodrow Wilson School. Not only did I study the details of the engineering of the dam during the 1930s, but also the politics of the initial project and the dam’s negative impact on Columbia River fish populations—especially salmon. I approached the problem from a variety of angles: by doing calculations, by wandering the stacks at Firestone, by visiting and photographing the dam, by exploring the National Archives, by interviewing dam engineers, and, of course, by writing. As a result, I found the thesis to be the most rewarding—and most frustrating—academic exercise at Princeton. All of this I had expected from the moment I realized, with no small amount of horror, sometime early in my freshman year, that Princeton had a senior thesis requirement.

What I had not expected to find while doing stress analyses and describing the construction process at Bonneville is my special friendship with my adviser, Professor David Billington. I first met Professor Billington when I enrolled in a course about dams during my sophomore year. He convinced me to spend the following summer at Princeton doing research related to dams, mostly on those built by the Tennessee Valley Authority. With his encouragement I chose a related thesis topic at the end of my junior year. Throughout my senior year, Professor Billington and I met weekly to discuss research, calculations, and drafts of various chapters. (O.K., I admit we also chatted about my orchestra concerts and his grandkids’ visits.) The ideas in my thesis are truly the result of the collaboration of our efforts, as well as those of Professor Jameson Doig in WWS. Professor Billington provided encouragement and new ideas when I needed them and also subtle nudgings, when necessary,
that perhaps a little more progress next week would be nice. We became good friends. One of my favorite Princeton snapshots is one of me and Professor Billington, both appropriately adorned in orange and black, taken at the 2002 P-rade.

And so, my words of wisdom to authors of future theses: you WILL procrastinate in beginning your research; you WILL spend more time than you would choose in the library, the computer cluster, or the lab; you WILL agonize over calculations, paragraphs, and an appropriately pithy title; you WILL proofread your classmates’ lengthy writings on topics you never expected to even think about (like Vermont dairy farms or east Tennessee’s early anti-slavery movement).

But writing your thesis is much more than that. If you choose your topic and your adviser carefully you WILL find it rewarding and even exhilarating!

David Billington
Gordon Y.S. Wu Professor of Engineering

I first came to know Abbie Liel when she was one of 12 students in a new course, “Rivers and the Regional Environment,” which Professor Michael Celia and I introduced in the fall of 1999. Her thesis would grow out of the course, but in turn her research would enrich the course because after her exemplary work in the seminar she became my research assistant. She went to the federal archives and developed materials that we have used in subsequent years as the course became permanent. At the end of her junior year she decided to write her thesis on Bonneville Dam, just a few miles upstream on the Columbia River from her hometown of Portland, Oregon. That was not the only reason she chose Bonneville Dam; it was one of those major Depression-era dams that included Hoover and Grand Coulee, yet it was far less famous. There has been no major scholarly work on that dam even though it is one of only three other dams that is a National Historic Landmark. Furthermore, Abbie was doing the certificate program in the Woodrow Wilson School while majoring in structures for her B.S.E. degree; the dam and its context in the Pacific Northwest was and is a significant political object as well as an innovative structure.

This combination of structure and politics made for an extraordinary thesis and required Abbie to have two advisers: Jameson Doig and myself. Professor Doig had attended the lectures in the rivers course, had been a principal adviser to James Smith and me on the course development, and was an invaluable guide to Abbie on her thesis.

I met with Abbie weekly as she worked her way though the archival documents and began to recreate the calculations necessary for the dam design. There had been a rush to get the dam started in 1933 as a job-creating project so that prior calculations had never been published in the scholarly literature; thus Abbie developed them on her own. These studies ranged from the concrete dam stability to hydraulic calculations for the spillway to the dimensioning of the fish ladder.
She had obtained detailed engineering drawings for the dam, and we studied them together as she organized her engineering computations and her understanding of the construction sequence, also an innovation in dam building at that time. At the same time she was going through the materials from the National Archives that connected engineering issues to political decisions and also explained the political controversies between the states of Oregon and Washington. These also involved the debates between promoters of Grand Coulee and Bonneville and between the plans of the U.S. Army Corps of Engineers and those of the Bureau of Reclamation.

Often I would suggest something to Abbie, which at times would involve difficulties unforeseen by me. But the result was invariably the same; she would return the next week with a thoroughly researched answer that would usually become part of her thesis. She was always remarkably calm and unfazed by such assignments, or by any assignments that I can recall. Our meetings together were more and more collegial; she was a real partner in scholarship. In a university setting, which is often seen as stressful with students and faculty overworked, Abbie seemed to have her work under control to a remarkable extent. While working on her thesis and at the same time serving as a research assistant on a funded scholarly study of the Tennessee Valley Authority, she remained active in extracurricular affairs and compiled an academic record unsurpassed by anyone else in the Class of 2002.

As we worked though her thesis we became conscious of its originality and have prepared from it a scholarly article to be submitted to the Journal of Technology and Culture. Working with Abbie Liel over the past three years has been a major highlight of my 45 years of teaching at Princeton and has set a standard for the senior thesis in civil and environmental engineering.

This thesis, as with most others that I have advised, is closely connected to my teaching and that means that it and the others have become documents for teaching as well as scholarly contributions. It is this intimate connection between teaching and scholarship that most pleases me and thus creates a close bond between teacher and student. The choice of topic is therefore crucial and because the students I advise all have taken at least one of my introductory courses, they are motivated to follow the material from these courses into archival research projects. Only a few such works end up published in scholarly journals but most have served well as resources for the courses that originally stimulated them.
Toward *De Novo* Protein Design: Novel Distance Based Force Fields

Christopher Loose ’02

**My senior thesis involved** the development of force fields for the prediction of protein structure. Under the guidance of Christodoulos Floudas in the Department of Chemical Engineering, I formulated and optimized two force fields that could be used to assign an energy to a protein in a given fold. With this tool in hand, one may design new proteins to serve as pharmaceuticals, which inhibit undesirable biological pathways in the human body.

Drug design appealed to me because of my longstanding interest in the pharmaceutical industry. As an intern at Merck & Co. during the summer before my senior year, I learned how biological research is carried out in industry and obtained a practical perspective on how the technology I was developing in my senior thesis could be applied in industry. My thesis research opened my eyes to the opportunities for drastic advances that may be made in business through the application of engineering theory.

The flexibility available in the choice of a research project allowed me to pick a topic that built upon my previous academic experience. My interest in business led me to pursue the engineering and management systems certificate, which consisted largely of classes in optimization and probability. I utilized the skills I learned in these classes extensively in the formulation and optimization of our force fields. My thesis research gave me a chance to use theory from classes to solve a real-world problem, and I think this will help me apply the knowledge gained during my coursework at Princeton to solve other challenging scientific problems in my future career.

My research began early in the fall of my senior year when Professor Floudas and I went over the mathematical formulation of the force field and drew up a plan on how to approach the problem. We also put together a timeline that specified when crucial components should be completed. Despite numerous challenges that arose during each phase of the research, I quickly discovered that the professors are leaders in their fields with extensive experience and that they can guide you through seemingly insurmountable problems. Professor Floudas was not only clearly capable of resolving difficulties, he dedicated as much time as was necessary to ensure the success of my research. In addition to the help from professors, I was able to get assistance from talented graduate students,
which prevented me from ever getting tied down too long by a single problem.

My thesis research was exciting because of the extraordinary resources available to me. Throughout the year, I had access to 80 high-powered microprocessors in parallel and licensed software, which gave me the ability to address problems much larger in scope than would be possible on my own. Additionally, when new developments in my research necessitated an expansion of these resources, upgrades were swiftly made to ensure the success of my project. The technology available in the department enables students to carry out research that could be accomplished at very few institutions.

The thesis experience was also rewarding because of the extensive opportunities for me to generate ideas to improve my research. Throughout the project, I was the first to recognize obstacles or potential improvements because I was carrying out the day-to-day research. While assistance from my adviser was always available if I wanted, I was often able to solve problems independently. This became increasingly true as the time went on because I learned how my adviser approached difficulties and improved my problem-solving skills. The successful outcome of the project was particularly gratifying because of the consistent personal contributions I made throughout the year.

The results we achieved in my project gave me the confidence to address unsolved scientific problems in the future. Our force field outperformed the leading model of its type in published literature when used to determine the native folds of proteins that had not been seen by the force field before. This success led us to submit two papers for publication in refereed scientific journals to document our model. These results assured me that I could make significant contributions to the scientific community.

My senior thesis was a great opportunity to address a novel problem with the assistance of outstanding professors. I was equipped with phenomenal resources which allowed me to solve problems much larger in scope than could be presented in the classroom. The skills I developed when making great improvements in the solution of current scientific research will be invaluable as I begin to confront new challenges in my career as a scientist.

Christodoulos Floudas
Professor of Chemical Engineering

It has been a great pleasure advising Christopher Loose for his senior thesis work. His project focused on the study and development of a novel distance-based force field which is instrumental for two important scientific areas: (1) the protein fold recognition, and (2) the *de novo* protein design.

Chris investigated an exciting new avenue for force field development which is based on a four-stage process. In the first stage, Chris studied a new way of generating decoy structures through imposing restraints on the secondary structure elements and utilizing the principles of NMR structure refinement via a state of the art methodology, DYANA. Chris enhanced significantly the
structure refinement approach through a very clever way of using the elements of DYANA and by taking into account important insights on the energetic characteristics. In the second stage, Chris introduced a novel approach for deriving the energy model, which is based on a linear optimization framework that ensures that the force field will be optimized in such a way that all the decoy structures will be of higher energy in comparison to the native structures of their respective proteins. The development of the energy model was complemented by key insights that were formulated as explicit constraints in the linear programming model.

Chris developed an ingenious approach for addressing this problem through a decomposition and constraints dropping scheme which allowed for the incorporation of all the decoys at successive stages. Furthermore, Chris investigated the advantages of a maximum feasibility criterion introduced recently in the literature. In the third stage, Chris studied the further development of two types of force fields. The first model is based only on a distance dependent between the alpha carbons of all pairs of the amino acids, while the second type of force field is based on the joint discrete distribution of distances between alpha and beta carbons. In the fourth stage, Chris performed very extensive validation studies and comparative studies to the best available force fields in the open literature. Chris’s work resulted in improvement compared to the leading force fields. The improvements have been quantified through extensive comparative studies on 21,800 decoys of 109 proteins based on rigorous criteria such as the rank of the lowest energy for the native conformation and the Z-score, which measures the degree of energetic separation between decoys and native conformation while it takes into account the variance.

Chris performed exceptionally well in his research work throughout the two semesters. He accomplished significant progress on a consistent basis and despite the heavy load in the fall semester. During the course of the senior thesis research he demonstrated independence, creativity, great passion for research, and commitment to excellence. Our numerous scheduled and unscheduled research meetings were driven by the pursuit of posing, interpreting, and addressing key questions related to the findings of the thesis. The enthusiasm for genuine contributions to the scientific understanding of this important class of problems was a prevalent theme in Chris’s approach, and it was complemented with demonstrated excellence in research.

In sum, Chris demonstrated a truly outstanding performance in his senior thesis work for which he received the Calvin Dodd MacCracken Senior Thesis/Project Award. The proposed novel and impressive force fields will serve as a basis for our work in the areas of (1) fold recognition, (2) de novo protein design, and (3) de novo protein-protein interactions. Chris’s senior thesis work is definitely comparable to our best graduate students’ work and will result in two full-length publications.
I arrived at my major through a rather erratic progression—from civil engineering to very undecided to the new Department of French and Italian. It is perhaps not surprising, then, that my thesis followed a similar course. As of September, I was planning on translating modern French Canadian poetry and analyzing its relation to the work of earlier Québécois poets. By October, I had started researching the new elementary curriculum for public schools in Ontario. The result was *De Langue Double, Maint Trouble: A Critical Review of the Ontario French Immersion Curriculum*. I think the sea change in thesis plans was just as important to my Princeton experience as my switch between majors.

I chose my first thesis topic because I thoroughly enjoyed writing my spring term JP, a poetry translation. I built a rapport with my adviser, Professor François Rigolot, and further explored an interest I developed through creative writing and comparative literature coursework. As I began my new research, though, I was far from excited. That didn’t seem a particularly good omen for a project that would last much of the year. At the same time, I was enrolled in a linguistics class about second language acquisition, and was intrigued about the relation of language acquisition theories to my personal educational background. Growing up just outside of Toronto, I had the option in public school of following a French immersion program. This meant that up to half of my instructional time, from grade one through high school graduation, was in French. Despite this, my French skills were (and remain) far from perfect. The Ontario government recently overhauled the entire elementary curriculum, so the intersection of curriculum design and second language development seemed both a timely and interesting subject for study.

There are certainly drawbacks to jumping into a subject where one has no academic experience. I started from scratch, working from secondary sources on curriculum theory back to primary works, and trudging slowly through hundreds of pages of government documents. I should mention that the Firestone Library staff is an invaluable source of information and ideas. In particular, the interlibrary loan department made writing my thesis possible. They acquired all kinds of obscure foreign
government publications on my behalf, even when I was crazed by fast-approaching deadlines. Starting from little knowledge meant lots of background reading, as well as a constant process of refining the focus of the paper.

As the second semester began, I felt that I had a good amount of theoretical knowledge about curriculum design. I found that this was untrue during a course on the sociology of education. That class introduced me to a different set of sources, and ultimately made my thesis more balanced and thorough. If you can take a class related to your thesis topic, even in the last semester of senior year, go for it. You still have time to explore related topics and use them to strengthen your argument, whether by expanding your evidence, questioning your assumptions, or focusing your hypothesis. Just take care not to be that person in precept who only talks about their thesis.

Professors—other than your adviser—are an oft-neglected resource. Princeton has assembled an amazing faculty noted for its accessibility to undergraduates. Take advantage of it. My linguistics and sociology professors were a great help to me, as were faculty members at other colleges. Since my adviser specializes in the literature of the French Renaissance, he acted most often as a sounding board for ideas, and as a guide in the writing and editing process. He could tell me when I was slipping into edu-jargon, and when I was compromising the broader focus of the argument by getting bogged down by less relevant details. When you’re dealing with a large amount of information, and trying to make it make sense to yourself and to others, it helps to draw on the critical distance of someone slightly less attached to the project. The light of the carrel and the glare of the laptop screen don’t help you see or think straight. Talking it over, however, just might.

When it comes to those discussions, don’t limit them to your adviser or to other professors. You’re surrounded by other students who are, well, really smart. And many of them are going through the same challenges and frustrations as you are. Friends aren’t just good for trips to the Wa or for complaining about how much work you have to do. They can help you focus your thoughts, edit chapters, build flowcharts, and retrieve documents that fall into the electronic abyss. There are many people out there who will be happy to help you, and both you and your thesis will be better for it.

Be a little bit scared. You’ve never written a thesis before. Just don’t be intimidated. In the end, a good thesis is one that allows you to learn an enormous amount about a topic that fascinates you. The surest way to make the experience positive is to find a subject that excites you, and then find an adviser who will support you in your efforts. Independent work doesn’t mean “a completely solitary scholastic endeavor.” It means drawing on the resources that surround you to produce a paper that is unmistakably yours. Be open to new ideas, to changing focus, to different perspectives. Save often. Buy a copy card. Enjoy this defining moment in your undergraduate career. You too can do it, you just don’t know it yet.
Senior thesis advising provides an opportunity for the director to engage intellectually with students on selected topics of scholarly interest, while leaving the students a great deal of freedom in the way they organize their research and frame their approach. It is wonderful to watch them grow intellectually and realize they are capable of putting their analytical and expository skills to work and producing a fine piece of scholarship almost on their own.

Caroline McGuire’s thesis, entitled “De Langue double maint trouble” (roughly meaning “if your language is double, that means trouble”), is a linguistically oriented piece of scholarship about second-language acquisition. It offers a remarkably well-documented evaluation and critical review of the 2001 Ontario French Immersion Curriculum, an official document which now replaces the Common Curriculum that had been in place in Ontario since 1995.

In a very short time span, Caroline was able to master a vast and difficult array of linguistic material and beautifully make sense of it. Her theoretical and practical research on the development of second-language communication skills was truly impressive. She was able to conceptualize her topic at the highest level, analyze the past and present Ontario curricula with great care, and make a number of substantial suggestions for improvements in a tactful, convincing way.

