Professional Science Master's (PSM) in Biotechnology Program

Self-Study

September 6, 2021

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A. Mission

The Professional Science Master's (PSM) in Biotechnology program's Mission:

> *Our Mission is to provide motivated students with the knowledge and skills needed to successfully enter a career in the biotechnology industry.*

Aligned with the University Mission, which states that USF "*offers graduate and professional students the knowledge and skills needed to succeed as persons and professionals and the values and sensitivity necessary to be men and women for others,"* our program endeavors to give students skills and experiences to embark on and advance in quality, meaningful careers in the biotechnology industry. They will work to advance health care, alleviate disease, and build a sustainable world in such roles. Knowing the powerful potential of this technology, our PSM in Biotechnology program seeks to teach students to consider how biotechnology can be used ethically and to instill an appreciation of the importance of succeeding responsibly.

Program Learning Outcomes:

1. Review and evaluate concepts from multiple disciplines (biology, bioinformatics, business) within biotechnology.
2. Interpret and execute best practices in biotech-related lab techniques, as well as exhibit an ability to assess the novelty of the research and prioritize protocols.
3. Comprehend the need for ethics in science and technology-based business/research/industry.
4. Critically review scientific papers and demonstrate science communication skills necessary to attain professional level employment in science and technology-based research/industry.
5. Demonstrate effective teamwork, team leadership, business communication skills, and networking skills, including exposure to industry members in molecular biology and biotechnology-based business/research/industry.

B. History

The PSM in Biotechnology program was initiated by USF Biology professor Jennifer Dever in 2011. The program is based on the Professional Science Master's model – a relatively new terminal degree recognized nationally and designed to allow students to pursue advanced training in the field of science while simultaneously developing business skills highly valued by employers. PSM programs span many different STEM disciplines and subject areas, but all are required to have a majority STEM content and at least 20% professional

skills content. Additionally, all PSM programs have a capstone internship or project requirement and utilize an external advisory board primarily composed of industry professionals. They are often interdisciplinary in nature. Being located in San Francisco, USF is situated in a prime location to interact with the biotechnology industry in a direct manner. The PSM combines rigorous study in science with coursework that includes workforce skills such as project management, communication, and team-building required in the biotech industry. It does not require thesis writing; instead the program culminates in a capstone internship that provides real-world biotech industry experience. Students enrolled in the PSM in Biotechnology program take core classes in both biotech science-related curricula and biotech business-related curricula. The rationale behind the proposal of this program was to allow USF to serve as a pipeline for those students who do not wish to pursue a Ph.D., but still seek a career in the biotechnology industry.

Demand for students with both molecular and professional skills was indicated by evidence at the time. The Centers for Applied Competitive Technologies 2010 report noted biotechnology employment significantly outpaced California's overall economy and was only "slightly impacted by the [severe] economic recession." (http://web.archive.org/web/20120619131752/http://www.makingitincalifornia.com/documents/Biotechnology%20Industry%20Report_Final.pdf) The report predicted growth in the biotech sector of 10.5% in the next five years. The US Dept. of Labor Occupational Outlook Handbook in 2010 predicted much higher career opportunities in biotechnology than all other occupations (http://web.archive.org/web/20111224185608/http://www.bls.gov/oco/ocos047.htm).

As the birthplace of biotechnology and one of the global hubs of this industry, the San Francisco Bay Area was particularly expected to experience such growth, expanding opportunities for well-educated students. However, surveys of available biotech positions at the time indicated that many such positions required Master's degrees and/or 1+ year of job experience—excluding many undergraduates that had completed only a 4-year undergraduate degree with a Biology major. Moreover, limited opportunity for those with only a four-year biology degrees was thought to be in part responsible for the significant attrition from the USF Biology major. The large majority of USF students enter the Biology major with the intention of entering medical school. Without near perfect grades, within a year or two many students realize this is no longer a feasible option. With limited career options for Biology bachelor's degree graduates, often students decide to leave the major and/or the institution for degrees with more concrete job potential.

To create this new interdisciplinary program, two tenure-track faculty were invited by Dr. Jennifer Dever: Dr. Christina Tzagarakis-Foster a molecular-cell biologist and fellow Biology department colleague, and Dr. Moira Gunn in the School of Management. Dr. Gunn was directing the Business in Biotech program at the

time and teaching MBA courses. She had developed four MBA Biotechnology business courses which could immediately be utilized in the new PSM in Biotechnology program, including a Biotech Academic Global Immersion course where students visited international biohubs such as London and Switzerland. With contributions from faculty in USF's College of Arts and Sciences and the School of Management, the PSM in Biotechnology became the first multi-school degree to be approved by the University. Dr. Gunn is also host of the weekly show Tech Nation and its segments BioTech Nation and Tech Nation Health on NPR.

Program Director Dr. Jennifer Dever and Associate Director Dr. Christina Tzagarakis-Foster recruited the first cohort in early 2012 and the program officially launched with the first classes being taught in Fall 2012. At this time, six full-time and one part-time faculty members were teaching in the program. Of the full-time professors, five members were tenured/tenure track and one member was term faculty. (USF full-time faculty are divided into research professors who are tenured/tenure track and 'term' professors who teach exclusively—see the *Department Structure* section).

