Molecular Feminisms

Introduction

Stolonic Strategies

> To be present at the dawn of the world. Such is the link between imperceptibility, indiscernibility, and impersonality—the three virtues. To reduce oneself to an abstract line, a trait, in order to find one's zone of indiscernibility with other traits, and in this way enter the haecceity and impersonality of the creator. One is then like grass: one has made the world, everybody/everything, into a becoming, because one has made a necessarily communicating world, because one has suppressed in oneself everything that prevents us from slipping between things and growing in the midst of things. One has combined "everything" (le "tout"): the indefinite article, the infinitive-becoming, and the proper name to which one is reduced.
>
> —GILLES DELEUZE AND FÉLIX GUATTARI

> stolon (runner): (i). A modified aboveground stem creeping and rooting at the nodes. (ii). It is an aerial shoot from a plant with the ability to produce adventitious roots and new clones of the same plant. Such plants are called stoloniferous. A stolon is a plant propagation strategy akin to a rhizome.
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> —DINESH KUMAR AND YASHBIR SINGH SHIVAY

A few years back, a severe rainstorm brought down a mighty oak tree in my neighbor's backyard. The tree fell toward my house, with the top branches just scraping the roof above the bedroom where I slept. I've had several tree encounters in my life—from climbing trees as a child, to planting saplings as a girl scout, to walking through the mighty trunk of an

ancient redwood in California. This particular tree encounter, however, was the first one that nearly ended my life. Despite this near-death encounter, I would not say that I am over trees, or even "tired of trees" as Gilles Deleuze and Félix Guattari's statement is often understood.[1] I've been around long enough to know that trees, like humans, have to live and die too. Interestingly, the event that was this tree spurred another very curious event that taught me a great deal.

The day the tree fell, I was in shock. This shock turned into immense awe as I watched countless animals and insects scurry in and out of the tree's topmost branches, which were now at my eye level. Had the tree trunk not been in imperceptible relationships with several different species of ants over a sixty- to seventy-year period, it would not have been hollowed by rot, too weak to withstand the wind gust that brought it down that day. It is not often that one has the opportunity to get up close to the leaves, branches, insects, and other tree becomings that generally transpire five to ten stories above ground. As much as they were opposed to arboreal thought, Deleuze and Guattari were also fully aware of such tree becomings. They stated: "A new rhizome may form in the heart of a tree, the hollow of a root, the crook of a branch. Or else it is a microscopic element of the root-tree, a radicle, that gets rhizome production going."[2] Indeed, by way of this fallen tree, I was brought into a new intimate relationship with grass, made keenly aware of the strategies used by grass stolons to grow and remake the world.

Removing the massive tree trunk and enormous branches from my backyard took several days, but once these were gone, I realized that practically all of the grass that had been growing, where the tree had fallen, was also gone. This tree may have deterritorialized when it was cut into hundreds of small pieces and removed from the yard, but the microscopic element of its root-tree made its way known through the remaining blades of grass that lay crushed upon my lawn. The easy answer would have been to lay down new sod. For several reasons (one of which was most certainly financial) I didn't want to replace the grass that had been destroyed, at least not immediately. I had a sense that the ground should have some time to recover from the blow, but more important I did not want to erase the event that was that tree so quickly.

By opening myself up to the route of least interference, I witnessed, over three full years, the slow processes of stolonic growth in a species of

everyday backyard Bermuda grass. I literally spent time watching grass grow. I witnessed, as Dinesh Kumar and Yashbir Singh Shivay explain in their definition of a stolon, how creeping grasses spread not by a rhizomatic root system that is underground and generally invisible to human senses but rather by the stolonic processes of developing new shoots and extending horizontal stems that grow above ground.[3] Over time, I became captivated with the outwardly stretching veins that ran along the surface of the ground, constantly reaching out, in search of connections, feeling around. This is how I realized that grass has a strategy that works. This strategy is one of becoming, and as Deleuze and Guattari write, this strategy works at making a communicating world.

I use a similar strategy throughout this book to think more carefully about new connections and communications that can emerge between molecular biology and feminism. My hope is to show that by thinking with *molecular feminisms*, *biophilosophies of becoming*, and *microphysiologies of desire*, we can see that biology and biological processes need not be essentializing or deterministic. As a feminist scientist trained in molecular biology and reproductive neuroendocrinology, I often wonder what knowledges we as feminists might have created by now if we weren't constantly having to spend our time and energy producing counterclaims to essentializing or deterministic language, paradigms, and experimental designs in the biological sciences. What if we were able to use, as Audre Lorde suggested years ago, our "power of the erotic" to think about science, biology, and molecular biology?[4] By the term "erotic," Lorde was referring to the potential, desires, and creative forces that lie within us to create change. Angie Willey has recently drawn from Lorde's work to introduce the idea of "biopossibilities" and to encourage us to think differently about bodies and biologies.[5]

Can biopossibilities and the playfulness that comes with powers of the erotic change how we approach bodies and matter in the lab? Would feminists be more willing to "do biology" if we knew from the start that the outcomes of our research would not bind us to an unwelcome fate? What if, after all, anatomy was not our entire destiny but was indeed involved in the emergent and expressive processes of life forms in all their becomings? What if biological reductionism was not seen as an end to scientific knowledge but instead as a means to connect more intimately to the multiple microscopic and molecular material actants that make up

the world within and around us? What if learning how to *see* the world was also about learning how to *encounter* that world? By using strategies inspired by grass, and by extending stolonic runners between new and old feminist engagements with science, I hope we will be able to think anew. What is at stake here is relevant to scholars in both the biological sciences and the humanities. It is the chance to learn how to approach bodies and matter through new lines of flight and to embrace the erotic possibilities and capacities that come with becoming a blade of grass.

Early in my scientific training, I conducted a series of lab experiments that inspired me to think about questions that lie smack-dab at the intersections between feminism, biology, and philosophy. I did my doctoral research in a molecular biology and reproductive neuroendocrinology lab that studies the molecular mechanisms of steroid regulation in an *in vitro* cell line of specialized hypothalamic neurons.[6] The goal of my research project was to further characterize these hypothalamic gonadotropin-releasing hormone (GnRH) neurons to better understand their role in the regulation of reproduction. One of the first experiments I contributed to involved applying molecular biology techniques to search for estrogen receptor gene expression and protein synthesis in these neurons.[7] Before I share more on this particular experiment, however, I want to point out the importance of learning the everyday nitty-gritty practices of experimentation in molecular biology and the impact that these practices have had on my development as a feminist scientist.

Throughout this book I emphasize the importance of developing practice-oriented approaches for feminist science and technology studies (STS). Perhaps driven by their background and training in the sciences, such feminist scholars as Donna Haraway, Isabelle Stengers, and Karen Barad have long highlighted the importance of these approaches.[8] Through her concept of cosmopolitics, for instance, Stengers has suggested that an emphasis on practices allows us to learn how to engage with and not simply judge a knowledge system that is not our own.[9] This shift from focusing on the construction of theories in science, to developing a better appreciation for experimental practices in science that can contribute to theory-making, is now a cornerstone of STS scholarship, perhaps best articulated by Ian Hacking, who has suggested that "experimentation has a life of its own."[10] I have tried to capture the erotic potential that lies within the life of experimentation, and by participating in this life I have gained a sense

of what Deleuze and Guattari meant by reducing oneself to an abstract line and finding a zone of indiscernibility with other traits. Discussing the research techniques of protein modelers, Natasha Myers has recently stated that "modelers, it turns out, cultivate intimate relationships with their molecules as they get themselves caught up in the involving work of molecular visualization."[11] In my case, training in a molecular biology lab has led me to create intimate relationships and zones of indiscernibility not only with molecules but also with many other traits, including feminist activism, feminist theory, reproductive justice movements, neurons, genes, steroid receptors, steroids, signaling pathways, and philosophies of becoming.