In her first chapter, Caroline clearly laid down the complex theoretical framework of her thesis, based on extensive readings in the field of bilingual education, and especially French as a second language. In her second chapter, she analyzed the goals set by the Ontario Ministry of Education in the context of cultural and political interests of the Canadian province. Finally, in her third chapter, she made substantial suggestions for improvements to the Ontario Curriculum. This most creative part of the thesis will certainly be of great interest to students of bilingual education as well as politicians in bilingual countries outside Canada.

Some of the highly technical aspects of this thesis may prove difficult to readers who lack familiarity with some sophisticated development theories of bilingual education. Yet, this should not be turned against Caroline but, rather, considered as a tribute to her determination to remain as logical and exhaustive as possible throughout her research project.

Chapter III is the most accessible part of the thesis. It formulates advice genuinely directed to the Ontario Ministry. Caroline’s passionate plea in favor of increased teacher control and expanded curricular flexibility is well taken and even moving. I hope her thesis will be widely circulated in Ontario political circles as it has much to offer in terms of linguistic policy in a highly bilingual province.

The year before, I had directed Caroline’s highly creative junior paper. She had decided to translate a collection of poems, “Regards et jeux dans l’espace” [Gazes and Games within Spaces], by a great Québec poet, Saint-Denys Garneau, who is virtually unknown in English-speaking Canada today. She did a
In a very short time span, Caroline was able to master a vast and difficult array of linguistic material and beautifully make sense of it. Marvelous job, explaining a number of difficult linguistic and stylistic choices she had to make. I had no idea that she would be able to turn to totally different research for her senior thesis, and be equally good at it. Caroline is remarkably at ease with technical language, and uses her analytical skills in a productive way. The advice she gives to the Ontario Ministry makes sense, and stems from a careful review and evaluation of a number of administrative documents she has examined with a great deal of sanity. In sum, this thesis is an excellent piece of scholarship.

If I had to give advice to next year’s seniors, I would say the following: (1) choose an adviser you respect who can give you maximum freedom; (2) pick a limited topic and be aware of the fact that your actual subject will end up being even more limited than what you had envisaged initially; (3) plan things early (as early as possible); (4) tell yourself that you don’t have to write a masterpiece. All you need is to sit at your computer every day of the week, and never leave your desk unless you have written two consecutive pages of simple prose!
The most unique feature of the Princeton experience is the ability to do serious research with senior faculty. I always wanted to explore topics in economics, and the thesis offers these opportunities in a way that regular classes cannot. The summer before my junior year, Harvey Rosen and I began studying the effects of wealth changes on the changes in people’s health. While the topic had been studied before, problems with estimation plagued much of the earlier research. After all, it is just as likely that healthier people earn more money as it is that rich people are in good health because they can afford better medical care—or, for that matter, that some unknown third factors drive both health and wealth. Working with a data set that had detailed information about both health and people’s assets, we developed a model that used inheritance as a proxy for wealth in an effort to deal with this endogeneity issue. Untangling this maze proved difficult, but the process was eye-opening. In the end, our results challenged the conventional wisdom—more money does not necessarily have as large an effect on health as had been previously thought.

The health-wealth paper became my junior independent work, as well as a cornerstone of my senior thesis. I found that health economics was to my liking, and Professor Rosen and I began another project, this one on the effects of insurance on both utilization of medical services and actual health outcomes. Polishing the econometric model used in the first paper even further, we applied our tools to this even more challenging problem. A similar endogeneity problem arises in this question: Do people get insurance because they expect to get sick, or do those that have insurance get sick less frequently, or are there unknown factors driving both the propensity to get insurance and health? We were able to address this issue using self-employment status as a proxy for insurance status. Again, there were frequent setbacks, but in the end we found that while having insurance increases the use of medical services significantly, it does not always have a significant effect on health. Clearly, these findings have serious implications for the debates on health insurance policy in this country. My thesis joined the two papers with a brief discussion of the importance of health economics in public policy.

The best piece of advice that I can offer to those starting their theses is simple—don’t settle for less. While it may be hard to write a good thesis, the rewards are worth the trouble.
It is unlikely that you will ever have an opportunity like this again, to learn a lot about something that appeals to you while being guided by an expert. Your thesis doesn’t have to be earth shattering, but it should be interesting—there is no reason to pick a boring topic, because you can pick anything you want. A dull subject, moreover, will make your work tedious instead of exciting as it should be. Start early, so that if you decide that the topic you chose is not as enthralling as you thought, you can change it without getting down to the wire. And if you know of a faculty member who is interested in the same field, seek that person out. Generally, he or she will be happy to find someone who is also attracted by that subject.

Inevitably, problems will arise during your research, as they did for me—if you do not find mistakes and surprises, then you probably missed something. Turning challenges into opportunities is the foundation of a good thesis. They may be frustrating, but that is where the real learning comes from. Chances are, your thesis, like mine, will expand far beyond its original scope. Don’t be afraid of not finding a definitive answer. Frequently, the most interesting result is the process itself, not the actual outcome. Regardless, seeing your work come together after months of research will give you a great sense of satisfaction.

From picking apart prior studies to refining exotic econometric models to defending the work, I learned a great deal about how good economic research is done while working on my thesis. While at other schools most senior faculty pretend that undergraduates do not exist, Princeton is full of great teachers like Professor Rosen, who patiently and carefully taught me how to critically evaluate the work of others and create models of my own. I have pursued my interests to graduate school, and I now recognize that the research done for theses is frequently of the caliber found among graduate students. While occasionally difficult, the thesis experience is, on the whole, an incredible experience. The opportunities involved should not be taken lightly.

Harvey Rosen
John L. Weinberg Professor of Economics and Business Policy

I first met Jonathan Meer when he enrolled in my freshman seminar on tax policy. I was struck by his enthusiasm and intelligence, and remember thinking at the time that he had the potential to be a first-rate economics major. We kept in contact after the seminar, and at the end of Jonathan’s sophomore year we agreed to work together on his junior paper. His senior thesis work was a continuation of his junior project; in effect, then, it was really a two-year project.

The thesis consisted of two chapters, each of which, in my view, formed the basis for a publishable article. The first chapter examined the well-documented positive correlation between wealth and health. On the basis of this correlation, some researchers and policymakers have assumed that wealth causes health, and argued that the best way to increase health among the poor would be to redistribute wealth to them. But correlation does not imply causation. One can
easily imagine that causality runs in the other direction—people have substantial wealth because they are healthy. With a creative application of the appropriate econometric techniques, Jonathan showed that the causal link from wealth to health is illusory. In the same way, the second chapter subjected the statistical relationship between health status and health insurance to careful scrutiny. Again, a sophisticated econometric analysis indicated that the link from health insurance to health status is weaker than one might guess.

Ultimately, the success of Jonathan’s senior thesis was due primarily to his talent and the breathtaking amount of work he put into the project. However, I like to think that at least some of the success was due to a little experiment I tried in the setup for advising him. At the time that I was working with Jonathan on his junior paper, I was supervising the senior theses of two exceptional members of the Class of 2001, Tom Peff and Craig Perry. My experiment was to organize Jonathan, Tom, and Craig into a “working group.” In addition to the usual one-on-one meetings with each advisee, I met with the group as a whole about six times per semester, generally during the evening at the Frist Campus Center. The working group was supposed to give the students the opportunity to bat around ideas for topics, to critique each others’ first drafts, to trade suggestions for dealing with various computer and statistical problems, and not least, to keep everyone on schedule. I was particularly hopeful that Tom and Craig would be able to pass onto Jonathan some of the wisdom that they had accumulated during the process of writing their junior papers the year before.

The working group was a great success. I think that the support that each member of the group received from his colleagues resulted in better products for each of them. The working group had one additional benefit that I hadn’t anticipated: it was really a lot more fun than the traditional way of advising. I hope that I’ll have a chance to try it again.
It was 4 a.m. on April 8, mere hours before politics majors cleared the final hurdle separating them from that coveted Princeton degree.

And the most happening place on campus was the WaWa. Wandering in a daze between the depleted chip, cookie, and soda aisles, seniors looked at each other with reassuring nods and unspoken well-wishes. No one mentioned the “paper” due in the morning. Even underclassmen, who looked far less comatose than their older peers, knew not to break the verbal silence beneath the shield of bad ’80s background music.

And then, someone made the mistake.

“Hey!” asked a perky freshman who actually chose to stay up late for fun. “How is that THESIS coming?”

The forbidden question. That was it. The word that had dominated our thoughts for months—or those particularly prone to procrastination—weeks or days.

How is that thesis coming?

How do you explain spending countless hours getting intimate with Firestone, a labyrinth of a library that not even Columbus could navigate easily? How can you explain reading everything experts ever wrote on your topic—and then showing why they are wrong or what they missed?

How do you describe crafting the eternal emblem of your undergraduate academic career?

Well, whether people in the ’Wa that night were on the brink of salvation or insanity—and whether they responded with a smile or a glazed stare—depended on the steps they had taken up to that point.

The best thing about the thesis is that it is completely within your control. If you map a master plan, set realistic goals and stick to them, and leave time for the unexpected, completing the thesis will be one of Princeton’s most fulfilling experiences.

And it will be a lot of fun.

Is this contrary to everything you may have thought? Well, we have all heard the horror stories and urban myths.

There are those who lock themselves in their carrel days before deadline with their only rest being quick prayers to the “Thesis Gods.” And there are those who give their advisers a
rough draft a week before the final is due—only to hear that a thesis statement can be found nowhere in their thesis.

But those are the extreme cases. Plus, after the due date the stories get more elaborate and morph into badges of bravery.

For most people, the thesis is a mental and academic challenge that they are proud to have conquered. And for the truly lucky, including myself, it is a life-altering experience that reveals and represents your greatest potential.

O.K., I admit it. I loved writing my thesis. And I am not alone. As much as seniors complain about it—and you will hear lots of complaints—the truth is the thesis is an open invitation to explore a unique question on a personally passionate subject. You are given the time, space, and resources to research and write in whatever manner moves you.

For me, that meant doing everything early.

During spring semester of my junior year, I approached Professor Michael Danielson, who was my junior paper adviser. I told him everything I knew about my thesis, and why I wanted him to advise me: “I think I want to write something generally about a historical view of boxing as a tool for social mobility. Well, maybe soccer. Or tennis? No, no, definitely boxing. Or something like that. Anyway, I liked working with you on my JP. Want to be my thesis adviser too?”

Somehow, Professor Danielson translated my ramblings and agreed to help me. After working with him on my JP, I already knew that he would always respond to my random e-mail, phone, and office drop-in questions. I also knew that he would force me to self-motivate. Unlike some advisers, who impose progress reports, Professor Danielson makes you set your own work schedule, and you choose to either succeed or suffer.

And most importantly, I knew that he would be honest and direct with his criticisms.

The first came in September, a few weeks into my senior year, when my thesis topic was still as incomprehensible as America’s obsession with Anna Nicole Smith. Professor Danielson recommended that before I write another directionless word, I find a complex issue that sparked my interest, and raise a question that could be either answered or argued.

At the time, I was taking an African-American history class with Professor Saje Mathieu, who made the past as vivid a reality as this instant. One week she told us to find a news article and analyze it. I immediately thought, “Gut Assignment,” happy that she finally gave us a project I could whip out during halftime of a football game. And then she added that the article had to be published before 1915.

She forced me to go to the microfilm section of the library, a small glass-enclosed cave located four levels into the depths of Firestone. Not having known that the research center even existed, it took two maps, three librarians, and over four hours before I found the room and the article.

But I also found a new love.

Scrolling through the reels of the permanently preserved yesteryear, I became fascinated with the numerous ways a single event could be portrayed. Depending on the writer, an incident could either be noble or cowardly, inex-
I didn’t choose my thesis topic: pure nosiness dragged me to it. I also noticed that the differences were literally traced in black and white.

Before 1915, African-American and mainstream newspapers were covering two separate worlds. Headlines, photos, articles, and even advertisements all revealed the papers’ subtle biases. I began wondering if that chasm changed throughout the years, and if it did, how.

I didn’t choose my thesis topic: pure nosiness dragged me to it.

After consulting with Professor Danielson, I chose six events ranging from 1938 to 1994 that would trace the evolution of the black press: the Joe Louis/Max Schmeling Heavyweight Championship fight; Brown vs. Board of Education; the Watts Riot; University of California vs. Bakke; the appointment of Colin Powell to the Joint Chiefs of Staff; and the O.J. Simpson trial.

Through these six cases, I highlighted the prejudices and the politics of both the black and mainstream press. I also gave a history of the black press, and projected how its role will change in an evolving society. Finally, I explored the racial divide that has historically—and continuously—split our nation.

Starting my work early allowed me to write a completely different thesis from the one I originally envisioned. It also gave me some breathing room for minor emergencies—such as when Professor Danielson rightly recommended that I expand my analysis base from four newspapers to six, which added 75 or so extra articles to the hundreds I had already examined.

But in spite of my early work, and sticking to my timeline, notice that I was still awake at 4 a.m. on the day the thesis was due.

One of the hardest parts of my thesis was letting it go. Every time I looked at it, I would see a word that I wanted to change, or a phrase that needed more power. I was almost thankful for the deadline because it forced me to stop editing and recognize that perfection isn’t possible.

This is not to say that I always liked doing the work. Once, I literally hid my books and research underneath my bed, because I was sick of looking at them and overwhelmed knowing how much more work I had to do. There were times where my hands would hover above the computer keys for minutes at a time, with nothing but a blank screen—and that annoying cartoon paperclip—staring back at me. And often, I just wanted to write THE END in the middle of a sentence or word and turn it all in. I didn’t care where I was, I just wanted to be done.

Now that I am done, however, I know that any other challenge I confront can be tackled using the same methods that were fine-tuned during my thesis: find a unique angle that sparks my curiosity, rely on the advice of respected advisers when I get lost, sacrifice an occasional full-night’s sleep for a lasting reward, and trust that the work I invest will be apparent in the product I present.

And if all else fails, a 4 a.m. run to the ’Wa doesn’t hurt either.
Advising senior theses, at least in large departments like politics and the Woodrow Wilson School, involves complicated mating rituals. Large numbers of seniors seek advisers in a relatively open market of faculty members. Some matches are quickly made, usually between a student with a clearly defined topic and a faculty member who specializes in the area of proposed study. Seniors who know a professor from a precept or junior advising or a freshman seminar often are able to link up with an adviser relatively painlessly. Those with prospective theses that do not easily match up with faculty interests, those with ill-defined or nonexistent topics, and those who lack a connection with a faculty member often wind up wandering Corwin, Robertson, and Bendheim Halls, peddling ideas good and not-so-good to a dwindling number of available professors. Every senior eventually winds up with a faculty partner, but some of the matches that result from this ritual turn out better than others.

Over four decades at Princeton, rarely has this process worked better for me than in the case of Shani Moore. By the time Shani arrived in my office to pop the question in the spring of her junior year, we were well acquainted: she had taken both of my undergraduate courses, been in my precept in one, and was writing a junior paper under my supervision. I was impressed by her work ethic, her steady intellectual growth, and her passion for exploring the African-American experience and questioning the conventional wisdom on both sides of America’s racial divide. Shani’s junior paper examined the negative implications of racial integration in elite sports in the United States, with particular attention to the reduced visibility of traditionally black colleges and the rapid demise of the black sports entrepreneurs and managers in the wake of Jackie Robinson’s breakthrough in 1947.

What was less than clear in the first thesis discussion was Shani’s topic. Initially, she thought about combining her interests in race, sports, and journalism, building perhaps on the subjects treated in her junior paper. We talked about possibilities in this general area, and she went off to frame her ideas more specifically. So far, this was a fairly routine preliminary discussion in the process of designing a senior thesis. What happened next, however, was not the normal second step of an advisee returning with a better defined topic or being overwhelmed by the possibilities. Shani came back with a new and more interesting subject, a clearly defined and fascinating topic, and a well-developed and eminently feasible research plan. On her own, she had leaped over two or three months of the senior thesis process; she had a topic of manageable scope, a clearly stated problem, and an appropriate research methodology, milestones that many seniors never reach.