The full-time science faculty were the Program Director, Dr. Jennifer Dever (tenured), the Associate Director, Dr. Christina Tzagarakis-Foster (tenured), Dr. Patricia Francis-Lyon (tenure-track), and Dr. Cary Lai (term). Dr. Ulka Vijapurkar contributed as a part-time faculty member. Dr. Dever, Dr. Tzagarakis-Foster, Dr. Lai, and Dr. Vijapurkar were representatives of the Biology Department who established and taught the science courses. Dr. Francis-Lyon, then in the Computer Science Department, taught Bioinformatics. The full-time business faculty from the School of Management were Dr. Moira Gunn (tenure-track) and Dr. Kathy Kane (tenured). Dr. Gunn recruited a part-time faculty member, Nola Masterson, to teach one of the business courses as well.

In 2015, program success and growth allowed establishment of an additional term full-time faculty line. Dr. Brian Young (term) was recruited, replacing the part-time faculty member Dr. Vijapurkar. In that same year, Dr. Dever went on her year long sabbatical and Dr. Tzagarakis-Foster took over as interim Program Director with Dr. Cary Lai serving as interim Associate Director. Dr. Tzagarakis-Foster was also recruited to a five-year term as Associate Dean for the College of Arts & Sciences, overseeing both the Biology Department and PSM in Biotechnology program in this position. In 2016, after returning from sabbatical, Dr. Dever resumed her role as Program Director.

In 2017, the Biology Department recruited a new tenure-track professor with strong expertise in Bioinformatics, Dr. Naupaka Zimmerman. Dr. Zimmerman replaced Dr. Francis-Lyon as the instructor for Bioinformatics. In January 2018, Dr. Gunn (now tenured) switched from an appointment in the School of Management to the College of Arts and Sciences and began as Associate Director of the program. In August 2018, Dr. Dever left the Biotechnology

program to become Chair of the Biology Department. Dr. Cary Lai took on the role of Program Director of the PSM in Biotechnology program.

In 2018-2019, during his first year as Program Director, Dr. Cary Lai spearheaded an effort to extend the PSM in Biotechnology program to include a 4+1 expedited program for USF Biology undergraduates. Such students begin taking courses in the PSM in Biotechnology program in their 4th undergraduate year and are able to obtain their PSM in Biotechnology degree with only one additional year of graduate work. In addition to providing opportunities for USF undergraduate students, this program is expected to increase revenue by increasing retention and recruitment of USF Biology majors. USF's administration approved the 4+1 program in 2018 ; the first 4+1 students matriculated in Fall 2019.

In 2020, Dr. Moira Gunn became the program's first Director of Bioentrepreneurship. Dr. Tzagarakis-Foster served as the Program Director and Dr. Young served as the Associate Director during the 2020-2021 academic year. In the spring of 2021, the program hired its first staff member, Luwei Xie, who is serving as Program Manager for the PSM in Biotechnology program and the Energy Systems Management MS program (his time is split 50% with each). Dr. Cary Lai replaced Dr. Tzagarakis-Foster as Program Director in Fall 2021 while she is on sabbatical leave for this upcoming academic year and Dr. Young is continuing as Associate Director.

USF's PSM in Biotechnology program was first granted affiliation by the NPSMA's Commission on Affiliation of PSM Programs from 2013 through 2019. In 2019, USF's PSM in Biotechnology program applied for re-affiliation and was approved for affiliation by the NPSMA from 2019 through 2024.

The PSM in Biotechnology program is housed in the Biology Department at USF. Most of the faculty that are currently affiliated with the Biotechnology program are faculty in the Biology department. As such, each has service responsibilities to both the Biotechnology program and the Biology department. For example, Biology department faculty are required to participate in undergraduate advising, attending department faculty meetings, and serve on department committees. Many teach some combination of Biology undergraduate and Biotechnology graduate classes each year with some of the electives taken by PSM in Biotechnology graduate students cross-listed with undergraduate Biology classes.

USF's PSM in Biotechnology program has been able to provide biotechnology companies with well-trained and skilled workers and has provided students with a stepping-stone to meaningful careers that utilize their biology backgrounds. The strong placement rate of Biotechnology program graduates over the past eight years of USF's Biotechnology program has demonstrated the validity of these original predictions. In addition, the program has provided additional revenue for

a University facing budgetary pressure (USF administration has sought to expand graduate student enrollment in all Colleges as an important and growing source of university revenue).