The Life of an Experiment

At the beginning of my doctoral work, I had the opportunity to find new forms of communication between GnRH neurons, estrogen receptors (ERs), and estrogen molecules. The molecular biology techniques I was required to learn in order to conduct my experiments taught me how to face the lab bench, how to form experimental togetherness around shared objects of perplexity, and how to "break bread" as it were with my scientific peers and colleagues in the lab.[12] I longed to create new zones of proximity between molecules and my own feminist political landscapes by examining a biological interaction and process that had been marginalized in the sciences but was relevant to both molecular neuroendocrinology and women's reproductive health. Thus, my excitement when one of my first experimental research tasks involved searching for the expression of estrogen receptor genes and the synthesis of estrogen receptor alpha (ERα) and estrogen receptor beta (ERβ) proteins in an *in vitro* cell line model of GnRH neurons called GTI-7 cells.[13] GnRH is known to be a central hormone of the hypothalamic-pituitary-gonadal (HPG) axis. It helps to regulate the synthesis and secretion of luteinizing hormone and follicle stimulating hormone in the pituitary gland and androgen and estrogen in the gonads.[14] I was tasked with investigating the possibility for direct feedback regulation of GnRH gene expression and synthesis by the gonadal hormone estrogen.

Estrogen of course is involved in much more than just the processes of reproduction, including the fusion of long bone epiphyses, the suppression

of osteoclast activity, and providing direct protective effects against atherosclerosis.[15] Although estrogens are synthesized primarily in the gonads, they are also synthesized in extra-gonadal sites and are known to play an important role in coordinating regulatory effects in adipose tissue, skin, the immune system, and more.[16] My doctoral supervisor at the University of Toronto, Denise D. Belsham, was interested primarily in examining the role of estrogen in the brain in its reproductive capacity. Estrogen is a very interesting hormone in this respect, as it has been shown to negatively regulate GnRH synthesis but is also necessary to induce the preovulatory surge of GnRH during the menstrual cycle.[17] One would imagine therefore that estrogen would have something to do with the regulation of reproduction at the level of the brain. The research we conducted would almost be considered unnecessary if it were not for the fact that experts in the field had for decades declared that GnRH neurons did not express the proper nuclear protein receptors that bind to estrogen. Thus the working premise in the field, and the belief held by most neuroendocrinologists at the time, was that GnRH neurons could not be directly affected by estrogen. Instead, interneurons contacting GnRH neurons were thought to be responsible for mediating the effects of estrogen and other gonadal steroids on GnRH synthesis and secretion.[18]

This is what I was up against when I started my doctoral research. I was working athwart to expert knowledge in reproductive neuroendocrinology that was unconvinced of a trait (that of a relationship between estrogen receptors and GnRH neurons) and unwilling or uninterested in spending time designing experiments to recognize new zones of indiscernibility. They dismissed this possibility because they could not imagine what estrogen would be doing in this part of the brain. The long-held belief that GnRH neurons functioned without experiencing direct contact by estrogen had resulted in a scientific milieu where novel relations between certain molecules had become inconceivable, and desires for creating fresh zones of proximity were cast aside. At the time, estrogen receptor research was of particular interest because these receptors had just been reported to behave in a manner that destabilized a dominant or "majoritarian" paradigm in neuroendocrinology. Estrogen receptors were traditionally thought to come in only one form. For a long time the field of endocrinology was not aware of the possibility that more than one type of estrogen receptor could exist. However, just before I started my research, the stable

unitary identity of the estrogen receptor was displaced by the discovery of another nuclear receptor that bound to estrogen.[19]

This caused a minor endocrinological skirmish in its day, forcing estrogen receptors to be reclassified as either estrogen receptor-alpha (ERα, the "original" estrogen receptor) or estrogen receptor-beta (ERβ, the "other" estrogen receptor). I began my nomadic wanderings in search of estrogen receptors in the *in vitro* model of GnRH neurons, moving in and out of Petri dishes, in the shadows of transgenic politics, surrounded by scandals of scientific authority, exposed to the gender, race, and class dynamics of scientists in the laboratory, and faced with the anxiety of protein otherness on many different scales—basically a day in the life of a feminist scientist. All this was worth it, however, because I knew that by participating in the production of scientific knowledge on the body, I would have a chance to bring together feminist politics and marginalized or "minor" literatures in neuroendocrinology to form new lines of inquiry. Many scientists as well as feminist health activists have suspected for some time that estrogens present in hormone-based therapies and reproductive technologies may be doing more than simply managing the symptoms of menopause or regulating ovulation. I was excited to participate in the production of scientific knowledge that examined the possible direct neurological impacts of estrogen and could perhaps help to address some concerns around the design and use of estrogen-based hormonal contraceptives, hormone replacement therapies, and new reproductive and genetic technologies.

I recall the excitement that my colleagues and I shared when we first searched for estrogen receptors. We used molecular biology techniques such as subcloning and sequencing to find the genes for ERα and ERβ. We then carried out reverse transcriptase polymerase chain reaction (RT-PCR) experiments on *in vitro* GnRH neurons, in search of ER cDNA (complementary DNA). The idea was to show that the transcription and translation of these genes ultimately led to the expression of ER proteins in GnRH neurons. Not only did we find ERα cDNA coding for the gonadal hormone receptor that had been excluded from the mind's eye of neuroendocrinologists, but we also found ERα's other, ERβ.[20] We went on to conduct more molecular biology experiments such as Western blot analysis, to search for the expression of ERα and ERβ proteins. Both were found easily. Our results proved not only that GnRH neurons express estrogen receptors but that these receptors directly repress GnRH synthesis in these

neurons. The life of these experiments set me onto a new line of flight and onto a series of interdisciplinary inquiries that continue to motivate me to this day. I faced and overcame scientific authority that had stacked the odds against this research and against the ability of estrogen and GnRH neurons to form more intimate zones of proximity. Although I did not have the vocabulary at the time to express myself in this way, I knew that I had witnessed a kind of ontological rupture that had moved my understanding of matter from one of fixity, stasis, and being to that of flexibility, change, and becoming. It was as if one night I had gone to bed with a materiality in which estrogen receptors could not be brought into closer proximity to GnRH neurons. The next morning, I woke up to an alternate materiality with new sites of play and unexplored biopossibilities for these biological matters.