Shani proposed to examine the intersection of race and journalism through a comparative analysis of the coverage of a number of racially charged events by the African-American and mainstream press. We spent a good deal of time discussing the events to be studied: which ones, how many, and over what time span were the main questions. Criteria—including importance, immediate im-
Working closely with very bright students is always a pleasure, especially when they share your passion for a subject or problem. Impact, long-term significance, and range of subject matter—were developed that helped narrow the field somewhat. Shani did a good deal of preliminary research before settling on six events spread over more than half a century: the Louis-Schmeling fight, the Brown decision, the Watts riot, the Bakke ruling, the Powell appointment, and the arrest of O.J. Simpson. The choices, and the thought that went into their selection, played a significant part in the production of a superior senior thesis.

The other major research issue was the selection of newspapers. The black side of the comparison was relatively simple: Shani examined the literature of the black press, and settled on the Baltimore Afro-American, the Chicago Defender, and the Philadelphia Tribune as the most important and representative papers. Initially, she proposed to use only one mainstream newspaper, the New York Times. I was concerned that relying on the liberal Times with its elite audience would not provide an accurate reading of the coverage of these events by the white press. I was, however, also mindful of the amount of work that would be needed to examine additional newspapers. So I waited until Shani had drafted one of her substantive chapters, and concluded that what was a very good treatment would be even better if additional mainstream papers were included. Shani agreed, selected two more metropolitan dailies, went to back to work, and wove her additional findings into her analysis. This broadening of the sample provided a better sense of the coverage than most Americans saw and reinforced her fascinating conclusions about the wide gulf between the world as presented on the pages of the black and white press.

In the final version of her thesis, Shani carefully examines the amount of coverage, the emphasis in each paper’s treatment, and its “take” on race. Her clear analysis underscores key differences in the approach of the black and white papers, and shows how these variations are repeated from subject to subject and over a long period of time, even though the blatant racism of the white press moderated over the years from Joe Louis to O.J. Simpson. These important findings are skillfully connected to existing research on the African-American press, and the thesis contributes significantly to that literature with thoughtful and solidly documented findings.

Senior theses have all kinds of rewards for faculty members. Working closely with very bright students is always a pleasure, especially when they share your passion for a subject or problem. Even better are theses that are learning experiences, as Shani’s certainly was for me; I had experienced most of these events through mainstream newspapers. Reading Shani’s accounts of the disparate coverage in the black and white press was a sober reminder about the wide chasm that exists between the way black and white America view events that shape how we think about each other and our society.
Cinematic Poetry: Reading Federico García Lorca’s *Poeta en Nueva York* through the Medium of Film

*Heather Morr ’03*

**Shakespeare’s simple-minded servant Tranio** had it right in Act I, Scene 1 of *The Taming of the Shrew* when he said, “No profit grows where is no pleasure ta’en. In brief, sir, study what you most affect.” This advice is as pertinent to Lucentio’s studies in Padua as it is to the senior thesis: You should study what interests you the most. A passion for your research in combination with guidance from your advisers is an assured recipe for thesis success.

As a second-semester junior, however, the thesis seemed to me like an unassailable obstacle in the way of graduation. I knew that in order to write a thesis and to write it well, I would have to make it a process I enjoyed, a process that I would be willing and eager to devote months to. Towards this end, I began my research with a latte and an afternoon trip to Micawber’s book shop. There I rummaged through the stacks and pulled off every book I wanted to read but had not yet found time to do so. As I thumbed through the tower of books I had accumulated, I noticed that I had a latent penchant for film theory and New York City.

I recalled a surrealist poetry collection by Federico García Lorca entitled *Poeta en Nueva York* (Poet in New York). While I had read many of Lorca’s peninsular works, I had never picked up this particular poetry collection because it was considered an outlier to his well known plays and ballads. I was particularly intrigued by a poem in the collection entitled “Oda a Walt Whitman” (“Ode to Walt Whitman”) written in the late 1920s. In this poem, Lorca invokes Whitman as a sort of demigod of the city. The characterization seems fitting given that Whitman’s poetry and editorials on New York are abundant with praise for the vitality of city life. Whitman, however, plays a paradoxical role for Lorca, who in *Poeta en Nueva York* writes about the city masses, not as vivacious, but zombie-like. I asked myself the basic question, “How could a poet who so harshly attacked the city with his poetry (Lorca), be so enthralled by a poet with such an opposing perspective on New York (Whitman)?”

Upon presenting my preliminary ideas to various advisers around the department, most professors agreed the *Poeta en Nueva York* is a difficult and less researched work of the canonical Andalusian poet. The surrealist poems supply an occasional
rational image (for example, the Brooklyn Bridge or the Chrysler Building) and the tone of the poems suggests compelling emotion behind each nonsensical line. The question “How can I try to explicate the poem if I can’t follow the words on the page?” became the question that my thesis aimed to answer.

To answer that question, my adviser led me toward biographical information on Lorca. Through my research on Lorca and his contemporaries, cinematographer Luis Buñuel and painter Salvador Dalí, I explored Lorca’s deep-seated interest in film. I revisited the film theory books I had amassed at Micawber’s and realized that many of Lorca’s perceptions in poetry aligned with surrealist perceptions of reality as portrayed in film. By reading the poems the way one might view a surrealist film, I began to unravel patterns and interwoven themes throughout the text. While Lorca’s work initially appeared unreadable, it was not undecipherable.

As I attempted to unravel the mythologies of Spanish poetry and German, French, and Russian film theory, I watched ideas and chapters come together. With so many potential directions for my research to take and so many theoretical questions waiting for an answer, my advisers were essential in helping me identify which arguments were worth pursuing and which ran outside of the scope of my thesis. They helped me hone in on issues that seemed too broad and offered new insights when it seemed I had reached a dead-end. In the end, I better understood what it meant for a work to be “comparative” and how a comparison of two media, film and poetry, fit within the often difficulty defined field of comparative literature.

It is hard to pinpoint a single rewarding moment in the experience. Being able to exchange ideas one-on-one with an expert in your field on a regular basis is pretty rewarding. So is uncovering that one resource that perfectly supports your hypothesis. So is holding a hard-bound book with your name gold-stamped on it. It may be a rare opportunity in one’s life that he or she is asked to write a book on any subject he or she chooses: embrace it.

I’ll conclude with some straightforward advice:

• Get the ball rolling early and keep it rolling throughout the process. Break the ice; start writing.
• Break your thesis down into steps and set artificial deadlines if necessary.
• Leverage your adviser(s) for their expertise and insight into your topic.
• Read other peoples’ theses or dissertations in your department and use them as a reference guide. These are useful both for formatting tips and inspiration when you begin to question your ability to ever churn out 70+ pages of text.
• When you run into a roadblock, take a step back and try mapping out your ideas on a large sheet of paper or jotting down your notes on note cards and reorganizing them (I did both).
• Once you have a chapter or two of your thesis written, re-read it periodically to make sure it flows with the remainder of your thesis.
• Allow plenty of time to proofread (leaving 10 days before your deadline is ideal).
• Finally, plan a fabulous post-thesis vacation.

Arcadio Díaz-Quiñones
Emory L. Ford Professor of Spanish

Teachers learn a great deal (much more than students realize) from a talented and committed advisee working on her senior thesis. This is precisely the way I feel about Heather Morr. I first came to know Heather as a student in a course I teach on Latin American modern lyric poetry. It was clear then that she valued poetry as art and thought, that she was perfectly fluent in Spanish, and that she was eager to discuss challenging poems by Vallejo, Neruda, Gabriela Mistral, and Borges. Heather was an outstanding student in what turned out to be a truly memorable group for me. But I must say that I really got to know her well while advising her senior thesis. Very soon I realized that thanks to her questions and insights I was rediscovering García Lorca’s *Poeta en Nueva York*, a book I had not read in many years. At Princeton, when an undergraduate advisee is someone with Heather’s talent and motivation, the experience is as intellectually enriching as working with a graduate student.

I found myself very impressed with Heather’s devotion and diligence. We met regularly every week. I held office hours from 3 to 4:30 p.m., and I remember quite clearly that after a few weeks I knew that at 3:00 p.m. sharp it was Heather knocking on my door. After those intense conversations I always felt great admiration for the quickness of mind and the vitality with which she came up with changes in interpretation or with careful readings of difficult experimental texts by García Lorca, or some of the relevant critics she was studying. Heather mastered a selected and well-focused list of critical literature and examined primary and secondary sources in English and Spanish. For example, she spent considerable time documenting García Lorca’s decisive friendship with Luis Buñuel and Salvador Dalí, and at the same time gave meticulous attention to the poet’s vision of the modern city and to textual detail. I got used to her work rhythm, which meant that early in December I was already reading careful drafts. I was impressed by the skill with which Heather responded to questions and by her obvious command not only of her material but of the questions she was asking it. Most important, she responded constructively to criticisms and suggestions for further reading, and she was always willing to revise her chapters.

A turning point occurred, I believe, around January. Drawing from Kracauer, Benjamin and others, the relationship of film and poetry became central to the thesis. Heather decided to cover not only García Lorca’s experience during his stay in New York but also the way film might have influenced the way he saw the city and his poetry. The thesis, in fact, came into its own with a chapter on “Cinematic Poetry” in which she discusses Vertov and Fritz Lang, and of course the importance of surrealist imagery, all to illuminate key poems in *Poeta en*
... seriousness of purpose is essential. That is, the student must be genuinely passionate about the topic she has chosen.

*New York.* She was thus able to read García Lorca’s texts in relation to a complex relationship of images and rhythms. The thesis represents an achievement: an illuminating and carefully documented new reading of a difficult book.

Advice to future seniors? I feel seriousness of purpose is essential. That is, the student must be genuinely passionate about the topic she has chosen. A firm commitment to find answers to the questions will allow the student to rise to the most demanding of challenges in research and writing.
In my mind, the thesis is ultimately an opportunity... an opportunity to investigate a problem that fascinates you, an opportunity to work closely with a professor who shares your interest, an opportunity to produce a body of work of which you are extremely proud. When my senior year began, I was determined to make the most of my thesis experience. Visions of a masterpiece filled my head—the perfect topic, a thorough and insightful analysis, an exceptionally written body of work. Expectations grew, anxiety mounted... it was only September.

Selecting a thesis topic proves to be an intricate process. I was looking for three general qualities in my thesis topic. First and foremost, my topic had to be interesting. The underlying motivation to carry out a yearlong research effort could stem only from a topic in which I was genuinely interested. Second, my topic had to be meaningful. It was important to me that I examine an engineering problem with a real-world application or some direct implication for society. The worst reaction I could imagine was having someone read my thesis and, regardless of my analysis and conclusion, say “Why is this important to begin with?” Finally, my topic had to present a feasible challenge. That is, I wanted a volume of research and difficulty of analysis that I was capable of accomplishing. No matter how interesting a topic might be, there was no reason to set myself up for unnecessary frustration. Overall I wanted to set the bar high, but not out of reach.

Let me insert some related advice about thesis topics here. There’s no greater mistake you can make than choosing a research topic that you find boring—all students know this. At the same time, don’t feel anxious if you’re not overwhelmingly passionate about your topic from the start. It may take a month or so of research before you fully grasp the potential of your topic, and your enthusiasm about it is likely to grow in the process. Your adviser is the best resource for questions about the scope and difficulty of possible topics. Most topics can yield research questions and problem statements of varying difficulty, but make sure there isn’t a wide gap (in terms of required time, funding, and expertise) between a mundane and innovative research effort. Be able to adjust the level of challenge and effort as your research progresses. Avoid overcommitment or selling...
yourself short. Bottom line—you can guarantee a successful thesis experience with a carefully selected topic.

My topic search was limited by a rather practical consideration—fulfilling multiple academic requirements. As a mechanical and aerospace engineering (MAE) major and Woodrow Wilson School (WWS) certificate student, my thesis needed to contain both a technical analysis and policy assessment. Since I had a strong interest in national security policy, I approached Professor Hal Feiveson, who co-directs the Program on Science and Global Security in the school. During an initial brainstorming session, the topics of ballistic missile defense and space weapons captured my attention. Coincidentally, Professor Feiveson had advised an MAE thesis (Melissa Ryan ’00) on ballistic missile defense. Professor Jeremy Kasdin, the MAE thesis/independent work coordinator (and also my academic adviser during my freshman year), had advised Melissa’s thesis as well. I immediately decided that the advising team of Professors Kasdin and Feiveson was a perfect fit for me.

As for my topic, I chose to investigate the prospect of using space-based weapons for ballistic missile defense. The policy component of my thesis looked to be timely and relevant given the current political circumstances. North Korea’s nuclear weapons and ballistic missile programs were receiving greater attention. President Bush had recently withdrawn the United States from the Anti-Ballistic Missile Treaty and accelerated plans to develop and deploy a national missile defense system. At the same time, the issue of weaponizing space was becoming a greater priority in international politics. The technical component of my thesis emerged as a proof-of-concept analysis of space-based interceptors. This required me to learn orbital mechanics, a subject I had not seen in previous coursework but was eager to add to my toolbox. Melissa’s thesis on ballistic missile defense provided a foundation on which I could develop my calculation methods. As different pieces of my research plan fell into place, my enthusiasm and confidence increased.

The greatest challenge to the development of my thesis was integrating the technical and policy components into a single, coherent research effort. In particular, I needed to isolate a specific technical problem that would have implications for the overall policy debate. After some preliminary research, I used the following line of reasoning to frame the technical analysis. Given a serious missile threat, the U.S. should consider developing a ballistic missile defense system. Space-based interceptors are among the options for such a system. Given the strong international support for banning space weapons, the U.S. should consider space-based interceptors only if they provide a significant capability that alternative weapons do not. Boost-phase interception—the destruction of a missile while its rocket engine is firing—is often considered such a capability. Thus, boost-phase interception became the focus of my technical analysis.

My calculations examined the technical feasibility and cost of a space-based interceptor system capable of boost-phase interception. The results of my analysis revealed that boost-phase intercept using a space-based interceptor
is theoretically feasible. However, there are numerous technical issues that would make it extremely difficult in practice. In addition, the cost of a complete and effective system would be extremely high. The political cost of space-based interceptors would be equally high. International space law asserts that space should be used only for peaceful purposes. There is increasing support for formalizing a ban on all space weapons. The U.S. has been strongly criticized for not backing this effort. The ultimate question becomes: Is boost-phase intercept absolutely necessary for ballistic missile defense and U.S. national security? From a technical standpoint, a U.S. decision to develop and deploy space-based interceptors would be exceedingly risky and costly. From a political standpoint, this move would be met with strong opposition from other nations. We will know what course of action the U.S. chooses within the next 10 years.

So did I make the most of the opportunity . . . did my September vision materialize in May? Admittedly, there were stretches of disappointment here and there. I was not completely satisfied with my final product, but an eternal perfectionist like me rarely is. Overall I came away from my thesis experience with a strengthened appreciation for research and renewed confidence in my ability to solve problems. I could not have asked for a more rewarding end to my Princeton career. My thesis experience truly serves as the culmination of my past academic work and the foundation for my future professional endeavors.

N. Jeremy Kasdin
Assistant Professor of Mechanical and Aerospace Engineering

In teaching design we often discuss the distinction between analysis and synthesis. This applies equally well to the undergraduate experience. Much of a student’s undergraduate education is spent analyzing—learning the fundamentals and developing a facility for the study of his or her chosen field. However, it is the creative leap into synthesis, using knowledge gained to create new ideas and insights, that marks the true maturation of the student into a professional and leader. Princeton is unique in that we ask all of our students to take this creative step. The senior thesis is to me an essential part of an engineer’s (or any student’s) education; the opportunity, often for the first time, to synthesize concepts in a new way. It doesn’t matter if our students go on to become engineers or bankers, this ability to apply knowledge, to think creatively and, most importantly, to articulate these ideas in an understandable way, is critical to their success.

For the faculty adviser, the senior thesis experience is no less rewarding. We do what we do out of a love of learning. The pleasure of advising is in both working closely with an individual student and watching as they grow and learn, and in the realization that we too have learned something new from the experience. I can’t think of a single advising experience where I haven’t learned along with my student. In many cases it is a new discovery, a new insight overall I wanted to set the bar high, but not out of reach.
...it is the creative leap into synthesis, using knowledge gained to create new ideas and insights, that marks the true maturation of the student...

into material I hadn’t looked at in some time, or new ways to teach. The thesis is also one of the only times to see the student experience the process of creation from start to finish. This experience of teaching and learning together with a student is uniquely rewarding in ways that classroom teaching is not. I have developed friendships and relationships with students that I know will last a lifetime.

Advising Jeff was a particular pleasure. It also had extra meaning for me, as Jeff was part of my first group of freshman advisees when I started as a faculty member. It was enormously satisfying to witness Jeff’s growth from the uncertainty of a new student to the maturity and capability he demonstrated in his thesis. Jeff did a superb job and produced one of the most well-written theses I have read.

When Jeff came to me early in the year and asked if I would co-advise him on a thesis relating to missile defense, I agreed but with some trepidation. A previous student had done a similar thesis and I was uncertain whether we could find a new problem. Jeff had also never taken a course in the orbital mechanics required for the problem. As a Woodrow Wilson School certificate student, he had the added requirement that his thesis incorporate a clear public policy component and he had yet to define it. In the end, my concerns were unfounded. Jeff did a beautiful job during fall term, investigating the various issues around missile defense, and, in particular, the thorny issues that surround the question of space-based interceptors. He demonstrated an impressive clarity of thought by his ability, through the policy analysis, to frame the appropriate questions and formulate a cohesive and manageable technical problem. He was also able to teach himself orbital mechanics from a series of textbooks I lent him.

Jeff’s thesis was truly an independent research effort. I have no current research activity in ballistic missile defense so I was only able to give general guidelines on the basic engineering science. Jeff was able to formulate the problem through careful policy analysis, learn the necessary technical tools, study possible space-based defense scenarios, and through careful analysis and simulation demonstrate the difficulties of relying on space-based defense. In addition to being a tremendous learning experience for Jeff, I believe his thesis made substantive contributions to an important national problem. Jeff was awarded the best thesis prize in our department at the end of the year.

I have the rare privilege of overseeing all of the juniors and seniors in our department who are doing independent work. My observation is that the biggest frustration for students is in the area of expectations. I imagine that this is particularly true in engineering. Prior to their thesis, students have only tackled problems formulated for them with a solution they know they will receive the next week. Or they have worked in laboratories where they know the results to be expected at the end of three hours. It often comes as a shock to them when they discover that their carefully formulated experiments or well thought out analyses fail the first time, as they inevitably do. I know that
when I was doing my thesis as an undergraduate here, I learned more from the consistent failures during fall term than from any successful problem set. Here is where the advice comes. Have high expectations and goals, but also expect the inevitable mistakes and wrong turns and recognize the learning that they are providing. The vast majority of learning takes place in the process of doing the senior thesis, not necessarily in the final solution.

And of course, start early.

Harold Feiveson
Senior Research Policy Analyst, Woodrow Wilson School and the Program on Science and Global Security

Many of the theses I have advised have given me great satisfaction either because of their high quality or, even when they were not of the highest distinction, because they represented at the end a real achievement surpassing what the students thought they were capable of doing. Many of these theses required lots of work by me, the adviser, and many others very little as it turned out. Jeff’s thesis was special in at once being of the highest excellence and involving, I must admit, very little work by me! It had the added satisfaction of being a thesis that lent itself to co-advising—in Jeff’s case, with Mechanical and Aerospace Engineering Professor Jeremy Kasdin.

Over the years, I have found such co-advising, particularly with faculty from the Engineering School or one of the science departments, a great learning experience for both the student and me. One of the forerunners of Jeff’s thesis was one such co-advised thesis, that by Melissa Ryan ’00, which also was directed by Professor Kasdin and myself. In brainstorming with Melissa, I suggested that she analyze the capability of a ground-based missile defense system located at a specific location in the United States to intercept a ballistic missile launched from various specific points abroad at various targets in the U.S. (for example, a missile launched from North Korea aimed at Los Angeles, with a missile defense battery located in North Dakota). The possibility of an intercept would then depend (among other factors) upon how soon after launch of the in-coming missile the defense could detect it and send out interceptors, the burn-out speed of the interceptors, and whether there would be time to send a second wave of interceptors if the first wave failed.

I also suggested a back-of-envelope, simplified way in which Melissa could set up the analysis, which struck me as adequate until Melissa and I met with Professor Kasdin, who suggested a far more accurate way to proceed using a few basic equations from orbital mechanics. And this is what Melissa ended up employing. She and I both learned much about how to think about trajectories.

Orbital analyses such as Melissa’s showed the possibilities (and limitations) of a missile defense relying upon mid-course intercepts—the intercept of an offensive missile in space by a defensive interceptor launched from the ground; and other analyses and a few tests have shown how in principle one can actually do the intercept—hit a bullet with a bullet. However, even if mid-course intercepts are technically and geospatially possible, an attacker could employ a
range of countermeasures. For this reason, many independent scientists examining the problem now believe that a missile defense system relying upon mid-course (space) intercept could be readily defeated by such countermeasures. This is because in space light objects can be made to appear virtually indistinguishable from heavy ones—so that a relatively heavy warhead moving through space could be accompanied by tens of light decoys. If so, the best hope for a missile defense system might be so-called boost-phase intercept, where the defensive interceptors are fired at the offensive missiles while the latter are still in their powered-boost phase, the first two or three minutes after launch, before they could release the decoys.

Enter Jeff and his thesis. A boost-phase defense could be sea-based, ground-based, or space-based—but the first two could work only if the interceptors were deployed relatively close to the point of launch, which is a strongly limiting constraint. Space-based defense, of course, also has drawbacks, as Jeff’s thesis vividly showed, but could in principle work under certain conditions and assumptions. For this reason, Jeff decided to look at the possibilities of a boost-phase defense based in space—and one founded on missiles rather than, for example, lasers—a theoretical possibility but one pretty far away from technical feasibility. With this initial idea for the thesis in hand, Jeff and Professor Kasdin together worked out how to attack the orbital mechanics problems involved, as I became mostly an interested and appreciative observer, looking over the technical results but mostly monitoring Jeff’s progress report at the end of the fall semester and then the thesis in its final stages to see whether he was describing accurately the policy and political context. He was.

In policy-motivated theses, students and advisers will often come to the thesis with a definite point of view and set of convictions. In some cases, these preliminary views of the student and adviser might diverge somewhat, as Jeff’s and mine did—a little. I don’t think this is bad. On the contrary, it imposes a bracing discipline both for student and adviser, as long as the analyses (and any criticisms by the adviser) are honest and unprejudiced. Whether the findings of the analysis do or do not support initial expectations or hopes, as long as they are solid, they must not be suppressed. A thesis should never be a kind of advocate’s brief, including only results supporting some pre-determined conclusion and ignoring those that don’t, though naturally oftentimes the thesis will have sharp policy conclusions and recommendations. Jeff’s thesis met this standard—pointing out the theoretical feasibility of space-based boost-phase defense, but at the same time underscoring the formidable technical difficulties and political problems that would have to be surmounted.

Finally, I would emphasize again the potential value to students of having co-advisers, in instances where such co-advising is appropriate. Most faculty are open to co-advising and certainly should be.
The Pair Correlation of the Zeros of the Riemann Zeta Function

Lillian Beatrix Pierce '02

Probably like most juniors who have just made a mad dash to finish the spring junior paper, I thought I would start reading for my thesis during the summer. Also probably like most juniors, I didn’t. Instead, I spent the summer after my junior year growing fluorescent bacteria, swimming laps in a pool surrounded by beds of fragrant agapanthus, and reading Graham Greene, Peter Carey, and some Shaw. Of course, I can always wonder how good a thesis I could have produced if instead of nurturing bacteria I had read a few classic texts on number theory, if instead of swimming I had found someone to talk to about the Riemann zeta function, and if instead of lying under a plum tree with a novel, I had brushed up on quantum chaos theory. But, luckily, the human lifespan is long enough so that everything I didn’t learn about math that summer, I’ll learn sooner or later.

Deciding which professor to ask to be my adviser was not too difficult. First of all, I had the feeling that no matter what professor in the math department I had as my adviser, I would have a valuable research experience. With that as security, I sat down to think about possible advisers. As it happens, the timing of my arrival at Princeton coincided with the development of a new sequence of math courses, taught by Professor Elias Stein. These four courses were designed to give an unusually deep treatment for undergraduates of the type of math called analysis, each course building on the last through a series of elegant lectures and intriguing problem sets. As a result of taking these courses I had become especially fond of analysis. In fact, I had already done my spring junior paper with Professor Stein on a topic inspired by his courses. In the process of doing my JP I found out how amazingly rewarding it was to use techniques I had learned in class to solve and understand the more difficult problems I came across in my research.

I decided that I couldn’t resist another chance to work with Professor Stein, so sometime during the summer before my senior year I e-mailed him to ask him to be my adviser. And he said yes! So then I had an adviser, but not a topic. I knew one very broad topic that really interested me: the Riemann zeta function. This is the function about which the Riemann hypothesis was composed—that famous problem, unsolved for over a hundred years. I had been introduced to this function in Professor Stein’s classes, when he showed us a proof of the
Prime Number Theorem, and I wanted to know more about it. So I went to the library and checked out one of the quintessential texts about this particular function. Soon after, I saw Professor Stein at the daily afternoon tea in the math department and mentioned that I was looking at that book. “Ah, you won’t find anything in there,” he said. And of course he was right. The entire point of the book was that it presented the classical properties of the zeta function in thorough detail—there were no more details for me to work out, and working through the book wouldn’t introduce me to cutting-edge considerations in the field. Instead, Professor Stein said there was something he wanted me to learn about, a new connection people were talking about between the zeros of the Riemann zeta function and random matrices.

This phrase, “zeros of the Riemann zeta function and random matrices,” immediately had me excited. First of all, the Riemann hypothesis is about the zeros of the zeta function, so I knew that anything about the zeros would be important. Second, I didn’t really know anything about random matrices, and I was fascinated that it was even possible to know anything about random matrices—if you just plop some numbers down randomly into matrix format, what can you possibly expect to know about that matrix? Third, it sounded absolutely shocking to me that there was a connection between these two seemingly completely different things, the zeros, and random matrices. So this sounded like a great topic for me to work on, a hard topic, an exciting topic, a cutting-edge topic. And it was.

Undergraduate math theses are usually not original work: it is unpredictable when one will have a good, truly new mathematical idea, and we undergraduate math majors are so young and know so little of the total mathematical canon! Instead, math majors are expected to research what has already been done in one particular area of math and maybe fill in a detail here or there, or prove a special case, or even just understand how a certain proof works—down to the very last detail. We then write down what we have learned in an expository thesis. I felt like the main goal for me was to read as much of the available material as I could, to understand truly how every single step in each proof worked, and then to present this material in a structure that was thorough and easy to read.

By winter break I had read through, nominally, the few mathematical papers I would use as the backbone for my thesis. At this point, I became puzzled. I knew basically what all these papers meant and what methods the mathematicians had used; it no longer seemed like news that there was a connection between the zeros of the zeta function and random matrices. But, all the same, I felt frustrated because I didn’t think I understood the core of the material. At that point I couldn’t have built up the proofs of the main theorems from the very bottom, from the very beginning definitions. Without this kind of understanding, I also couldn’t really appreciate the beauty of the mathematics.

At the start of the second semester, I went to Professor Stein, unsure how to proceed. He opened up to the first page of a book I was reading and he pointed to a word in one of the first sentences. He asked if I knew what the word was, and I did. Then he asked if I knew how that particular mathematical
object was calculated, and I said “No.” Well, I was to start with that, he said. I spent the next two months working on learning how to calculate that object.

So that is when I began working really hard on understanding random matrices. It is still amazing to me that you can know anything at all about random matrices—arrays of numbers, rows and columns of numbers, where each number is chosen randomly. I decided that in order to understand the computation involving random matrices that I needed to know, I would stop short of nothing but tracing each proof back down to the most basic definitions. This was the crucial decision that set my thesis on the right track: I would accept nothing but total comprehension, from the bottom upward, of each mathematical proof.

This meant that if I saw a proof that relied on a certain property of a function, I would prove that the function did actually obey that property. And if in the process of proving that function obeyed that property I needed to use another statement about yet another function, I would prove that statement as well. And if in proving that statement I needed yet another nontrivial fact, I would prove that fact as well. In effect, I mapped out a tree for each theorem: the “theorem” was the trunk, and if I needed “propositions” to prove it, they were the limbs, and if I needed “claims” to prove the “propositions,” they were the branches, and if I needed “lemmas” to prove the “claims,” they were the twigs, and I wasn’t satisfied until I got to the leaves, the original “definitions.” All of these things, the lemmas, and claims, and propositions, fed into the proof of the big theorem. And I grew to understand them all.

Math is a funny thing—I never know when I will be able to do it and when I won’t. One week in February I was in the right mood and suddenly I wrote out about 50 handwritten pages of math, which turned out to form about one third of my thesis. Then after that I couldn’t do any satisfactory math for several weeks. This was, of course, inconvenient, as the deadline for my thesis was approaching! But then, a few weeks later, math was going well again, and I did another big chunk of work.

One of the most important parts of doing my thesis was learning how to discuss math with other mathematicians, learning how to do math at a chalkboard in real time. In fact, it was during the course of writing my thesis that I truly began to feel like a part of the math department. I went to the afternoon teas and talked with professors; I asked questions of graduate students—sometimes I had to ask the same question several times, as each time I still couldn’t quite get my proof to work. In this process of asking questions of graduate students and professors my awe of them grew. As they answered my questions I could see how they were thinking about the problem, how they were drawing on all of their experiences to find the right method of attack. However, as my awe grew, so did my comfort with the mathematical environment: I was learning to “talk math.”

Of course, in order to write a thesis, I needed not only to talk math, but to write math. Luckily, I love writing math. I love the process of finding the most comprehensible way to write down a mathematical thought: the best words to

... the joy I take in crafting mathematical prose is the same joy that an English major takes in crafting literary prose.
choose, the best symbols to use, the most illuminating equations to include. If I write down a piece of math, I want everyone to be able to understand it—why it is true, why it is important, why it is interesting. One day as I was sitting at a computer typing part of my thesis, I had a realization: the joy I take in crafting mathematical prose is the same joy that an English major takes in crafting literary prose. Writing my thesis will always seem like a defining moment—a very, very long moment—of my time at Princeton. It truly was the culmination of everything I had learned about math so far.

What is the work of doing math actually like? To an outside observer, it probably seems about as slow as a game of cricket. I sit down at my desk, or on a windowsill, or on a couch, and write on a clipboard, and pile up books around me as I look up various facts. I use pencil and plain white paper, or a fountain pen and plain white paper, depending on my mood. Some days I work better at night, very late at night. Other days I have my best thoughts at about 11 in the morning or 2 in the afternoon. (It’s one of the ironies of math that I can’t do it when I’m under pressure. Often as soon as I find out that I don’t need to turn in a certain problem, I can sit down and just do it. But if it were due in an hour, I’d have no luck at all.) When I do weekly problem sets I listen to violin music and hum: Bach sonatas, Biber sonatas, or maybe the Stravinsky violin concerto. But for each big project I do, I pick out special music I will listen to, just for it. For my thesis, I listened to Brahms symphonies.

So from the outside, doing math might look quite dull. But from the inside, it is a different story altogether. About two years ago a new acquaintance asked how mathematics felt to me. “What’s it like to do math? Why do you call it beautiful?” I suddenly remembered standing in Gaudi’s half-finished Sagrada Familia in Barcelona at dusk, the large nave obstructed with scaffolding like orderly cobwebs. I replied, “It’s like being in a place so dark that you can’t see around you, but you can sense something strong and structural. Perhaps, if you’re lucky, you have a mathematical insight. Then it’s as if a flashlight goes on: you see a perfect crystalline structure surrounding you. That is the math. The beam of the flashlight only goes a little way, but you know that the structure, that precise scaffold, goes on through the darkness. The goal is to climb up into that structure and shine your flashlight out farther and farther through the ordered web making up the mathematics.”

All the previous summer, as I worked long nights in a molecular biology lab I had thought about what math meant to me. My friend’s unexpected question prompted me to an understanding. Years ago I found that I could do math, and it alarmed me: I couldn’t tell why I was able to feel instantaneous, complete proofs in my head. I was working in the darkness of intuition without comprehension, and I worried that at any moment I would lose what felt like luck. Then, three years ago I perceived the first fragments of a structure crystallizing in my mathematical knowledge. Now I see flashes of that structure in all my math studies. Math is not easy for me; it is in fact the hardest thing I do. But it is also the most beautiful, and I have decided that the rare ecstatic moments of deep comprehension and insight are worth the work of the rest of my life.
I met Lillian Pierce during her first year at Princeton, but the story of her senior thesis does not really begin until the next year. In the spring of 2000, I had started a series of new courses whose goal was an integrated presentation of the core areas of mathematical analysis that emphasized the organic unity that existed between the various parts of the subject, and that illustrated the applicability of analysis to other parts of mathematics and science. Lillian was one of the 17 students who took the first course and she then continued to take the other three semesters.