Since I conducted these initial experiments, there has been even more reason to see that biologies are not fixed and to appreciate the value of moving toward playfulness and the power of the erotic in our search for biological knowledges. It has been further reported, for instance, that ERβ actually comes in not one but four different orientations or isoforms, including ER-β1 as well as ER-β2, ER-β4, and ER-β5.[21] A third type of estrogen receptor has also been isolated, known as GPER1 (also referred to as GPR30).[22] What is fascinating about this particular estrogen receptor is that it is a G protein-coupled transmembrane receptor (GPCR) and not a traditional nuclear steroid receptor. In GnRH neurons, which have been found to express this GPCR, this means that estrogen not only regulates nuclear transcription mechanisms, which happen on a timescale of hours, but that estrogen is also capable of eliciting rapid excitatory membrane-initiated actions, which can take effect within seconds to minutes. This membrane-bound estrogen receptor can directly modify GnRH neuronal activity and can trigger several different signal transduction pathways that are not affected by the traditional ERs that act as nuclear transcription factors.[23] Once again, this discovery of membrane estrogen receptors may be of particular interest to feminist health and reproductive justice advocates, as rapid and direct effects of estrogen can help to explain the long-observed "side effects" that many women experience while using estrogen-based contraceptives and therapies. The discovery of ERs in GnRH neurons, and the further discovery of G-protein coupled estrogen receptors in both GnRH neurons and other tissues throughout the body,

serve as opportunities for feminists and molecular biologists to reach toward not just one but several shared objects of perplexity.

The life of this particular lab experiment continues to shape my efforts in theory-making. Beginning with my efforts as a scientist trying to become a feminist scientist, to a feminist scientist trying to become a women's studies scholar, this lab experiment has encouraged me to slip and grow in the midst of many disparate fields and has extended itself into an immensely productive experiment in interdisciplinary scholarship. It has provided me with the impulse to bring together scholarship that is typically separated by disciplinary distinctions such as the humanities and sciences, as well as by cultural distinctions such as concepts of the East and the West. *Molecular Feminisms* was written with several different audiences in mind. In addition to joining some ongoing conversations in the fields of feminist theory, postcolonial and decolonial studies, posthumanism, new materialisms, and science and technology studies (STS), this book hopes to provide a reflective space for both feminist scientists who wish to participate in bench research and the production of scientific knowledge as well as scientist feminists who are eager to use scientific research and data to inform their feminist analyses.[24] The past few decades of work in feminist STS has prepared us for noninnocent entry into lab spaces and participation in the production of scientific research. However, rather than following the more dominant women-in-science pipeline ideology, I argue that feminists might want to try to proceed in this noninnocent entry by exploring less common, marginalized, or minor modes of engagement with the sciences. My goal is to contribute to theory-making by creating conceptual frameworks that can be used to approach the lab bench, bring scientific research and data out of the lab, and revitalize how we think about bodies, biologies, and matter.

As a feminist scientist, I recall my interest and excitement after learning several feminist critiques of science. These critiques were eye-opening, compelling, and made great sense to me. Inspired by these critiques, I faced the challenges of actually trying to apply feminist epistemologies and methodologies at the level of practices at the lab bench. This was no easy task. While conducting research in the lab, the feminist scientist does not have a great deal of spare time, or the tools for that matter, to reflect upon and build connections between their love of science and their commitments to social justice. Facing this challenge has perhaps been the

most productive and rewarding aspect of my intellectual career. Learning how to articulate this challenge into questions that make sense to both feminists and scientists has been an experiment in itself.

The scientist feminist who is interested in working with the sciences and scientific data may also benefit from learning more about the nitty-gritty practices of experimental biology. Recent projects have encouraged feminists to turn to questions of matter, and to animal, vegetal, and molecular bodies to develop more intimate treatments of materiality. Although new ontological gestures have revived feminist theory's engagements with the sciences and with biology in particular, without an effort to connect this theory to the theory and practices taking place at the level of the lab bench, these gestures run the risk of suffering a similar fate as that of poststructuralist feminist theory and earlier feminist critiques of science, which rightly or wrongly have been accused of working to restrict our access to the natural world. Worse still, what appears to be a growing tendency in some recent materialist scholarship to accept scientific knowledge at face value could in fact do feminism a disservice. As a feminist scientist, I offer some new perspectives and tools that one might use to approach biology from outside the lab.

I address some big questions that both feminist scientists and scientist feminists may have in common. How do we continue with science after the critiques of science? How do we work toward a biology that we desire? How are we to encounter matter? How can we bring questions of context with us when we do encounter this matter? How can we reconfigure the relationship between the scientific knower and what is to become the known? These and other such interrogations are visited several times, in multiple ways, throughout *Molecular Feminisms*. Admittedly, some of these interrogations are theory-heavy and draw from larger philosophical projects, but a genuine effort is made to make them relatable to the busy bench scientist. I articulate these interrogations by providing examples of the challenges one might face while trying to practice science as a feminist or practice feminism as a scientist. These examples provide tools that can be used for going into the sciences, developing methods, presenting our results and data, and facing ethical dilemmas in our research.

Part of the challenge of developing an interdisciplinary experiment involves starting with distinct disciplinary vocabularies, even when one is trying to address an idea or concept shared by these different knowledge

systems. Building shared vocabularies takes a great deal of patience. Having said this, I encourage humanities scholars to work through the scientific experiments and data presented, and similarly I encourage scientists to push through the more philosophical aspects of the book. Chapter 1, "Biophilosophies of Becoming," is a particularly theory-heavy chapter. Establishing the book's philosophical framing, it provides tools for thinking about a broader conversation at the intersection of philosophy and science. Truly interdisciplinary work takes time, is full of failures, and can often leave everyone concerned unsatisfied. As excited as I am to bring this interdisciplinary conversation forward, I am fully aware that in my attempt to write a book for multiple audiences, I may have in fact written a book that is legible to no one, except perhaps myself—and even that is not guaranteed. What can I say? It's an experiment.

Feminism, Science, and the Politics of Knowledge Production

Feminists have a long history of intervening in the politics of knowledge production in ways that are specific to their time, location, and culture. They have argued that such factors as one's sex, gender, sexuality, race, ethnicity, class, age, abilities, location, and more influence who gets to conduct research, which questions generally get asked, and what knowledge is ultimately produced.[25] With today's fast pace of biotechnological developments, feminists are aware, more than ever, of the importance of bringing these critical perspectives into dialog with the sciences. There are many different types of feminisms, and although there is overlap, each has its own various forms of analytics. Among the different genealogies of feminism, the project at hand highlights some of the distinct approaches that exist between what has been referred to as liberal feminisms or feminisms of equality and what is often referred to as difference feminisms. Although these genealogies are no doubt messy and tangled, Elizabeth Grosz has provided an explanation of some of their distinctive features. "In place of the essentialist and naturalist containment of women," she explains, "feminists of equality affirm women's potential for equal intelligence, ability, and social value."[26]

Grosz suggests that for many, equality feminisms are generally motivated by a "logic of identification," which is "identification with the

values, norms, goals, and methods devised and validated by men."[27] Alternatively, difference feminisms highlight women's differences from men. However, as Grosz further explains, "it is vital to ask how this difference is conceived, and, perhaps more importantly, who it is that defines this difference and for whom."[28] As she notes, it is important to understand that for these feminists "difference is not seen as difference from a pregiven norm, but as pure difference, difference in itself, difference with no identity."[29] These distinctions between feminisms of equality and feminisms of difference can be understood to roughly align with the philosophical and political approaches referred to respectively as "Molar" and "molecular" politics by Deleuzian scholars.