From the beginning it was clear that these courses were tailor-made for Lillian! Not only was she immediately fascinated and engrossed by the subject matter, but she understood the ideas involved with amazing quickness and with an exceptional depth of understanding. One of the points she obviously appreciated from the start was the various synergies that illuminated analysis. A striking example of these lucky connections was the applicability of “complex analysis” to “number theory.” What makes this relation remarkable is that on the one hand complex analysis begins with the calculus-like study (of continuity and differentiability) applied to functions defined on the complex numbers; while on the other hand number theory concerns itself with the divisibility and additive properties of integers (expressed, for example, in terms of prime numbers), and there would seem to be no possible connection between the two. Yet, a marvelous link did exist—the “zeta function”—and it had yielded some noteworthy results. However, much more seemed to still be hidden in the mysteries surrounding the unproved Riemann hypothesis regarding the zeta function. About these questions it’s fair to say that they encompass some of the most important unsolved problems of current day mathematics.

However, beginning in the last number of years a further unexpected link appeared that seemed to relate these problems with some very different questions arising from a class of probabilistic models in the theory of “random matrices.” The latter objects occurred in the study of certain quantum-mechanical ensembles, and their properties had been of interest to physicists for more than 30 years. What had happened seemed like a remarkable accident: A very particular formula that arose in the study of the zeta function occurred also in the study of certain models (GUE’s) used in the analysis of nuclear energy for large nuclei! Could it be that the long sought-after path to unravel the mysteries of the zeta function by expressing its zeros as the spectrum of some physical system—that this was now in reach? That was the initial hope several years ago; despite great efforts this has not yet been realized, but clearly the new insights that developed from it are of utmost interest for all future research in these questions.

It was natural, given her interest and background, that when Lillian turned to her thesis she would choose this subject. But because of the inherent difficulty of the subject involved, the variety of different ideas and techniques that had to be mastered, and the limited time available to write the thesis, it was necessary to focus one’s goal on a realistic project.
She soon presented me with a plan. This took account of the fact that there were essentially three branches to this new subject. Each branch seemed to be the province of its own group of practitioners, and each required a very different mathematical expertise. These branches were a) the study of pair correlations for the zeta function; b) the sophisticated computational analysis used to check the conjectures arising from a); and c) the probabilistic theory underlining the GUE. Lillian’s plan was nothing less but to learn and master all three branches and write an exposition that would motivate and present each of the three. Moreover, this effort would culminate in an overview of the whole subject that would explain (to working mathematicians, including me!) all the relevant interconnections and ideas of the theory.

This was an extremely ambitious project. Because of its daunting difficulty I at first hesitated to encourage Lillian to try to do more than a part of it. Nevertheless, she succeeded completely and brilliantly in all her goals. Lillian wrote a wonderful thesis of great clarity, full of remarkable insights, that is exceptional even among the best I have seen in many years. In conclusion, I can say that working with her was for me one of my most rewarding experiences as a teacher at Princeton.
Computational Investigations of Heterogeneous Brain Tumors

Jonathan Schmitz '02

“Man, I hope tonight’s not another one of the hard-core P-chemists. Their presentations go straight over my head!”

It was with this less-than-scholarly comment that I began the evening on which I first encountered my thesis topic. It was a Monday in early December. Along with some fellow chemistry majors, I was strolling down Prospect Avenue to Frick Laboratory. Just as on the 10 previous Mondays, we had left dinner and were off to attend the event that had become a matter of weekly habit for all new members of the department: the Junior Colloquium. As our formal introduction to the chemistry faculty, the Junior Colloquium gave professors a forum to present their research interests. It was through these presentations that we were to choose advisers for our upcoming thesis research. Although it was the semester’s last colloquium, I admittedly had not yet made this important decision. And while I did not expect inspiration from the lectures that Monday, I at least hoped not to be lost amidst a mathematical sea of quantum mechanical formulae and potential energy surfaces.

The reason for my apprehension was simple—I was a relative newcomer to the chemical world. I did not decide to concentrate in the department until the end of sophomore year, switching from my original intended major of molecular biology. Even though I was enjoying life as a chemistry major, my research interests still possessed a distinctly biomedical bent. Consequently, whenever a physical chemist would speak during the colloquium, I had developed the regrettable tendency to let my eyes glaze over and begin daydreaming. Fortunately, such habits changed that Monday night.

One of the evening’s speakers was Professor Salvatore Torquato, a theoretician whose research interests involved the mechanics of heterogeneous materials. Needless to say, my hopes going into the presentation were not incredibly high. Then something unusual happened: he started talking about brain tumors—yes, brain tumors! Apparently, Professor Torquato’s group had developed a cellular automaton simulation of brain tumor growth in conjunction with a group from Harvard Medical School. An automaton simulation is a computer program that generates a collection of virtual cells that represent biological cells.
In this way, Professor Torquato was utilizing his knowledge of three-dimensional lattices to investigate a crucial biomedical topic. I was familiar with the term “cross-curricular research,” but I had never before imagined encountering tumor biology in the lab of a chemical theoretician. Despite my rather close-minded expectations, I found myself undeniably excited about the possibility of becoming involved with the project. So although my exposure to the physical sciences was less than thorough—and although I had absolutely no experience with computer programming—I joined Professor Torquato’s group and began to work on his tumor-modeling project.

Granted, during the subsequent months, my transition into the world of computational research was hardly seamless. The challenge of learning a programming language while trying to apply that language to original research was a daunting one. (I won’t even divulge the gory details of having to wean myself off of a Windows interface and onto a UNIX machine.) And, of course, I encountered the same general challenges that any researcher faces in the world of science—problems can arise, experiments might not work, and projects sometimes must be re-evaluated. In fact, after spending both a junior semester and a pre-senior summer on one project, I had to abandon it entirely. Much to my chagrin, Professor Torquato and I decided that this particular application of the tumor simulations was not feasible. Despite such setbacks, however, my computational knowledge eventually grew and I devised a thesis project that was both achievable and informative.

For this work, I extended the group’s original simulation of brain tumor growth to account for the effects of treatment and drug resistance. By introducing several new parameters to the model, I could simulate cellular death, treatment-induced mutations, and heterogeneous drug resistance. With this model, I was able to suggest several trends for development of tumors under the effects of treatment. In fact, my project was the first time that an automaton cell simulation had been utilized to investigate such topics. Consequently, when I submitted my thesis at the end of senior year, I was proud that it involved work never previously attempted. The fact that, just one year before, I hadn’t the slightest knowledge of cellular automatons or C++ programming made the accomplishment even more gratifying.

Of course, none of this would have been possible without my relationship with Professor Torquato. In fact, our interaction was one of the most edifying aspects of my thesis experience. Upon first glance, one might describe Professor Torquato’s advisory style as “laid-back.” He allowed me to work at my own pace, he did not demand constant updates, and he gave me the freedom to determine the focus and scope of my work. This seemingly relaxed style, however, was not to be confused with relaxed expectations. Just the opposite: Professor Torquato clearly expected that I take command of my research and apply my own unique insights.

Overall, this was a relationship based on mutual respect with a tacit goal of generating publishable findings. He could expect creative effort from me,
and I could expect sound guidance from him. In this way, I consider our work together my transition away from the more didactic professor-to-student relationship of underclass lecture halls and toward the more collaborative dynamic of graduate school. I obviously had a tremendous amount to learn from Professor Torquato’s expertise, but I was struck that he also valued my own insights. Truly, working with him was an invaluable part of my scientific growth as an undergraduate.

Looking toward the future, I must now ask myself: how will my thesis experience impact me in the years to come? I must admit—although I seek a career in biomedical research, I will not likely focus on computational biology in the future. Unquestionably, though, my laboratory work as a Princeton senior will play a role in my ongoing scientific development. Certainly, I now possess a deeper appreciation for the more physical and quantitative aspects of biomedical research. In fact, I have grown from someone who avoided such topics into one who enjoys them. I will certainly never make the mistake of disregard research options simply because they involve quantitative rigor! In general, I have learned not to fear new academic possibilities, even quite unfamiliar ones. I cannot predict when—just as on that Monday night in December—a new opportunity will catch me off-guard and take me to places I had never considered.

Consequently, if I had to give advice to an upcoming Princeton senior, I would offer the following thoughts: choose your thesis topic because it is exciting; choose it because it is unique; choose it to work with a particular adviser; but, above all, do not choose it merely because it is safe. With their theses, Princeton seniors have the unique opportunity to expand their horizons with a seemingly countless number of options. Some of these options might seem unfamiliar, or even unsettling, at first. As I discovered myself, however, thesis projects that begin this way can also end with some of the greatest rewards. Such theses are undeniably and quintessentially Princeton.

Salvatore Torquato
Professor of Chemistry and Princeton Materials Institute

One of the most enjoyable experiences that I have had as a Princeton professor has been advising senior theses. This comes as a pleasant surprise because I did not have a positive impression of senior theses during my initial interview trip. I was skeptical because a bona fide thesis requires one to delve into uncharted research waters in a systematic investigative fashion with the goal of making scholarly contributions to a field. Given the time demands of courses and career preparation in one’s senior year, it was not clear to me that a student could manage to write more than a glorified book report in the space of a year. I soon learned that my initial skepticism was ill-founded. Indeed, I have been very fortunate to have attracted and supervised some of Princeton’s brightest seniors on their theses. The final product has always been one of high quality. However, the most rewarding aspect of advising seniors is the joy I derive in interacting with the students and seeing them transformed from receptors of information to innovators of useful ideas.
My interactions with Jonathan Schmitz provide a wonderful example of my positive experiences as a thesis adviser. It is customary in the chemistry department for faculty to present their research interests to the junior class in order for the students to select senior theses topics. Jonathan was attracted to the project I was offering on the modeling of the growth of the most malignant of brain tumors: glioblastoma multiforme. A patient diagnosed with this fatal disease has on average about 12 months to live. Sadly, in the last 50 years there has been virtually no improvement in the survival time of such a patient. This suggests that a new perspective on the problem is required to break the logjam in our ability to treat and eradicate glioblastoma multiforme. We have undertaken an interdisciplinary research program, involving physical scientists, applied mathematicians, cell biologists, and medical researchers, who seek to study brain tumors as complex systems. Key to the project is the development of a computer-simulation model that enables one to simulate realistically the tumor growth process, treatment strategies (e.g., chemotherapy and surgery), cellular mutations, and other medically relevant aspects of the disease. In short, the goal is to develop a “virtual” patient on the computer that would enable us to develop novel treatment strategies. When Jonathan approached me with questions about the project, I sensed in him a combination of excitement and apprehension. He had absolutely no experience with computer programming and did not have the greatest fondness for physical chemistry. I knew that Jonathan was the top student in his chemistry class and attempted to convince him that he had the ability to learn the necessary skills to carry out the research. Jonathan was up to the challenge and joined my group. In a matter of a month or so, Jonathan became a proficient user of UNIX (a computer operating system less friendly than the Windows environment) and C++ (a computer programming language). Jonathan’s initial task was to become familiar with the basic cellular automaton program that we had already developed to model tumor growth. A cellular automaton divides space into “cells” (in this case biological cells) and then uses simple rules to describe how these cells interact with one another. Once Jonathan mastered the inner workings of this program, I asked him to pursue a certain extension of the model. It was after spending several months on this project that we decided it would not yield fruitful results. Jonathan was obviously frustrated with this setback but he learned an important lesson: research is typically fraught with pitfalls and winding roads that sometimes lead nowhere. To his great credit, Jonathan asked whether he could extend the model to account for effects of treatment and drug resistance. The green light was given and the end result was a stellar thesis that incorporated cellular death, treatment-induced mutations, and heterogeneous drug resistance. Indeed, a peer-reviewed scientific paper based on his thesis will be published in the Journal of Theoretical Medicine. In this instance, Jonathan’s perseverance, a crucial characteristic of any capable researcher, paid great dividends, and he was able to experience the exhilaration that comes with discovering something new and significant.
Jonathan has received numerous awards in recognition of his academic achievements, including the prestigious Churchill Scholarship to pursue postgraduate research at Churchill College at Cambridge University. Interacting with Jonathan on his thesis project was a great delight from an intellectual standpoint but more importantly I enjoyed Jonathan immensely as a person. Jonathan is a great human being and I have been enriched by our relationship.

My advice to seniors is to be adventurous rather than conservative in selecting a research topic and adviser. This usually means having to stretch oneself intellectually but the rewards for this extra effort can be enormous, as Jonathan’s case beautifully illustrates. Seniors should take advantage of the diverse and unique thesis project choices that are quintessentially Princeton.
I did not write a senior thesis; however, I still graduated from Princeton with a bona fide undergraduate diploma. How did I cheat the system, you ask? I didn’t really. Instead, I cheated semantics.

As a Program Two Visual Arts major in the Department of Art and Archaeology, I did not write a senior thesis like most of my classmates, but instead, I created a multimedia video installation. In the middle of December, while my friends locked themselves in the dark dungeons of Firestone Library writing chapters, I spent hours becoming well acquainted with my dorm room ceiling. Contrary to popular belief, I was not procrastinating. Instead, I was waiting . . . for inspiration, divine intervention, or anything that would point me in the right direction. Little did I know that the thesis topic I was waiting for had been with me all along.

No one is precisely sure of the exact moment when Madison, my imaginary three-and-a-quarter-year-old daughter, came into existence, but the general consensus is that she made her first appearance when my girlfriend and I started dating my freshman year at Princeton. I rarely questioned the strangeness of having an imaginary child because it felt comfortable and normal within the context of our relationship. Once we started letting our close group of friends know about our “little secret,” their initial disbelief was soon followed by their own desires to have imaginary children as well. Thus, the Goda Gang came into being. The group consisted of five imaginary children—Madison, Stravinsky, Marcel, Yves, and Penelope. Each child had his or her own distinct personality that simultaneously acted as both an acknowledgment and a gentle caricature of his or her parent. Although, in months prior, I half joked about using the Goda Gang as my thesis topic, the desperation of my situation made me crazy enough to seriously consider it as a viable option. All I had to do was figure out how I was going to tell my thesis adviser, Su Friedrich.

Su has always intimidated me due to the incredible amount of respect I have for her as an artist, mentor, and person. Although I am my harshest critic, Su is a close second. From the first class I took with her, she has constantly challenged me to take my artwork to the highest level possible. I figured I could rationalize my “unique” idea by downplaying the strangeness of having an imaginary child and instead focusing on how my
topic was situated within cinematic discourse and queer scholarship. Building upon the foundations of my previous video projects, my senior thesis lent itself to a feminist-slanted, “the personal is political,” autobiographical, nonlinear narrative structure. Su’s films, which follow a similar format and at times are intensely personal, had obviously had an effect on me. Perhaps her insistence that I let more of myself into my work was finally taking hold.

Additionally, like Su’s personal narrative films, my thesis touched on much broader issues as well. The Goda Gang and the Goda Gang parents could be situated within the dialogue on “fictive kin.” This term, coined by sociologist Kath Weston, explains the phenomenon wherein gays and lesbians create self-described family units that often include other gays and lesbians. This practice of creating nonbiological families of choice stands directly in the face of a culture where biogenetic ties are privileged. I wanted my thesis to challenge an oft-made assumption that male-headed, nuclear families are the sole acceptable units of kinship and that all alternative patterns are less desirable exceptions. Although Madison and her friends were imaginary, the issues they faced were very real. My thesis had to be the realization of the Goda Gang’s world—a fine line between serious adult concerns and lighthearted child’s play.

I decided that the best way to illustrate my topic would be through a multimedia video installation. Ultimately, the Goda Gang world was one that I wanted my audience to engage with and explore first-hand. An installation would be able to bring this world to life more easily than the standard video format. I knew that I had the entire Lucas Gallery space to work with, which totaled over 1,000 square feet—a gigantic blank canvas with unlimited possibilities. Within the space, I created multiple components that were functional on their own, but that were also united through the artistry of the installation. Many of these components had been imagined from the onset while others evolved through the artistic process, which included weekly meetings with Su.