Following major feminist social and political interventions in the 1960s and 1970s, which in the US context were generally aligned along feminism-of-equality frameworks, many feminist scholars and activists turned their attention to the authority, validity, and impact of scientific claims. These claims were examined specifically for their role in supporting gender-based discrimination of women within academia, the home, and the workplace. For example, beginning in the late 1960s, feminists in the women's movement who were invested in participating in the production of scientific knowledge in the biological and reproductive sciences came together to form such groups as the Boston Women's Health Book Collective (1969), the feminist Self Help Clinic in Los Angeles (1971), and the National Black Women's Health Project (1984).[30] During this era feminists in the United States formed these organizations and developed their own knowledge bases in response to, and as an alternative to, decades of research on women's bodies, biology, and health that had originated from scientific disciplines and governmental institutions with long histories of excluding women and other minority groups as credible researchers and/or policy makers.

Beginning in the early 1980s, and working mostly in the US, Canadian, and European contexts, feminist philosophers of science, feminist historians of science, feminist sociologists and anthropologists of science, and several critical scholars contributed to the efforts of disciplinary and institutional change by developing highly sophisticated critiques of traditional and dominant forms of scientific research.[31] Many of these feminists made their interventions in the sciences by conducting in-depth critiques of the epistemological framings, methodological approaches, and language and

metaphors commonly used in scientific teaching, research, and publications. These modes of critique are still relevant and operational today and continue to serve as important sources of feminist engagement with the sciences, particularly within the biological and life sciences. Some key aspects of these feminist critiques include (1) questioning the capability of achieving "pure" or aperspectival objectivity; (2) interrogating the impact of reductionist thinking; (3) problematizing the use of binary categories in the organization of observed biological and behavioral differences; (4) pointing out essentialist assumptions in scientific theories, specifically those that reinforce and promote biologically deterministic reasoning; and (5) questioning linear logic and oversimplistic models that move too easily from observations of correlation to explanations of causation. Many of these feminist critiques of science were also accompanied by practical suggestions for the diversification and democratization of science, both in terms of who should have the opportunity to participate in the production of scientific research and which ideas should be included in the pursuit of evidence-based scientific knowledge.[32] Put together, the work of early feminist health advocates and the strategies of critique developed by feminist academics trained in the humanities and social sciences have served as crucial cornerstones in the theoretical development and applied practices of the field of feminist STS.

In addition to humanities and social sciences–based scholarly engagements, in the early 1980s several notable feminists who were also scientists began contributing to the early formations of feminist STS. They made their contributions by first meeting the challenge of training and practicing in the "hard" sciences in academic and workplace climates that were more often than not hostile to women. Many of these feminists went into the sciences because of their love of biology, physics, or chemistry, and after having met the material challenges of working within these disciplines, they began sharing their experiences, critiques, and informed calls for change. Starting in the early 1980s, many feminist scientists shared their hands-on experiences of living and working within the sciences. They include, for instance, Margaret Benston, Evelyn Fox Keller, Ruth Bleier, Anne Fausto-Sterling, Lynda Birke, Sue V. Rosser, Ruth Hubbard, Donna Haraway, Lesley Rogers, Ursula Franklin, Bonnie Spanier, Karen Messing, Donna Mergler, and Karen Barad. Their critiques of the sciences, conducted from the "inside," were not meant to shut down

feminist dialog with the sciences or discredit the sciences but were rather aimed at improving and furthering scientific knowledge in their respective fields.[33]

Feminist biologists working during this era were well positioned to critically analyze research and data, at the level of basic laboratory bench science as well as at the level of behavioral studies conducted on animal and human subjects in the clinical environment. They conducted intimate critiques of the multiple disciplines of biology while also working with animals, plants, microorganisms, and other biological materials in the lab. Their careful analyses were produced through firsthand experiences and insights of the specificities associated with scientific practices such as experimentation, statistical analysis of data, and scientific publishing. The skills these feminist biologists acquired while working within the sciences were hard-earned and gave them a degree of legitimacy that was required in order to critique and comment on the state of their particular discipline's understandings of bodies, biologies, and matter. They continue to serve as role models for generations of feminist scientists to come, because rather than shying away from the challenge of training and working within the hard sciences, or keeping their experiences in the sciences to themselves, these feminists shared their thoughts and made the inner workings of scientific research and knowledge production more transparent to others. Their efforts made it possible to know more about what one was getting into by signing up to become a feminist scientist.

Having said this, many of the early critiques of biological research and knowledge made by feminist scientists beginning in the 1980s were structured along liberal equality-based feminist frameworks. These critiques were in line with feminist critiques taking place at the time in humanities and social sciences–based disciplines such as philosophy, history, literature, political science, anthropology, and sociology. Rightly so, feminists during this era were primarily invested in questioning the dominant gendered paradigms operating in the traditional disciplines of the humanities and social sciences whereby women, or traits associated with femininity, were deemed as being inferior to men or masculine traits. Feminist scientists critiqued essentialist and deterministic modes of thinking and experimentation within the sciences, largely by addressing the epistemological and methodological biases apparent within their own particular areas of scientific expertise. However, these studies did not explicitly develop

alternative epistemological or methodological approaches for conducting biological research that could be viewed as being nonessentializing or nondeterministic. In addition, not a great deal of attention was paid to the ontological assumptions and implications operating within their own disciplinary frameworks.

Despite this, it is misguided to suggest that feminists who took the trouble to train and spend time within the natural sciences, and particularly within the life sciences, did not develop their own intimate inquiries into the nature of matter or were not deeply aware of the importance of developing a *feminist ethics of matter*, even if that is not the vocabulary they used to describe their work. It is problematic to suggest that their critiques of scientific research were aimed at dismissing the contributions of bodies, biologies, and matter, or rejecting the knowledge that could be gained by the disciplinary fields of biology, genetics, and molecular biology. Interestingly, a similar accusation has been brought against feminist theory that has been influenced by poststructuralism and cultural theory, and unfortunately in some cases to all of feminism in general. By returning to the earlier work of feminist health advocates, women-of- color feminists, feminist philosophers, historians, sociologists and anthropologists of science, and particularly to the accounts of feminist scientists with the productive generosity of generational feminisms, we can begin to view this important work in new ways and thereby sharpen our current analyses in feminist STS.[34]

Much has transpired in both feminist political struggles and various areas of biological research since these early feminist engagements in the 1980s. The vibrant field of feminist STS has become an integral part of disciplinary training in women's studies, and for feminists who continue to train and practice in the sciences, feminist STS has come to serve as a toolbox, providing a compass from which one can navigate their own attempts at scientific knowledge production.[35] As the importance of feminist STS becomes more recognizable to scholars working in other fields, we are witnessing an explosion of interdisciplinary activity in an already interdisciplinary space. For example, feminist and queer scholars working at the intersections of philosophy, poststructuralist theory, cultural studies, literary studies, and psychoanalysis have also turned their attention to STS. They have brought with them the skills of questioning dominant metaphysical traditions and are imagining new ontological orientations

and ethical gestures that can be used to think more critically about our relations to matter and the world around us.[36] They offer the experience of developing alternative frameworks for thinking about questions of difference, identity, and representation.

Many of these ontological and ethical reorientations and gestures may not be entirely new or unfamiliar to feminist scientists or feminist STS scholars. For instance, the question of the relationship between the scientist and their "object" of study has been at the heart of several feminist reflections on science and scientific method.[37] What is new is the interdisciplinary and shared vocabulary that is developing around common questions related to matter, ethics, and knowledge-making practices thanks to the commingling of theories and vocabularies between various fields. Over the past decade these intellectual collaborations have led to an exciting burst of scholarship found in feminist STS. This long trajectory of feminist materialisms—starting with feminist health and reproductive justice activism, to early feminist critiques of science, to current-day interests in feminist theory regarding the ontological status of matter—has brought me to write this interdisciplinary book about feminism, molecular biology, and the importance of theory-making both inside and outside of the lab.

Why Molecular Feminisms?

Other than my own interest in molecular biology research, and the obvious word play between "molecular biology" and "molecular politics," what claim or distinction am I trying to make by turning to the molecular? Although I am in no way interested in dismissing current feminist STS projects that are aligned with women in science and feminisms-of-equality projects, I am invested in theory-making that can emerge from using philosophical and political approaches that turn to more marginalized or underplayed ideas, literatures, and thinkers in both feminism and the sciences. What can happen at the intersections of feminism and science when we look to less familiar figures, both human and nonhuman, for our theory-making? I must admit that it is my training as a scientist (specifically as a molecular biologist), and not my interest in feminist theory, that first brought me to think about the difference between molar and molecular approaches. It is the years of making chemical solutions in the lab,

learning about the behavior of molecules, and studying the microdynamics of signal transduction pathways that have led me to gravitate toward the molecular.

In their collaborative text *A Thousand Plateaus: Capitalism and Schizophrenia*, Deleuze and Guattari have described those modes of thinking and politics that draw upon philosophies of being, stasis, and identity as being "majoritarian" or "molar" in their approach. Alternatively, they describe those tactics that build upon the ideas of becoming, change, process, and events as being "minoritarian" or "molecular" in their approach. Deleuze and Guattari repeatedly emphasize that these tactics are not opposed to each other, but rather that they can be distinguished by their orientations to matters of scale.[38] In *A Thousand Plateaus*, Deleuze and Guattari attempt to move away from a Platonic metaphysics. To do so, however, they know it is necessary to account for the presence of forms and substances, which they attempt to do by suggesting that forms and substances are "generated by intensive processes rather than imposed on intensive processes from without."[39] During this treatment of forms and substances, Deleuze and Guattari make a distinction between the molar and molecular. They state:

> It is clear that the distinction between the two articulations is not between substances and forms. Substances are nothing other than formed matters. Forms imply a code, modes of coding and decoding. Substances as formed matters refer to territorialities and degrees of territorialization and deterritorialization. But each articulation has a code and a territoriality; therefore each possesses both form and substance. For now, all we can say is that each articulation has a corresponding type of segmentarity or multiplicity: one type is supple, more molecular, and merely ordered; the other is more rigid, molar, and organized. Although the first articulation is not lacking in systematic interactions, it is in the second articulation in particular that phenomena constituting an overcoding are produced, phenomena of centering, unification, totalization, integration, hierarchization, and finalization.[40]

Inspired by their interests in the natural and physical sciences, Deleuze and Guattari draw distinctions between molar and molecular thinking by turning to and drawing parallels with geology, chemistry, and biology.

They have described majoritarian politics as having molar tendencies, because these approaches often deal in identity-based, territorialized, organized, originary, and often privileged terms.

The term "molar" in chemistry refers to a unit of concentration (known as molarity) that is equal to the number of moles of a substance per liter of a solution. A mole, in turn, is a chemical mass unit of a fixed number (6.022×10^{23}) of molecules or atoms of a substance, also known as Avogadro's number. This representation of a group of molecules or atoms that come together to form one entity is what Deleuze and Guattari allude to in their use of the term "molar." Alternatively, they describe minoritarian approaches as molecular tendencies, not because they belong to a minority group or that they operate only at a subcellular level but because they entail those ethical actions and ontological maneuvers that work to deterritorialize our thoughts. As Eugene Holland has explained:

> There are several ways of approaching the relations between molar and molecular. One is in connection with the articulation of content and expression. As we have seen, a substance can take liquid form on the molecular level, and then get transformed into a crystal on the molar level: water vapor becomes a snowflake. Notice that molecular and molar are relative terms: when individual snowflakes combine to form a snowdrift, or a snowman, it is now the snowflakes that constitute the molecular level, while the snowdrift and snowman are molar. . . . The recourse to statistical probabilities may be what gives rise to the false impression that the difference between molar and molecular is a matter of size, when in fact it is more a matter of perspective.[41]

My reason for turning to the molecular, and to questions of *becomings*, is directly related to becoming a feminist scientist, working at the intersections of reproductive neuroendocrinology and molecular biology, and the quandaries regarding matters of perspective that these experiences have produced.

This distinction between major/minor and molar/molecular politics and matters of perspective is also found in the work of new materialists but is best expounded by Elizabeth Grosz and Rosi Braidotti. Both Grosz and Braidotti have reflected carefully on Deleuze and Guattari's philosophical interests and are aware of the valid feminist criticisms of molecular

concepts such as *becoming-woman*.[42] However, they have also created a space for lively exchange between the work of Deleuzian ethics, feminist theory, and feminist STS. Their contributions to feminist theory and feminist STS—particularly their ontological and ethical reflections on questions of difference, sexual difference, and molecular politics—have served as crucial points of reflection for me. Grosz, for example, has argued that the molecular is a way of thinking through difference in terms of difference in and of itself. "If molar unities, like the divisions of classes, races and sexes," she writes, "attempt to form and stabilize an identity, a fixity, a system that functions homeostatically, sealing in its energies and intensities, molecular becomings traverse, create a path, destabilize, enable energy seepage within and through these molar unities."[43] Interestingly, Grosz cautions that molecular projects such as those aligned with difference feminisms might often appear to reify differences and work against liberal feminisms committed to equal rights.[44] Despite this fact, she argues that molecular projects are necessary in order to think about difference, particularly to think about sexual difference through multiplicities rather than what Luce Irigaray has identified as a logic of the Same.[45]

Explaining the distinction between molar and molecular projects, Braidotti suggests that "the 'Molar' line" is "that of Being, identity, fixity and potestas—and the 'molecular' line—that of becoming, nomadic subjectivity and potential."[46] We can look, for instance, to the impact of identity- based molar politics, which in the case for humans has led to many advancements made by women's rights, civil rights, gay liberation, and disability rights movements. The ability to claim membership within a group that is marked as a stable identity—or as Gayatri Chakravorty Spivak has explained, to be able to strategically invoke an essentialized identity such as calling oneself woman, lesbian, transgender, intersex, or disabled—can carry much political import.[47] It is therefore crucial to make clear that by turning to ideas of becoming, movement, change, and intensities—what I refer to as *molecular feminisms*—I am not attempting in any way to discredit or devalue majoritarian naming practices or molar identity-based representational politics. Also, I am not suggesting that one must necessarily have to choose one mode of thinking about and approaching the world over the other. Rather, I want to acknowledge, as Deleuze and Guattari point out repeatedly in *A Thousand Plateaus*, that being and becoming coexist and even work to coproduce each other.[48]

Similarly, we could keep in mind the fact that stoloniferous plants grow by both extending stolonic shoots and establishing adventitious roots at its nodes. Yet, I also want to acknowledge that our habits of logic have limited how it is that we most often pursue knowledge about ourselves and the world around us. We have been limited by an all too familiar mode of questioning and reasoning through molar modes of being. This has been the case in the vast majority of encounters between feminism and biology.