In the end, monitors were embedded in a sandbox, a wagon, a playhouse, a tire swing, and a refrigerator—the five objects I chose to represent the Goda Gang’s world. I covered the entire floor of the gallery with Astroturf, not only to visibly change the terrain, but also because the artificiality of the material conveyed the general tension within the installation between what is fake and what is real in the larger realm of fictive kin. I also had 77 four-foot long text panels covering the four walls, with each panel representing a vocabulary word that Madison and her friends used on a daily basis. The words were placed in alphabetical order and included etymological origin, dates of use and example sentences, as if they were directly pulled from a dictionary. A last-minute addition to the installation, suggested by Su, was a reading nook that housed children’s books for each of the Goda Gang kids and a computer set-up that allowed viewers to interact with each of the Goda Gang families as SIMS characters.

The weekend before my opening was intense. It required flexibility and patience, since it was the first time I was able to have the space to myself. I spent every waking minute in the gallery laying the Astroturf, centering the text panels on the walls, building a 10-foot tall tire swing, embedding the monitors into the objects, finalizing the videos into two-hour loops, and meticulously
... the originality of topic and form proved that a thesis does not have to be written in order to be valid. scrutinizing all of the tiny details that often go overlooked. As each day passed, the installation slowly began to take shape. On opening night, pure exhilaration consumed me as I finally saw my vision come to life.

For me, the most challenging part of my thesis was also the most rewarding. Like many artists before me, including my very own thesis adviser, I cut myself open for the world to see. There were certain aspects of myself that I kept hidden from the public. These secrets (being a lesbian, having an imaginary child, etc.) had now become the center of attention, thrown onto the walls of a gallery space, screaming: “Here I am... scrutinize me.” Yet, the experience was as cathartic as it was frightening. The fact that strangers came up to me during the opening reception in order to ask me questions about Madison and her friends (surprisingly, with no intentions of locking me up in a psych ward) completely normalized my senior thesis, allowing me to walk away from it, not embarrassed or ashamed of what I had shared, but rather proud of myself and my accomplishment.

Although some senior theses have major impacts on their fields of study, I am hardly convinced that my senior thesis drastically changed the world of contemporary art. I had dreams of some hotshot curator stopping by my exhibit and pleading with me to permanently install my thesis in his SoHo gallery. But, alas, no such suitor came knocking. Instead, I think that the marks my thesis left were much more local, affecting several communities at Princeton. For the arts community, glowing feedback from students and faculty alike about the originality of topic and form proved that a thesis does not have to be written in order to be valid. Being a finalist for the University-wide Sudler Prize, winning the Francis LeMoyne Page Class of 1922 Award for Visual Arts, and being asked to contribute to “Quintessentially Princeton” reinforced this theory. For the LGBT community, my thesis allowed further dialogue on topics of queer scholarship and created another avenue of visibility on campus. For the Goda Gang itself, my thesis created a living testament to our lives and experiences during our time at Princeton. For me, it seemed only appropriate that the Goda Gang, which created numerous pages of my life story at Princeton, would also be the final chapter of that experience as well.

So, after all is said and done, would I do it again? You bet. Besides, Madison has been clamoring for a sequel.
Kelly might have expected, or probably hoped, that I would advise against such a thing—that I would think it too risqué, too vast a topic, or simply too weird. On the contrary, I was delighted. There are some genres of film and video that don’t require the maker to put themselves on the line—making a documentary about coal miners doesn’t have to involve any revelation of intimate and sometimes bizarre personal facts about the filmmaker—but if someone is working in a more personal vein (as Kelly had been doing in her prior class projects and her junior independent work), then the more honest, the better. I would say that this confession qualified as one of the most honest I’d heard, and I commended her on being courageous enough to even float the idea. I then insisted that she actually proceed with the plan, and she finally acceded, though not without several more attempts to convince me that maybe it was just too much.

But making a video installation takes more than having a good idea—it takes an enormous amount of aesthetic and practical work to bring it to completion. Since Kelly had a somewhat late start, she was faced with a real challenge. The technical and artistic scope of the piece was much bigger than her junior installation, and we both knew how hard it would be to finish it in time without sacrificing any aspect of the project. She would have to do numerous audio interviews; shoot original footage; research and collect archival footage; construct various families through “The Sims” computer game; buy, build, or beg numerous objects in which the video monitors would be housed, and then edit six different channels of audio and video and choreograph them in a complex way so that the installation would be an active, engaging, and informative experience for the viewer.

The next few months were impressive to witness. We would meet, she’d show me her latest materials, we’d consider and reconsider how the next phase of the operations should proceed, and she’d leave with a long “to do” list and a date for our next meeting. At each meeting, she’d have done most of what was meant to be done, and she’d go away with a promise to finish that work and do all the new things I’d piled on her plate. I sometimes wondered how she found the energy and time for all of it, but I also saw that she was indeed managing. So, late in the process, as we spoke one afternoon, I (somewhat idly) suggested that it would be interesting to create children’s books—to make a “reading room” where the viewer could read short books that were (as if) created by each of the imaginary children who were represented in the installation. As soon as I suggested it, I recognized the madness of it. She was struggling to get everything done, and here was a new idea that would mean many more hours of writing, drawing, binding, etc. But Kelly had already shown herself to be tireless and enthusiastic and open to a challenge, so of course she picked up that ball and ran with it. I felt somewhat guilty about throwing more work her way, but the books turned out wonderfully and were a strong addition to the installation.

There have been a few other video installations done by seniors, and most have been quite strong, not just conceptually but in the way they used the available gallery space. However, I think Kelly took it up a notch. She completely
transformed the gallery—she covered the walls with text, laid astroturf carpeting throughout, brought in lots of furnishings to house the video monitors, including a refrigerator, and installed a computer so that visitors could play “The Sims” game and further evolve the families which she had created. I had high expectations, but was really astonished at the degree to which she had followed through on all the smallest details. In making work, I know how damnably hard it is to dot those last i’s and cross those last t’s, and it’s usually a losing battle to make a student understand the need to hang in for that long. Kelly, in contrast, was determined to finish the installation as she had envisioned it, and as far as I’m concerned, she succeeded admirably. If I had had any doubts, they would have been quelled by the news that she was one of only two students nominated that year for a Sudler Prize for her thesis.

On a final note, I have to commend Kelly for her willingness to come out in such a big way by doing an installation that made public the fact that in her private life she was involved with a woman (not to mention that they have an imaginary child, but anyway…). It’s certainly a different era from the one in which I grew up (in the 1970s), but even though times have changed remarkably since then, there’s still a certain amount of pressure to conform and to hide one’s identity from one’s peers. As a lesbian, I think I was able to give Kelly a particular kind of reassurance that she could and indeed should speak openly and honestly about herself, but in the end, taking that risk depended on her own strength and clarity of purpose. I was very proud of her for doing that, and I hope that the visitors to her installation felt the same.
On my first freshman visit to Firestone Library, I entered my last name into the library’s search engine, wondering what I would find. My father had told me as a child about our distant relation to Joel Elias Spingarn, a founder and long-time leader of the National Association for the Advancement of Colored People (NAACP), so I was not surprised to see his name appear in the search results. But one of the books I found by Spingarn, *Creative Criticism*, surprised me very much: the civil rights crusader also had written quite intriguingly about art and literature. Refined and confident, his prose succinctly rejected the old modes of criticism, instead exalting the critic to the creative heights of the artist.

Reading *Creative Criticism*, I felt a strong sense of Spingarn’s elitism in contrast to the thoroughly egalitarian approach to literature of my Princeton professors. Unlike my professors, who tended to describe literature as commonly accessible and discernible, Spingarn took a decidedly more selective approach. I was puzzled by his elitism, for it seemed to be in direct opposition to his decades of work with the NAACP, where, as a wealthy white man, he had fought for complete and immediate civil rights for blacks. The civil rights crusader Spingarn and the literary aristocrat Spingarn almost seemed to be two different people.

Intrigued, I began reading Spingarn’s criticism whenever I had a couple of spare hours, feeling an urge to reconcile these two visions of the same man. My vague idea was to one day write something about him, but I had no idea that this exploration would become my first efforts at my senior thesis until A. Scott Berg ’71, Pulitzer Prize-winning biographer, gave an inspiring talk in the fall of my sophomore year. His account of his own senior thesis, which had been the basis of his first book, a biography of literary editor Maxwell Perkins, pushed me immediately to begin investigating how I might turn my interest in Joel Elias Spingarn into my thesis—and, perhaps one day, into a book.

I determined that the first step of the project would be to read through the 10 linear feet of material on Spingarn in the New York Public Library’s Rare Books and Manuscripts Division, a project that would certainly take up an entire sum-
I urge those beginning their theses to select a topic that genuinely and intensely compels them. Fortunately, my sophomore academic adviser, William Gleason, was supportive of the project idea, but finding thesis funding as a sophomore at first seemed impossible. Then, in a fantastic swoop of luck and fate, I received a notice that Scott Berg had inaugurated a summer fellowship for independent work by English department sophomores and juniors, and so of course I applied. When I found out that I had won the fellowship, I was thrilled to discover that my work on my thesis could begin in earnest.

My work at the New York Public Library was often exhilarating and sometimes lonely (I talked to no one all day but the occasional librarian), but the project continued to provoke and compel me. Naturally, I wrote my spring semester JP on Spingarn, and after more research the following summer at Howard University and at New York’s Schomburg Center for Black Culture, I was all set to begin writing my senior thesis—or so I thought.

At my first meeting with my thesis adviser, Elaine Showalter, she immediately pointed out to me the necessity of fixing my archival research within a broader contextual framework, and so I began the next phase of the project. I read all about subjects related to Spingarn’s life: American universities and Columbia University in particular, the public intellectual, the creation and evolution of the NAACP, even about horticulture.

Having read my JP, Elaine had a clear vision of the layout of my thesis, and her suggestions ended up working out nicely for the finished product. I had never even met Elaine when she became my adviser, but I thought that, as a sometimes controversial public intellectual herself, she would be an ideal adviser for an unconventional English thesis. She was extremely encouraging about every aspect of the project, urging me to follow the project wherever it took me without worrying about whether it fit into the usual description of an English thesis. Sometimes I did want more criticism from her, but ultimately she had a much better idea of the demands of a senior thesis than I did, and she struck the right attitude towards it.

Although most papers I wrote at Princeton felt like monumental struggles to birth an original idea, the argument for my thesis came to me even before I’d done much archival research, and developed naturally. Certainly, there were moments when I questioned my thinking—there was one memorable night when I thought, in my tendency towards melodrama, that I’d disproved my argument, and decided that my whole thesis idea had completely unraveled—but the process was much less painful than I had expected.

Certainly, I began research very early, but I didn’t actually start writing my first chapter until December of my senior year, and I completed the other four chapters in the next couple of months in two intense one-week-long spurts of two chapters each. I gave myself plenty of time to write my introduction and conclusion, and to tweak the whole text. But I had difficulty admitting completion of the project, and one night a few weeks before theses were due, I e-mailed Elaine to suggest that I research and write a sixth chapter—to which she immediately responded, “You need to let go!” Still, letting go was difficult; walking
to McCosh to turn in my thesis, I felt overcome by all of its shortcomings.

Researching and writing my thesis was one of the best experiences I have ever had, academic or otherwise. Developing an original project and forming my own argument resounded deeply with my inclinations toward exploring uncharted territory. Because my senior thesis spanned all four years of college, it was the defining project of my Princeton career and the crucial basis for my development as an independent thinker. My thesis was the first thing written about Spingarn in more than 30 years and it brought together his literary criticism and social activism for the first time. I hope that my work revitalized Spingarn as a subject of study, and that one day I’ll publish a more complete book that will put him back on the academic and popular radar.

My thesis was such a great experience for me because it was something I was interested in and committed to outside of the requirement of a thesis, and I urge those beginning their theses to select a topic that genuinely and intensely compels them. Starting early is very helpful, of course, but that will be a lot easier if the project is personally meaningful and you follow your inclination wherever it takes you. Though it always requires a great deal of work, writing a thesis does not need to be a painful experience.

Elaine Showalter
Avalon Foundation Professor of the Humanities, Emeritus

The pleasures of thesis advising are personal and intellectual. I enjoy the close relationship that forms with a student over a year. In many cases, these friendships last long beyond graduation. Intellectually, thesis advising has much in common with editing—helping the student define the topic, set out a reasonable schedule, grapple with research and writing problems, revise and polish. I’m more of a coach than a teacher, in the sense that this project belongs to the student, and does not have to meet the demands of my course or a specific set of skills and facts I want to convey. Writing a senior thesis is like writing a book; that’s a scary prospect for a young person, and I like helping them break it down into manageable units, and, once that initial panic of the enormous task is past, guiding and encouraging them to find their own voice.

Adena wrote to me during her junior year when I was on leave in London, and she was trying to find a director who would be interested in her project and who would give her the kind of direction she felt she needed to produce a mature, comprehensive intellectual biography of Joel Elias Spingarn, her great-great uncle, who had played a major role in American life as a literary critic, political activist, and philanthropist. I knew vaguely who Spingarn was, and wanted to learn more. Adena had already done a lot of archival research in various libraries with the support of a Scott Berg fellowship. So we faced the task of shaping a story that would encompass all the facets of Spingarn’s career, and analyze its crises, commitments, and achievements. Joel Spingarn was a distinguished scholar of comparative literature, and the first Jewish professor to receive tenure at Columbia at the beginning of the 20th century. But he left academia to engage with politics and social reform, primarily as one of the
founders of the NAACP. Although two biographies of Spingarn had been published, one treated him as a literary critic and the other focused on his efforts for racial equality. Adena wanted to show the continuity between Spingarn’s aesthetic criticism and his politics, to define him as a public intellectual who drew on his academic training for values and concepts that informed his devotion to social justice.

We began meeting the first week of fall term, and set up a regular schedule of conferences and deadlines, supplemented by talks on e-mail and phone. Adena was immersed in her subject, and eager to get going; we had no problems about writing blocks. Instead we concentrated on getting the whole thesis down on paper, and working to bring out its main themes, to establish dominant and subordinate ideas within a richly documented and exciting life history. How much emphasis to give to internal quarrels within the NAACP? To his turbulent academic career? To his silence about or denial of his Judaism? To his marriage and children? To his journals, dreams, sexual experiences? To his interests as a collector and horticulturist? Probably the most difficult aspect of the supervision for me was keeping Adena from getting lost in the voluminous archives. Towards the end, when she had finished a complete and eloquent draft of the thesis, she wanted to spend her spring break investigating a brand-new archive of letters at Yale for another chapter, and I had to persuade her that part of the wisdom of scholarship is realizing that research is an infinite process, but finally you have to call a halt and say what you have to say. The thesis was brilliant and important in its illumination of the sources of the civil rights movement and the complex social and ethical factors that led prominent white Americans to participate in it, as well as in the light it cast on this one remarkable man. Adena and I have stayed in close contact; she worked with me as a research assistant in London in the summer of 2003, where her resourcefulness and tenacity as an archival scholar were a great asset. I know that she will continue to work on J.E. Spingarn, and I expect to see this senior thesis eventually become a book.