Approaching Matter through New Lines of Flight

I have always had a passion for the natural sciences. *Molecular Feminisms* is written from the perspective of a feminist STS scholar who had the benefit of learning from feminist critiques of science; in fact, because of (and not in spite of) these critiques, I went into the "hard" sciences purposefully at a time immediately following the "science wars."[49] Encouraged by feminist activists and scholars around me, who themselves were deeply involved in identity-based women's rights and reproductive justice movements, I pursued my doctoral training in molecular and reproductive biology in order to gain expertise in the scientific theories and practices that were directly related to our knowledge of women's reproductive health. I was exposed to some crucial scholarship in feminist STS while I was training in the lab, including theoretical interventions mapped out by, to name a few, Donna Haraway's situated knowledges and cyborg manifesto, Helen Longino's outlines for socially just science, Sandra Harding's concept of strong objectivity, Emily Martin's suggestions for new ways of conducting reproductive biology research, and Banu Subramaniam's metanarrative on science and scientific method.[50] Bonnie Spanier's *Im/Partial Science: Gender Ideology in Molecular Biology* was particularly eye-opening for me, as the work provided a methodology for revealing gendered paradigms in molecular biology research.[51] These were the feminist theoretical interventions and methodological tools I took with me to the lab bench while training to become a scientist.

However, I wasn't prepared for the journey of ontological and ethical reorientations that I was to embark upon as a direct result of my training in molecular biology. Nor could I have anticipated the reactions I would encounter from my feminist colleagues in women's studies departments,

women's health movements, and reproductive justice organizations as a result of these reorientations. I went into the biological sciences in the first place because of the strong impulse *not to ignore questions related to matter* that I had learned from feminist philosophers of science, women of color feminisms, postcolonial studies, and women's health activism. I knew very well that I was making a noninnocent entry into the lab. Once I got there, I realized that I was somewhat on my own in my attempts to bring my feminist interests in matter and materiality, which were directly related to women's reproductive health, together with the everyday, nitty-gritty practices of molecular biology. As a feminist scientist, I wanted to participate in the production of scientific knowledge, but as a result, I found myself asking a series of challenging and difficult questions that I had to face head-on if I wished to learn more about matter through the practices of molecular biology. These questions were multiple and varied, and when I tried to bring the challenges of doing bench science back into conversation with my feminist peers who worked outside of the sciences, my questions were often met with a fair bit of confusion, if not alarm. The reactions I received after posing such questions as "Should feminists clone?" (a genuine question I needed to ask as a molecular biologist) indicated that my ontological and ethical reorientations had led me to venture out a little too far.[52]

Learning the everyday practices of bench science in molecular biology taught me a number of invaluable lessons. Before I was introduced to the work of Isabelle Stengers, I had a hunch that in order to create meeting places for meaningful interdisciplinary conversations and opportunities for imagining joint biological and technological futures, both molecular biologists and feminists could benefit by learning about each other's practices.[53] While training to become a molecular biologist, I was genuinely interested in learning how to work with biological matters through the practices specific to this field of scientific research. During this process, did I take with me the feminist critiques of science that taught me how to recognize sexism in the sciences? Yes. Did I learn to recognize and name institutional racism and how it operated in my university and department? Yes. Did I register the gendered, racist, classist, and ableist language and paradigms that surrounded me in molecular biology or reproductive physiology textbooks, lectures, or scientific articles to which I was exposed? Absolutely, yes! Did I see a relation between those who wore a white lab coat, their pursuit of pure objectivity, and the drive within the sciences to

erase matters of context? Repeatedly, yes. Despite these active recognitions, however, I did not approach the actual nitty-gritty everyday practices of molecular biology and reproductive neuroendocrinology laboratory techniques and experiments through a sense of irony or distrust. Nor did I intentionally plan to become a scientist and spend years of my life learning the incredibly complex practices of my field only to simply dismiss them or to "bring science down" as it were. Constantly aware of the importance of thinking with molecular biology, I also registered the constraints and difficulties posed by this research. Ultimately, I was driven by the desire to proceed.

As a direct result of my participation in molecular biology research, I learned how to ask informed questions about the scientific method, objectivity, reductionism, and how to develop informed feminist critiques of science. I also began to articulate a new line of philosophical inquiry for myself into the nature of knowledge, the nature of biological matters, and the nature of being. I have always been drawn to the minor literatures of molecular biology. Years later, after having a chance to more carefully read the work of other feminists who also trained in the sciences (such as Haraway, Stengers, Barad, and Subramaniam), I am able to express my reasons for entering into the sciences in the first place. I feel more capable of expressing my earlier insights into the importance of learning from disparate practices, in terms that are more familiar or recognizable to my colleagues in the humanities and social sciences. I am better able to express the interdisciplinary impulse that I have had to bring feminism and molecular biology into conversation in less commonly explored ontological, epistemological, methodological, and ethical terms. I am now able to truly appreciate the value of learning *how to encounter* the varied materials and practices of a discipline that is not one's own, through the productive lens of "shared perplexities."[54]

Most important, my original hunch about the importance of learning to appreciate and respect the practices of disparate disciplines has led me to reframe how we might think about molecular biology and feminism together, how we may be able to work together to create new lines of flight to think about the world that we inhabit, and how we can produce knowledge about that world. This is why I am drawn to molecular projects, both in molecular biology research and feminist politics, that can present alternatives to dominant modes of thinking.

A Note about Methodology

Grasses, apparently, are notorious for crossing taxonomical boundaries but are generally recognized to grow in three ways: as cespitose grasses (grass that grows in bunches with straight roots), turf or sod grasses (grasses that grow by spreading their roots outward horizontally), and matgrasses (which fall somewhere between the other two grass formations). The roots of cespitose grass grow in clonal patterns, whereas all other grass species grow and extend their roots either as rhizomes or stolons. Like the rhizome, the stolon is not just a taxonomical classification but also a strategy for plant propagation. Both stolons and rhizomes form internodes from where new root systems can begin. Stolons, which are referred to as "runners" for their ability to move horizontally above ground, have the additional capacity of serving as "foraging organs for light."[55]

Stolons have the ability to extend runners in multiple directions and also the capacity to sense their surroundings. As an interdisciplinary project, *Molecular Feminisms* goes by the way of the stolon and the stoloniferous plant, creating runners along different directions, foraging in and out of properly defined disciplinary formations—all the while aiming to connect and contribute to the field of feminist STS. If extending toward and trying to touch shared objects of inquiry counts as a methodological strategy, this book does just that by attempting to extend runners between feminist theory, postcolonial and decolonial theory, posthumanist ethics, new materialisms, philosophy of science, and molecular biology. While there is a clear emphasis on the foraging strategies used by the stolon, the fact that stoloniferous plants also grow nodes with roots that go down into the ground is not ignored in this work.

To sketch the methodological approach that ties this book together, I want to briefly recall an exchange I had with a well-known sociologist and STS scholar soon after completing my PhD and starting my tenure-track position. During that encounter this very generous colleague cared to ask me about my work and was curious about how and why, with a PhD in molecular biology and neuroscience, I had ended up in a women's studies department. After briefly listening to me fumble my way around saying that I wanted to bring feminism and science together to generate new kinds of conversations, he quickly summed up my methodological

allegiances by saying, "Oh—so you're an ethnographer! You study scientists in the lab!" If being an ethnographer means observing and interpreting the actions of the people and culture around oneself, then yes, I am an ethnographer. But to be clear, this book in no way meets any standards of a proper ethnography. While I was training to become a scientist, and conducting my own experiments in a lab, I was not systematically taking notes on my colleagues around me or documenting how as scientists we come up with our hypotheses and conduct our scientific experiments.

Rather, I went deep into studying the practices of molecular biology, and through a slow and sometimes imperceptible process, perhaps much like watching grass grow, I became an expert in learning how to spot both the challenges and possible points of entry for creating interdisciplinary work and shared moments of perplexity. Having been trained in the biological sciences and having now spent a significant amount of time as a feminist STS scholar, I have come to the conclusion that the hardest task of interdisciplinary scholarship entails not only learning how to come to the table but also knowing how to assemble a table that will actually support joint conversations. This process takes time, and the results are not always immediate. A methodology of reaching out and making connections requires the slow and painstaking work of developing shared vocabularies and respect for distinct and sometimes quite disparate practices. It takes time to learn how to frame one's questions in a way that they can actually be heard from another disciplinary standpoint.

Another important point on the methodological framing: as mentioned previously, I write as a feminist scholar who conducted graduate training in the sciences after the science wars. As a result, this book has been deeply informed by debates between social constructivism and positivism and the intellectual fallout that transpired between poststructuralists and scientific realists. In the framing of *Molecular Feminisms*, science and feminism are treated as being co-constituted. This interdisciplinary text aims to bring together the work and methodologies of diverse groups of scholars to think about overlapping sets of questions regarding the nature of scientific inquiry, the nature of the relation between a knower and the known, and the nature of feminist political movements. Whether articulated in a similar way or not, both groups of stakeholders—molecular biologists who may not necessarily identify as being feminist and feminists who are not trained scientists—know that it matters how one

orients oneself toward an object of inquiry and that the practices of scientific observation carry with them the weight of great political impact.

By taking into account our orientations toward a blade of grass, it could be said that I am also trying to work "from below"—or in the case of using stolonic strategies, from along the surface of a flat plane or ground. Feminist philosopher Sandra Harding has taught us the importance of using feminist, postcolonial, and decolonial theories and practices to approach the "sciences from below."[56] What I am in search of, however, are ways to think about feminism and molecular biology through minor literatures and modes of molecular thinking, as Harding reminds us, by "keeping both eyes open."[57] In chapter 1, I develop biophilosophies of becoming, which is about learning how to start thinking not just from below but from "far far" below the usual human point of entry and view. It is about learning how to take ourselves down a notch or two, how to come to eye level with the stolon, and how to become like the blade of grass in order to make a more communicating world. The hope is to draw from disparate theories and practices that can become part of our everyday politics. These practices exist both inside and outside of the lab and can help us, as Claire Colebrook has stated, to "grasp all the inhuman perceptions and forces beyond the order of our point of view" that contribute to flourishing.[58]

I am also aware of Harding's methodological prompting of approaching the sciences from below in order to locate the Eurocentrism in our own work.[59] It is indeed the case that as a scientist trained in the global North, I have been exposed to those canons deeply embedded within male-dominated and Eurocentric knowledge traditions. In addition, my limited language skills block me from reading and writing about both science and feminism in any other language than English. I acknowledge these factors up front as methodological limitations of the work presented here. To address this point, I attempt to reach out toward a number of different thinkers, a great many of them from South Asia, to reflect on diverse accounts of the world around us and diverse accounts of how we can come to know this world. These accounts do not aim to displace modern scientific understandings or theories of origin and evolution of the universe. Rather, I draw from scientists and philosophers whose work has been marginalized within both the sciences and feminist theory to think more broadly about questions of ontology, epistemology, and ethics and how these may add to our theories of the universe and its inner workings. Just

as important as it is to recognize that I am a scientist trained in the global North, as a diasporic South Asian, born and raised in Canada, with Bengali immigrant parents who grew up during India's partition, it is important to recognize that there are also certain anticolonial and postcolonial logics that have been woven into my methodological approach. Much like the character and scientist Sneha in Subramaniam's essay "Snow Brown and the Seven Detergents," I know very well that ignoring, whitewashing, or cleansing these logics from my intellectual palette is impossible, not to mention undesirable.[60]

Many of the figures I draw from are purposely Bengali (including Baba Premananda Bharati, Rabindranath Tagore, and Jagadish Chandra Bose), presented as anticolonial figures, who as colonial subjects under British rule in India were actively trying to communicate alternative ontologies and ethical approaches to matter and the world around us through religion, literature, and science at the turn of the twentieth century.[61] As Ashis Nandy wrote in his biographies of the scientist J. C. Bose and the mathematician Srinivasa Ramanujan, both British colonial subjects in India at the turn of the twentieth century, "How much has science lost by its mechanistic and physicalistic concepts of the universe, how much by its denial of all alternatives to the scientific culture of the industrialized world? How much has the Newtonian idea of a world machine contributed to the ethical predicament of modern science, to its role in fostering human violence, and in violence towards the non-human environment?"[62]

My intention behind creating runners between these figures is not to develop a project in comparative science or comparative philosophy. Nor is it to create a divide between the "East" and "West" and draw from Eastern traditions in order to dismiss Western traditions (or vice versa), as if these traditions and cultures could even be divided and determined so simply. I certainly do not provide in-depth biographical accounts of these thinkers or spend a sufficient amount of time reflecting on their full philosophical contributions and anticolonial positions. That would be a different book. I turn to these anticolonial figures for the minor literatures they developed in their own ways, and use these literatures to reframe majoritarian thought found in both science and feminism. Lastly, this book does not intend to use molecular biology research and methods to dismiss feminist concerns or, alternatively, to use feminist theories and methodologies

to poke holes into molecular biology research. Rather, at the core of this inquiry is a deep curiosity that wants to see what is possible when two modes of thinking, simultaneously distinct yet in multiple ways co-constituted, are encouraged to interact reciprocally. What becomes possible when two modes of inquiry are allowed to move closer toward each other through unexplored processes of desire and produce new ways of thinking? *Molecular Feminisms*, like the stolon, is a strategy for *becoming-minoritarian*, *becoming-molecular*, and *becoming-imperceptible*.