After many years of advising seniors, on topics ranging from punk rock to Philip Roth, I certainly developed my own methods for helping people get started and keep going. First of all, I advise students to write out the entire thesis, albeit in rough form, rather than revise as they go along. That means starting to write fast, before they have read everything in the library, setting deadlines for chapter drafts with their adviser, and resisting the urge to go back, rewrite and perfect a chapter until the whole project is complete. It also helps to calculate how long the entire thesis will be, and to think of each chapter as a 25-page chunk, rather than to imagine an Everest of blank pages to be filled. In the early stages I encourage students to start thinking both about the structure of the thesis, and the structure of each chapter, in terms of an introduction, subsections and subtitles, and conclusions. Together we map out on the calendar a schedule for writing and conferences, with the goal of having a complete draft of the thesis a month before the deadline. I suggest that
the student save the introductory chapter for last. Invariably, the final month before due date is intense for the student and the supervisor alike, as gaps are filled, questions answered, and conclusions firmed up; but this method makes the thesis a tangible and finite project, rather than a daunting prospect; and those final weeks are usually also exhilarating, satisfying, and triumphant.
On a crisp late autumn afternoon, I emerged from the depths of Firestone Library confident that I’d cleared the first hurdle in Princeton’s “quintessential” senior-year experience. Finally! Inspiration—in the guise of a long-awaited thesis topic—had struck. I could now approach my adviser, Professor Susan Naquin, with something more than “I’m going to write about Chinese history,” with substance to support my promises. Having just seen Zhang Yimou’s Shanghai Triad and read a few intriguing articles on that city’s modern development—and having recently visited Shanghai myself—I’d come to believe that it would constitute an ideal backdrop to my research. Though my knowledge of modern Chinese history was still rudimentary, I knew that early 20th-century Shanghai had evolved very differently from its urban counterparts. Foreign influence had penetrated the city limits and created a world independent of the vast empire surrounding it. Socially and culturally, that Shanghai was simultaneously Chinese, European, American, and . . . something else, something intangible. The city’s more “basic” qualities—crime, gambling, prostitution—fascinated me most; how did an orthodox Chinese culture and a free-spirited international philosophy, two seemingly conflicting ways of life, coexist? As Shanghai is something of a fashionable topic among modern-day scholars, I expected to have little trouble gathering source material. Fascinating and well-documented: the Shanghai underworld of the 1920s. My plan seemed both focused and sensible.

Focused and sensible—so I thought. I approached Professor Naquin, who raised her eyebrows, responded that “everyone studies Shanghai,” and urged me to consider my potential to say anything original on a topic that, however fascinating, had been studied so exhaustively in recent years. Frustrated, I left her office with a book title and some good advice, both of which would prove invaluable in subsequent months. The title was Frederic Wakeman Jr.’s Policing Shanghai: 1927–1937. And the advice? Don’t reiterate the work of those before you, but rather aspire to say something new; explore the familiar but do not be hesitant to tackle the obscure. And above all else, select a topic with a narrow focus.
Later that week, and once again in a dark corner of C-Floor, good fortune struck: as I searched for the elusive “narrow topic” around which I would frame my research, it was one sentence in *Policing Shanghai*—a brief reference to three Indians arrested by the Shanghai Municipal Police for “seditious behaviour” in the 1920s—that caught my eye. Indians in Shanghai? I recall thinking it strange; and yet, the focus was appropriately small and the topic both familiar and inherently interesting to me, given my own background as the child of Indian immigrants. Digging deeper, I soon realized that while seemingly exhaustive, the historiography of modern Shanghai had to date overlooked the city’s sizeable Indian population (comprised partially of Sikh policemen—whom the British brought there to help maintain order in a politically volatile environment—and partially of Sikh anti-imperialists aspiring to spread their distaste for British rule throughout Asia). What was the relationship between these two groups, so similar ethnically, yet so different in their culture and loyalties? I wondered. I approached Professor Naquin with the idea and she responded with enthusiasm; and so, crossing my fingers that primary source material on this little-known community actually existed, I began the project that would (though it perhaps sounds trite) serve as the academic pinnacle of my undergraduate career.

The period of time that elapsed between my discovery of a good idea and my actual search for sources was admittedly longer than it should have been. Obviously, some good advice is not to procrastinate; a few of my own nightmares suggest that reaching early March and realizing you have nothing to write about would be truly terrifying. I later mused on what I’d have done if in February I’d suddenly realized that no one had written about Shanghai’s Sikh communities because not enough source material existed! In any case, I was lucky that the necessary material did exist (in the Shanghai Municipal Police’s records and International Settlement newspaper articles from the late 1920s, as well as in the Chinese-language newspaper *Shen Bao*) and that my ideas developed rapidly once I’d set some loose boundaries. As per my late-autumn idea, I did ultimately write about early 20th-century Shanghai. However, my optic—that of the city’s vibrant Sikh community, exploring the unique relationship between Sikh policemen and Indian nationalists and aspiring to draw more general conclusions about the city’s complex social fabric—was original and deliberately quite narrow. This previously untold story proved fascinating, continually motivating me as I attempted to piece together a well-supported argument.

Upon reflection, I would be lying if I were to say that writing a senior thesis was “not as bad” or “not as difficult” as I initially thought it would be. Even after having successfully written mine, I believe that it was by far the most demanding task I have undertaken to date. The countless hours spent in my carrel, poring over Chinese and English newspapers, the frustration of restructuring entire chapters deemed illogical (or simply pointless!), the panicked e-mails, phone calls, and visits to my adviser at all hours of the night . . . I am not likely to soon forget these moments. When I began, I tried telling myself that writing a thesis was just like writing five 20-page papers and then cleverly piecing them together; sadly, such was not the case. It is justifiably daunting to write 100 pages that make sense as a cohesive single entity.
As you begin thinking about your thesis, you should be prepared to face a host of new challenges, but so too should you know that your previous three years of undergraduate course and independent work have provided you with the basic tools to overcome these challenges (whether or not you perceive their existence, I assure you they are somewhere, in some form). In retrospect, the academic challenges (particularly in those last weeks before the ominous thesis due date, when I was forced to replace thinking and planning with tangible production) are soon forgotten when I stop to consider the tremendous satisfaction that the experience afforded me. That moment—coming after weeks of endless reading, drafting, and re-drafting, probably in that Bermuda triangle where time between the late night and the early morning always seems to vanish—when the fatigued, frustrated Princeton senior finally realizes what he is trying to say... that moment is priceless, for with its crystallization, the many episodes of adversity that preceded it instantly fall away.

In speaking to friends, I’m quite convinced that my experience was unusually fulfilling. I found a topic that inspired me as no prior academic pursuit had done and was blessed with an adviser who provided tremendous scholastic and personal support during a time that is sadly quite horrible for some less fortunate Princeton seniors. Professor Naquin challenged me to overcome my weaknesses, both as a historical thinker and (perhaps more importantly) as an overworked, under-rested Princeton student. Her dedication in reading reams of drafts and providing insightful feedback to me was matched only by her patience for my bad habits and mild hysterics as April 8 drew nearer. Guidance that was firm but not restrictive, coupled with a topic that held my interest through the project’s duration, made certain less-than-healthy “thesis habits”—such as my brilliant idea to adopt a 24-hour nap schedule to sustain round-the-clock productivity—somewhat bearable (although my poor roommates would likely argue that I became quite insufferable!). And after April 8—following the “post-partum” period in which the Princeton senior is suddenly left searching for activities to fill now-ample free time—my life slowly recalibrated itself to normalcy, but with a new challenge having been successfully overcome.

Speaking from experience, it’s useful to select a topic that may seem too narrow and then expand it if necessary; this is far more manageable than choosing something broad (e.g., the Shanghai underworld of the 1920s!) because you are concerned about filling requisite pages. The pages will fill themselves as long as you allow yourself to be inspired; thus, choose a topic wisely, for it will be your constant companion for many months, and to suddenly lose interest and be forced to continue plodding away while lacking the desire to do so would undoubtedly make an already difficult experience truly painful. I also found that choosing an adviser who knows you both academically and personally is perhaps the most valuable decision you can make as you begin. Your thesis adviser has many years of experience (both as a scholar and as an adviser to many Princeton seniors before you) and is potentially an amazing source of knowledge; but to tap into that knowledge, it is essential for you to understand... you will not only learn more about your field of study but—perhaps more important—about yourself and your own abilities.
one another’s demands and requirements and get along well.

Overall, however, I believe it would be silly for me to opine on how Princeton seniors should, as a group, embark upon the thesis-writing experience. Part of what makes the undertaking so exciting is that each student can tailor it to suit his own goals and needs. Moreover, we all thrive under different conditions: a good friend in the Class of 2002 had his history thesis drafted by mid-December while I, in contrast, did not actually begin writing until… many months later! While it would of course be unwise to wait until two weeks before your due date to begin working, the thesis is ultimately an independent project and the important decisions (practical and otherwise) are at your own individual discretion. It is a challenge but also an opportunity, and if you seize the opportunity you will not only learn more about your field of study but—perhaps more important—about yourself and your own abilities. And that, in my opinion, is what makes the senior thesis so revered, so valuable, and such a defining institution within the Princeton undergraduate experience.

Susan Naquin
Professor of History and East Asian Studies

It is such fun to work with a student who is energetic, enthusiastic, and fearless. I had known Vidya Venkataraman from her junior year, and eagerly agreed to advise her thesis in modern Chinese history. She had studied the language, was a good student, and had a contagious enthusiasm for life. Not surprisingly, time on her thesis competed with applications, job interviews, the orchestra, and Taekwondo.

My favorite part of advising senior independent work is watching the thesis emerge and take form, week by week. In history, this process begins with conversations that range over many topics; success depends greatly on the availability of appropriate source materials (a particular challenge when the subject is China). Then, as the student explores various topics, one that seems both interesting and feasible gradually comes into focus; the first of many outlines is written; and finally we can see the question to be answered, the problem that will be explained.

With Vidya, these conversations began immediately in September. We first rejected various topics as too big, too familiar, or too unresearchable, and then began to focus on Shanghai in the first half of the 20th century. Vidya already knew something about life in that cosmopolitan city, and I knew that the English language records of the Shanghai Municipal Police from the 1920s and 1930s were available on microfilm. This conjuncture seemed promising.

I offered my routine senior thesis advice: Find a problem with which you have some personal connection however tangential (to take you through the dark days of February). Still, she and I were both taken aback when I casually suggested, Why not write about Indians in Shanghai? Vidya’s interests were resolutely in China and things Chinese, not her own roots in India. But she knew that Indians were very visible in the city, and I knew that they had received virtually no scholarly attention. So we turned to the microfilms and she set out to investigate. We were both pleased and surprised when she discovered
that most of the Indians in Shanghai in that era were actually Sikhs: a group with which we were both unfamiliar. The Sikh minority in a Chinese city, that seemed promising, especially when Vidya learned that Indians were the subject of a special police file that could serve as the core of her source material. So we were off.

Sikhs in Shanghai turned out to be an intellectually productive topic. How was it that when the British referred to “Indians” they actually meant Sikhs (especially the Sikh policemen who worked for the colonial government)? Why did Sikhs, especially those who wanted to overthrow British rule back home, also refer to themselves as “Indians”? How did these different “Indians” come into conflict with the British and with each other in Shanghai in the 1920s? A chapter would be necessary on the Sikh diaspora and their role in the empire, another would cover life in Shanghai, and a third would examine the conflicts of the late 1920s. Working out the answers wasn’t easy, but Vidya plunged in to the police records and steadily hammered the chapters and her argument into place.

When Vidya’s enthusiasm for work pushed her toward an unrealistically broad definition of the subject, she was smart enough to see quickly how to bring it in focus. Neither of us realized, however, that that attention was going to have to be given instead to her writing. Early on, Vidya had confessed that she wrote quickly but not economically. I had confessed that I liked long papers and wouldn’t worry about the history department’s 100-page limit. Vidya’s drafts came steadily, but by February we realized that much condensation was going to be necessary. This wasn’t the relatively easy editing of dropping big chunks of text, but the laborious work of examining each sentence word by word and pruning out the unnecessary ones. We both struggled with this problem—I did not want to discourage the flow of text or distract from the development of the argument, but as the pages piled up, Vidya’s task became heavy. She bore up bravely, and tackled her drafts fiercely. In the end, the thesis was a tidy (we thought!) 120 pages (plus 43 more pages of illustrative back matter). Extensive, well researched, and interesting.

I do like Class Day. (I’m especially curious to meet the parents.) And I enjoy the ceremony particularly when I know in advance that a student of mine is going to win a prize—as Vidya did—and I can anticipate her pride and pleasure. I look forward to the squeals of surprise from family and friends when the prize is announced—in this case for the best thesis in non-western history. The award told everyone of Vidya’s achievement, but when I looked back and remembered how the thesis had been nurtured and pruned, then the moment was especially satisfying. And it is a bonus when the process has been such fun.
Eschatology and World Renunciation in the Synoptic Gospels and Thomas

Asher Weiss ’02

In my junior year, I was writing a short paper for Elaine Pagels’s Religion 252 class—one that compared the canonical gospel of Luke to the enigmatic and little-known Gospel of Thomas—when I stumbled upon a surprising similarity between these two texts that would first become my JP and later spawn my thesis. Scholars had always placed these two gospels in completely different categories, and for good reason—anyone who has read Thomas knows that although it is considered a Christian text, superficially, and more substantively as well, it bears little resemblance to Luke and the other canonical gospels. My discovery was exciting because it suggested that these two gospels couldn’t be placed so neatly in separate categories after all. My JP argued that while the messages of the canonical gospels, Matthew and Luke, are closer to each other than either is to Thomas, Luke has some striking similarities to Thomas that Matthew does not, similarities that could not be overlooked. In my thesis, I was able to show why these similarities exist by defining Luke’s stance on issues it shares with Matthew and Thomas.

But my thesis topic didn’t develop overnight. I read a few interesting texts over the summer between junior and senior year, texts that had been found alongside the gospel of Thomas in Nag Hammadi, Egypt, in 1945. When senior year began, however, all I knew was that my thesis would somehow involve Thomas. Professor Pagels, who was on leave, was good enough to meet with me. She convinced me that I should begin work on my thesis by attempting to refine the central argument of my JP. This effort, which did not begin until winter break, eventually became the first chapter of my thesis, and was essentially a revision of and improvement upon my JP.

My thesis adviser, Professor John Gager, helped greatly with the development of the second and final chapter. He encouraged (or perhaps coerced) me to read secondary source material that I never would have touched had I been left to my own devices. I was always interested in examining primary texts such as Thomas, but reading scholarly books 500 pages long and full of brilliant ideas but turgid prose not directly relevant to my topic, was not an appealing prospect. That said, I recognized that judicious use of these sources would broaden my outlook and improve my arguments immeasurably, and
therefore, I engaged them as much as I felt—and Professor Gager said—I had to.

The best part about the thesis is that it allows one to make a personal and original contribution to one’s field. My pursuit of a topic about which so little is known and so little has been written, allowed me, I hope, to make a mark of some significance. For this reason more than any other, the 70 pages that are my thesis were at times—believe it or not—very exciting to write.

John Gager
William H. Danforth Professor of Religion

The Gospel of Thomas belongs to a remarkable body of ancient religious texts. Many years ago, in the city dump site of ancient Oxyrhynchus (Egypt), archaeologists discovered an astonishing number of ‘scraps.’ The publications now cover more than 4,500 separate documents, in over 70 volumes. Among the early finds (1897) were four isolated sayings of Jesus, preserved in Greek (Oxyrhynchus # 1, 654, 655, 1224). But since these sayings were not identical to anything found in the gospels of the New Testament, they were quickly forgotten by scholars and relegated to the status of curiosities. But all that was to change in 1945 with the discovery of 13 codices (bound volumes), in Coptic, near the Egyptian village of Nag Hammadi. Among the more than 50 texts in this ancient library was the Gospel of Thomas. And included among its more than 100 sayings were the Greek originals discovered 50 years earlier at Oxyrhynchus!

Ever since the discovery and publication of the Nag Hammadi library, scholars have raised fundamental questions about the significance of its contents for understanding the origins of early Christianity and ultimately the figure of Jesus. Does the Gospel of Thomas, which consists entirely of sayings, without any narrative storyline, take us back even earlier than the canonical gospels? Does the rather ‘mystical’ figure of Jesus in Thomas possibly stand closer to the real roots of Christianity than the ‘authorized’ versions preserved in the New Testament? Or do we see in Thomas a Gnostic reworking of Jesus, to be read in the light of the overwhelmingly Gnostic character of the Nag Hammadi library as a whole?

This is not easy material and the territory has been worked over by countless scholars, many with scarcely hidden agendas. But my advisee, Asher Weiss, was not to be deterred. In his junior paper, he began to work on the Gospel of Thomas with my colleague, Elaine Pagels, a world-renowned student of the Nag Hammadi. I read through his JP in preparation for my role as his adviser for the senior thesis. Two things became apparent as he finished the JP. First, Asher is a sensitive and careful reader of texts. He pays attention to the details (which, as we know, is where the devil lives). And second, he had written his JP without paying much attention to scholarly literature on the Gospel of Thomas.