Overview of Chapters

Chapter 1, "Biophilosophies of Becoming," establishes the theoretical framing of the book. It defines and deals with key questions of ontology, epistemology, and ethics that drive feminist, postcolonial, and decolonial STS interrogations of scientific knowledge production. The chapter asks us to reflect on how it is that we orient ourselves toward a diverse range of matters, starting with a blade of grass. It questions the nature of nature and what status we as humans have given to others, humans as well as nonhumans. It addresses a metaphysics and humanism that has influenced both our philosophical and scientific approaches to encountering the world around us and argues that in addition to spending our creative energies toward identification and classificatory practices (the values of which are not dismissed), we must also ask what matter, molecules, bodies, and organisms such as grass *are capable of doing*. This line of questioning opens us to the opportunity of developing *biophilosophies of becoming* that rethink matter in terms of flux, motion, and capabilities, and reframe biology in terms of events and processes. New ontological, epistemological, and ethical reorientations must also be contextualized and therefore I turn to postcolonial and decolonial STS approaches to consider the broader implications of knowledge-making practices. Building upon connections that can be made between feminist, postcolonial, and decolonial approaches, biophilosophies of becoming are more thoroughly articulated in terms of the qualities of (1) changefulness and nonhuman becomings, (2) kinship and hylozoism, and (3) univocity and immanence.

Chapter 2, "Microphysiologies of Desire," visits a long tradition of intimate ontological, epistemological, and ethical considerations made by

feminist scientists and feminist philosophers of science regarding the relationship between the knower and the known. It acknowledges generational feminist materialisms and revisits questions that are familiar to feminist scholars—namely, how we can continue with science after the critiques of science and how we can reconfigure the relationship between the scientific knower and the known. The chapter explores earlier interventions made by Barad, Patti Lather, Stengers, and Haraway. By bringing together the scientific work of Bose and recent scholarship in posthumanist ethics, I examine what the implications would be of shifting our ethical stance from a transcendent understanding of "responsibility" toward the other, to a more immanent awareness of the "ability to respond" to the other. I offer *microphysiologies of desire* as strategies that bring us closer to a biology that we desire. Inspired by Evelyn Fox Keller's work on the life and scientific research of Barbara McClintock, I playfully reconfigure McClintock's famous dictum "a feeling for the organism" to "feeling *around* for the organism" to lay out a more immanent rather than transcendent orientation that can be put into practice in the lab. The aim is to speak to those feminist scientists and those scientist feminists who, in the wake of recent material turns, are eagerly looking for ways to participate in the biological sciences and work with and beside molecular actants in the lab.

Chapter 3, "Bacterial Lives: Sex, Gender, and the Lust for Writing," outlines key arguments in relation to poststructuralism, feminist theory, and posthumanist ethics. Following the lives of bacteria and the creativity and labor of bacterial writing, the chapter explores what new politics become possible when we think with members of a domain that have been noted for their qualities of changefulness and nonhuman becomings. Thinking alongside biophilosophies of becoming in relation to bacteria, the chapter confronts three binaries that are commonly used by scientists and feminists—namely, sex/gender, biology/culture, and matter/language. Beginning with the rich body of work left behind by the biologist Lynn Margulis, I trace how our understanding of bacterial sex has created new feminist theories and treatments of sex. I take note of the confusion that often exists between the terms "sex" and "gender" in biological research. Using the materiality of bacterial writing, reading, and modeling, the chapter illustrates the importance of including analytical frameworks in our theory-making that have been informed by decades of scholarship in feminist, postcolonial, and decolonial STS. Emerging from political

movements that are invested in social justice, I argue that these frameworks not only allow us to posit new ontologies but also help us with the difficult task of putting these ontologies into practice.

Chapter 4, "Should Feminists Clone? And If So, How?," proposes a model for feminist inquiry from *within* the sciences. This model has the potential for broad use in the natural sciences but is most directly applicable to feminist scientists working in molecular biology labs. Michelle Murphy has suggested that women's health activists in the 1970s showed the "most sustained efforts to practice science as feminism."[63] Readers familiar with my earlier work will know that I also view my entry into and contributions to the sciences as expressions of my feminism. For this reason, and for the greater part of my feminist STS career, I have been committed to developing practices that are relevant to the feminist scientist in the natural sciences. After feminists learn the very important critiques of science, or learn to make astute ontological and ethical claims, they still need to directly engage with the sciences and the practices of scientific knowledge production. This can only take place when we spend time developing practice-oriented approaches in feminist STS and methodological interventions for the feminist scientist working in the lab.

Using the technology of subcloning, my goal in chapter 4 is to extend the scope of how we think about practicing science as feminism or feminism as science today. Theoretical interventions can emerge from both inside and outside of the lab, often as a direct result of the everyday nitty-gritty practices of both feminism and science. Formulating new feminist or molecular politics from a scientific protocol, a biological actant, or even a machine used in an experiment can be difficult. However, when we frame these efforts through biophilosophies of becoming, and through the qualities of hylozoism and kinship in particular, new modes of knowledge production become possible. The model of scientific inquiry proposed is based on a "mutated subcloning protocol," designed to acknowledge that a feminist scientist is accountable to multiple communities of knowers, which can lead to several tensions and dilemmas in their research. The model allows the researcher to take these dilemmas into account and move forward with a research agenda by formulating their questions in the lab in contexts that are most relevant to their own social justice commitments. The chapter details my own experience of conducting molecular biology research in a wet lab. Delving into my scientific research and discoveries

in molecular biology and reproductive neuroendocrinology, I reflect on the tensions of using recombinant DNA technologies to search for estrogen receptors in GnRH neurons and the experiments that brought me to some of my current ethical and ontological queries.

Chapter 5, "*In Vitro* Incubations," focuses on new developments in the field of synthetic biology and explores how synthetic lives such as minimal genome organisms force us to reconsider the boundaries of interdisciplinary thinking. Starting with my experience of working in a molecular biology lab, I highlight several questions that I only learned how to ask by working with and paying careful attention to an *in vitro* neuronal cell line. Two main challenges face feminist STS scholars today—namely, addressing the question of what constitutes life and the living in this age of synthetic biology, and figuring out how to respond to and deepen our human entanglements with these lives by paying attention to questions of context and social justice in this molecular era. Turning to the qualities of univocity and immanence, the chapter explores how biophilosophies of becoming can present a different set of tactics that can be used for reaching out toward and responding to synthetic lives.

Following Deleuze and Guattari's idea of the machinic assemblage, both molar and molecular approaches are employed to understand the monstrous couplings that bring together digital DNA, humans, DNA synthesizers, Petri dishes, bacteria, yeast, and more. Synthetic biology has created a machinic assemblage that moves through three phases or strata of a new kind of synthetic life cycle, including the inorganic, organic, and social. In the inorganic strata we see the important role that the central dogma in molecular biology has played as a far-reaching paradigm, giving material form to minimal genomes. Through the organic strata we see the beginnings of expressive life in minimal genome organisms whereby they learn to communicate with each other and their external world. The last stage of the life cycle is examined through the social or alloplastic stratum, where we see how our machinic assemblage modifies the external world. Using the tools of postcolonial and decolonial STS, and through a series of vignettes, I analyze how synthetic lives simultaneously are produced by and work to produce social institutions and behaviors that are undoubtedly human but are not limited to the human.