Unlike many Princeton students, Asher decided to stay with his junior work for his senior year. His struggle with Thomas was not yet finished. My first task
was to convince him that the ‘independent’ of independent work did not mean that he was free to ignore the work of other scholars. Over the years, it has been my experience that many Princeton undergraduates, as they approach junior and senior independent work, suffer from an excess of academic hubris. They are loathe to choose a topic that anyone has ever worked on before. And if, by misfortune, they are forced to work on some previously explored topic, they feel obligated to come up with something radically new and uncontaminated by any sort of influence from previous scholarship. Some have called this ‘the anxiety of influence.’ We struggled, Asher and I, over this. But I prevailed, persuading him that his own thinking and writing would only benefit as he engaged in conversation with other scholars. My point was—and still is—that all scholars—undergraduates and professors—think and write more clearly when they are forced to respond to the views of other scholars. But even as Asher took the bait, he never renounced entirely his independent style of work. He worked on his own and produced significant blocks of writing that we then discussed at length.

Asher’s first goal was to describe the eschatology of Thomas. What was the End like? Was the End, the Kingdom of God, to be experienced as some cataclysmic event that would bring this world and our history to a dramatic close, say, like Kingdom in the book of Revelation or in the gospel of Matthew? Or was the End in some sense already present as an inner process of search and discovery? Clearly, he argued, it was the latter. The second part of his thesis pursued the question further by examining the theme of world renunciation, again comparing Thomas to the canonical gospels of Luke and Matthew. Here the results confirmed his earlier conclusions. While each of the gospels revealed elements of world renunciation, the motivation behind this for Thomas was quite distinctive: attachments to this world distracted attention from humanity’s main concern, the inner, spiritual search for the kingdom of God by isolated individuals.

More broadly, Asher made two important observations about the course of future research on the Gospel of Thomas. First, that the canonical gospel of John stands much closer to Thomas than do Luke or Matthew. Indeed, that, as his JP adviser, Elaine Pagels, has argued, these two gospels are to be seen as engaged in debate and dispute with each other. And second, against the grain of much recent research, that Thomas can be read as a continuous narrative, that it has an inner logic. It is not just a helter-skelter collection of Jesus sayings.

In the end, Asher produced a really fine piece of work—polished and straightforward in its writing. Once again he revealed his strengths as a close reader of texts. But at the same time, he managed to widen his focus and to reach conclusions that extend well beyond this single text. What is more, as the adviser, I came away from the experience with the highest possible benefit. I now understand the Gospel of Thomas better than I did before advising—and reading—Asher’s thesis.
Since the first days of high school biology, I have been excited by the quest to understand life and have hoped to one day become a biologist. The very concept of life trying to understand itself seemed fascinating. Thus, I arrived at Princeton planning to major in biology. My freshman year, I took a biology course, as well as Physics 103 and 104—the introductory physics classes geared toward engineers. I decided to take those introductory physics classes because it seemed like it would be a good idea to keep as many options open as possible, but I did not expect to find the classes particularly exciting. To my surprise, I found the way of thinking and posing questions in these basic physics classes to be clear and powerful, and I became excited by the idea of applying physical thinking to biology. Thanks to the flexibility of the biology and physics programs at Princeton, I was able to pursue such interdisciplinary research. I ended up majoring in physics, getting a biophysics certificate, and doing my independent research in the molecular biology department. In my thesis, I was able to apply to biological analysis the quantitative skills I had fostered in my physics curriculum.

One aspect of biology that fascinates many people, including myself, is its complexity. As biologists have probed further and further into the processes that make cells tick, they have not found parsimonious Swiss watches, but rather mechanisms so complicated and seemingly haphazard that they have been compared to “explosions in a spaghetti factory.” The majority of biological research focuses on identifying and describing details of biological functioning, a logical focus given the incredible complexity of biological systems. It can, however, be interesting to explore broader principles that govern these systems, and study not only what is happening, but also why.

Optimization is one technique that can be used to search for design principles and simplicity in the complexity of life. One can ask whether or not a system performs a certain task optimally, given the relevant constraints. My thesis was an effort to apply optimization analysis to a biological system. In my thesis, I attempted to test if one cell type of the nervous system encoded information in a metabolically efficient manner. I measured the electrical impulses of neurons in the salamander retina that encode visual information, and compared aspects of the neural
code of these cells with the neural code of an “optimal” visual encoder. In other words, I asked whether or not the neural code of the retina evolved to be metabolically efficient.

Although preliminary results suggested that the model of metabolically efficient coding was correct, more thorough analysis revealed a failure in the model. The model did not explain the response of the retina to a range of stimulus conditions, even though it made successful predictions for the responses to a given stimulus. The failure of this elegant and plausible hypothesis taught me never to hold too dearly to any hypothesis before it is proven. I still believe that optimization principles can be used to understand biology, but I realize more clearly than before that it is essential to keep in mind that evolution optimizes for many parameters at once, and it is difficult for the researcher to identify the relevant constraints.

Apart from some problems with the theoretical model, I also encountered many difficulties taking experimental measurements from the salamander retina. Obtaining electrical measurements from neurons is challenging because the process of placing electrodes near neurons inevitably damages either the cells themselves or the tissue that provides nutrition to the cells. The nature of my analysis required a lot of data in which the response of the neurons is unchanging with time. There are many variables that may cause the response of the neurons to be inconsistent over time, including decay in the health of the neurons or minute changes in the relative position of the neurons and the electrodes. I had to perform my experiment countless times before I was able to obtain usable data. During the first few months that I worked on my thesis, I repeated my experiment time and time again without making any changes to the procedure. For months, every experiment resulted in data that were inadequate because the neurons did not stay in good health for a sufficiently long period of time. Only when I learned to adjust the experimental technique so that it would better suit my goals could I gather usable data. One thing I learned is that experimental science requires constant experimentation with procedures and techniques, and that continually refining them is part of the experimental process itself.

These very difficulties helped to convince me that neuroscience is an excellent field for applications of physics to biology. The wealth of neural activity data that scientists can obtain begs for quantitative analysis and theoretical modeling. Furthermore, I think that neuroscience is a field that is limited by technology. Methods to observe activity in individual neurons are very invasive and not always accurate. I believe that it is important for the future of the field that physicists and engineers invest efforts into improving the technology to allow for better neural recordings. Inspired by this sentiment, I ended up taking an electronics class during my senior year.

Interactions with my adviser and the other researchers in the lab were just as important as my thesis work itself in convincing me to pursue neuroscience research. My adviser played a central role in my growth during this project. He taught me the experimental techniques and was available whenever I needed

By the end, I was certain that I wanted to continue my career as a scientist.
help. I also found the lab environment extremely stimulating, as the postdocs in the lab provided a seemingly endless pool of resources and skills I could always count on.

Like all theses, mine had its ups and downs, and there were times when I was afraid it would never end. But I enjoyed the process itself, and I accepted the results of my research, even if they were not what I had hoped to get. By the end, I was certain that I wanted to continue my career as a scientist. I am now enrolled in a Ph.D. program in neuroscience at Stanford.

Michael Berry
Assistant Professor of Molecular Biology

During my tour of colleges long ago, I remember being faintly intimidated by Princeton’s senior thesis requirement. Now that I take part in administering it, I am very impressed with the institution and think of it as one of the great strengths of Princeton’s undergraduate education. By senior year, most students have mastered the art of taking college courses. They have sensitive radar for how much work is required to get the type of grade that they desire. And they also have well-developed expectations for what kinds of experiences they might have in lecture-based classes. In contrast, the senior thesis is an unpredictable period of sustained effort that draws upon many skills that play a lesser role in classroom performance, such as persistence, improvisation, and teamwork. In many ways, the senior thesis more closely resembles the professional activities of later life. These are some of the reasons why the senior thesis experience is so valuable.

Ilana Witten arrived in my office, interested in the intersection between physics and biology. She was majoring in physics and doing the certificate in biophysics, so she had both an interest in biological detail as well as the mathematical skills to approach biology quantitatively. For her junior paper, she performed analyses to study how the retina, a neural circuit in the back of the eye, adapts its function to the range of light intensities it has recently seen. She saw a complex variety of subtle changes in retinal function. So for her senior thesis, we explored whether many of these changes could be understood in terms of a simple, overarching principle: metabolic efficiency.

Neurons are some of the most energy-intensive cells in the body. The brain uses approximately 20 percent of your daily calorie intake, even though it only accounts for approximately 2 percent of your body mass. Whenever neurons send electrical pulses, or action potentials, to other neurons, they must expend energy. Thus, it is plausible that the brain has found coding schemes that can transmit necessary information at a reduced energy cost. In the case of the retina, Ilana measured the noise in the number of action potentials produced by visual stimulation. This noise degrades the information content of the visual messages sent from eye to brain. The retina can make up for this loss of information by sending more action potentials, but this costs more metabolic energy. To make this trade-off more formal, Ilana found the coding scheme that would transmit the most information per energy cost and compared this
optimal coding scheme with the one used by the retina.

One of the early challenges of this project was to get retinal recordings that were stable for long periods of time; the efficiency of retinal coding must be tested not just for one or two particular visual stimuli, but for a large set of stimuli. Ilana got numerous recordings that started out looking promising, but then declined in activity too quickly to be useful for subsequent analysis. Faced with these difficulties, Ilana got advice from members of the lab and repeated her experiments until they succeeded. Her persistence and ability to incorporate different approaches were crucial for getting good data. When she applied her analysis, Ilana found that the retinal code agreed with the optimally energy efficient code in some ways, but disagreed in other ways. Perhaps it was too ambitious to think that the many complexities of biology would yield to a simple optimization principle, but we learned a lot form the effort. Along the way, Ilana mastered several subjects that are far beyond the typical undergraduate curriculum in neurobiology and learned how to perform delicate electrophysiological experiments. Her energy and enthusiasm made her a pleasure to work with, and her organization and persistence still impress me. I was very pleased to see her go on to graduate work in neuroscience.

My advice for students contemplating the senior thesis is to start early. Novel research does not unfold according to detailed plans, and many experimental manipulations turn out to be more difficult than they originally seem. For students in the sciences, it is especially important to begin senior thesis work during the summer before senior year; this uninterrupted time allows one to focus exclusively on the thesis. Experimental projects in the sciences usually exhibit a threshold-like phenomenon, in which initial, sporadic efforts fail almost completely, but after sustained, focused effort, one gets the knack of doing the experiments. Then, progress can continue with less intense effort. The satisfaction of reaching this threshold, where one has developed a competence on par with the best in the world, is one of the major joys of experimental science.

... the senior thesis is an unpredictable period of sustained effort that draws upon many skills ...
## Index

<table>
<thead>
<tr>
<th>Field</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Art &amp; Archaeology</strong></td>
<td>The Goda Gang: A Multimedia Video Installation</td>
<td>126</td>
</tr>
<tr>
<td><strong>Chemical Engineering</strong></td>
<td>Toward <em>De Novo</em> Protein Design: Novel Distance Based Force Fields</td>
<td>90</td>
</tr>
<tr>
<td><strong>Chemistry</strong></td>
<td>Computational Investigations of Heterogeneous Brain Tumors</td>
<td>121</td>
</tr>
<tr>
<td><strong>Civil &amp; Environmental Engineering</strong></td>
<td>Technological Innovation and Political Conflict: The Evolution of Bonneville Dam as a Structure and as a Symbol</td>
<td>87</td>
</tr>
<tr>
<td><strong>Classics</strong></td>
<td>Hektor's Mortal Glory: Balance and Irony in the Iliad</td>
<td>81</td>
</tr>
<tr>
<td><strong>Comparative Literature</strong></td>
<td>Cinematic Poetry: Reading Federico García Lorca's <em>Poeta en Nueva York</em> through the Medium of Film</td>
<td>105</td>
</tr>
<tr>
<td><strong>Computer Science</strong></td>
<td>Digital Privacy-Rights Management for Ubiquitous Recording</td>
<td>59</td>
</tr>
<tr>
<td><strong>Ecology &amp; Evolutionary Biology</strong></td>
<td>The Distribution of Native Bees in an Intensive Agricultural Area</td>
<td>15</td>
</tr>
<tr>
<td><strong>Economics</strong></td>
<td>Two Essays on Health Economics</td>
<td>97</td>
</tr>
<tr>
<td><strong>Electrical Engineering</strong></td>
<td>Super-elastic Gold Conductors on Elastomeric Substrates</td>
<td>36</td>
</tr>
<tr>
<td><strong>English</strong></td>
<td>A Clematis Understanding: Joel Elias Spingarn, Scholar and Activist</td>
<td>131</td>
</tr>
<tr>
<td><strong>English</strong></td>
<td>Cast in Treen Mould: Arborification and Its Ramifications</td>
<td>9</td>
</tr>
<tr>
<td><strong>French &amp; Italian</strong></td>
<td>De Langue Double, Maint Trouble: A Critical Review of the Ontario French Immersion Curriculum</td>
<td>93</td>
</tr>
<tr>
<td><strong>French &amp; Italian</strong></td>
<td>Development, Duality, and Synthesis in the Breton Legend of the City of Ys (Stones that Stay Whole, and the Sea Splits in Two)</td>
<td>31</td>
</tr>
<tr>
<td><strong>Germanic Languages &amp; Literatures</strong></td>
<td>The Sorrows of Young Graetz, a Jewish Historian in the Making, from Aufklärung to Wissenschaft</td>
<td>25</td>
</tr>
<tr>
<td><strong>History</strong></td>
<td>Shanghai’s “Number Three Redheads“: Policing Indian Nationalism and Constructing Sikh Communities</td>
<td>136</td>
</tr>
<tr>
<td><strong>Mathematics</strong></td>
<td>The Pair Correlation of the Zeros of the Riemann Zeta Function</td>
<td>115</td>
</tr>
<tr>
<td><strong>Mechanical &amp; Aerospace Engineering</strong></td>
<td>Analysis of Space-Based Kinetic Energy Weapons Used for Ballistic Missile Defense</td>
<td>109</td>
</tr>
<tr>
<td><strong>Molecular Biology</strong></td>
<td>Genomic Identification of Yeast Mutants Defective in Stationary Phase Exit</td>
<td>68</td>
</tr>
<tr>
<td><strong>Philosophy</strong></td>
<td>Games With No Rules: The Wittgensteinian Conception of Language</td>
<td>45</td>
</tr>
<tr>
<td><strong>Physics</strong></td>
<td>Constraints on the Properties of Quintessence from Weak Gravitational Lensing</td>
<td>5</td>
</tr>
<tr>
<td><strong>Physics</strong></td>
<td>Testing for Metabolic Efficiency in the Neural Code of the Retina</td>
<td>144</td>
</tr>
<tr>
<td><strong>Politics</strong></td>
<td>Straight-up Medium with a Twist: A Comparative Analysis of the African-American Press vs. the Mainstream Press</td>
<td>100</td>
</tr>
<tr>
<td><strong>Psychology</strong></td>
<td>Emotional Face Perception: A Behavioral and fMRI Comparison of Still and Animated Video Stimuli</td>
<td>74</td>
</tr>
<tr>
<td><strong>Religion</strong></td>
<td>Cinematic Transfigurations of Jesus: A Study of Films by Pasolini and Scorsese</td>
<td>40</td>
</tr>
<tr>
<td><strong>Religion</strong></td>
<td>Eschatology and World Renunciation in the Synoptic Gospels and Thomas</td>
<td>141</td>
</tr>
<tr>
<td><strong>Sociology</strong></td>
<td>Passion: The Development and Role of Contemporary Worship in American Evangelicalism</td>
<td>54</td>
</tr>
<tr>
<td><strong>Sociology</strong></td>
<td>White Gold, Weed, and Blow: The Drug Trades of Afghanistan, Colombia, and Mexico in Comparative Historical Perspective</td>
<td>20</td>
</tr>
<tr>
<td><strong>Spanish &amp; Portuguese Languages &amp; Cultures</strong></td>
<td>Maquinaciones narrativas: Plot, Desire, and the Machine in Adolfo Bioy Casares’s <em>La invención de Morel</em></td>
<td>64</td>
</tr>
<tr>
<td><strong>Woodrow Wilson School</strong></td>
<td>Beyond Charity: America’s Moral Obligation to the World’s Poor</td>
<td>50</td>
</tr>
<tr>
<td><strong>Woodrow Wilson School</strong></td>
<td>Providing Uncompensated Care and Community Benefits: Challenges Facing Hospitals in New York City and Philadelphia</td>
<td>77</td>
</tr>
</tbody>
</table>