In preparing for the PSM in Biotechnology program review, the faculty have identified the following as core issues and challenges that the program faces:

1. Increase enrollment in the program to 25+ students per year consistently
2. Improve marketing of program – particularly to biotech companies
3. Adding housing options for our students – including better on-campus and temporary student housing
4. Modification of internship course requirement
5. Maximizing contributions from and the utility of the Scientific Advisory Board
6. Increasing program alumni involvement and connection to current students
7. Integration of content across courses in program
8. Adding concentrations – diversification of specialization choices
9. Keeping curriculum updated with most cutting-edge research and technology

C. Curriculum

The PSM in Biotechnology program is a two-year, four-semester, 36 unit degree, graduate Master's degree program (Table 1). The program does not require the completion of a thesis. Instead, students complete a required capstone internship typically in the second semester of their final year. This internship experience gives students the valuable on-the-job training that helps to propel their careers in the biotechnology industry. To facilitate this, all class requirements can be completed in the evenings, allowing students to work full-time or near full-time while students at USF. Some students enter the program with biotechnology jobs and stay in those jobs after starting school. Most other students begin interning/working during their first year in the program or in the summer between their first and second year. The overall tuition cost of our full 2-year, 36 unit Master's degree program is $54,360 ($1,510 per unit). Students pay this tuition cost usually by some combination of student loans, family contributions, personal savings, paid internships while in school, company tuition reimbursement, and program or other scholarships.

The curriculum is interdisciplinary, emphasizing not just rigorous science but the practical understanding of bioentrepreneurship that is needed to bring innovations to market. Courses are put together in consultation with the PSM in Biotechnology Advisory Board, composed of industry experts with broad experience. The board helps communicate employer needs, including relevant technical and professional skills (for more details on the composition and role of

the Scientific Advisory Board – see *Departmental Structure* section). Each semester, courses receive student evaluation through the university's electronic evaluation system, and professors use this feedback to continually improve clarity and content.

Due to the limited number of faculty, no formal 'concentration' specialization is currently part of the program. Students can, however, fine-tune their degrees by taking specific electives, such as data science classes to complete the 8-unit Foundations in Data Science Certificate. As several of our students have ultimately focused on regulatory affairs, more regulatory content has been included in the bioentrepreneurship courses. If the program continues to grow with 30+ new students brought in each year, additional specialized concentrations and more elective choices may be possible.

Two degree pathways for this curriculum are available. The traditional two year PSM, offered to all of the graduates before spring 2021 is scheduled as shown in Table 1. Starting in 2019, as mentioned above, an additional degree pathway ("4+1") is available for USF Biology-major undergraduates. Scheduling of this option is shown in Table 2. More information on classes is provided below with courses grouped into either science or bioentrepreneurship categories.

Table 1: 2-year PSM in Biotechnology degree courses

Course Number and Title	Units
Fall 1st year courses	
BTEC 620: Molecular Biology (4)	4
BTEC 610: Global & US Regulatory Affairs (2)	2
BTEC 611: Legal-Social-Ethical Biotech (2)	2
BTEC 601: Career Preparation Seminar (1)	1
Spring 1st year courses	
BTEC 612: Local-National-Global Biotech (2)	2
BTEC 615: Bioinnovation Management (2)	2
BTEC 685/686 Molecular Genetics and Biotechnology (4)	4
Fall 2nd year courses	
BTEC 640: Bioinformatics (4)	4
BTEC 688/689: Advanced Research Methods (4)	4
Intersession or Summer	
BTEC 619: Bioentrepreneurship AGI (2)	2
Spring 2nd year courses	
BTEC 600: Graduate Seminar: Molecular Biology (1)	1
BTEC 697: Internship in Biotechnology (4)	4
Elective: for example Molecular Medicine or Disease, Physiology, and Immunology, or Master's in Data Science courses.	4

Total Required Course Units = 32; Total Elective Course Units = 4

Table 2: 4+1 PSM in Biotechnology degree courses

Note: The 4+1 students take the typical Biology major requirements during their first three years at USF. They apply for the 4+1 at the end of their third year and during their fourth year take the BTEC courses listed below along with their other Biology B.S. and core required courses. They take only PSM in Biotechnology program courses during their +1 year.

Course Number and Title	Units
Fall 4th year courses	
BTEC 620: Molecular Biology *	4
BTEC 601: Career Preparation Seminar	1
Spring 4th year courses	
BTEC 685/686 Molecular Genetics and Biotechnology *	4
BTEC 600: Graduate Seminar: Molecular Biology	1
Fall +1 year courses	
BTEC 610: Global & US Regulatory Affairs **	2
BTEC 611: Legal-Social-Ethical Biotech **	2
BTEC 688/689: Advanced Research Methods	4
BTEC 640: Bioinformatics**	4
Intersession +1 year course	
BTEC 619: Bioentrepreneurship AGI	2
Spring +1 year courses	
BTEC 612: Local-National-Global Biotech **	2
BTEC 615: Bioinnovation Management **	2
BTEC 697: Internship in Biotechnology	4
Elective: for example Molecular Medicine or Disease, Physiology, and Immunology, or Master's in Data Science courses.	4

* Courses that count for both the B.S. Biology and PSM Biotechnology degrees (8 units)
** Courses that can be taken during a student's 4th year instead if they have room in their schedule

Most Biotechnology students take classes three days a week, Monday to Wednesday most frequently, with classes beginning as early as 4:35 pm and ending as late as 10:30 pm, depending on the day and semester. For a detailed schedule, please see Appendix i: Course Schedule.

i. Science Courses

Required science core courses are Biotechnology Speaker Seminar (BTEC 600), Career Development Seminar (BTEC 601), Molecular Biology (BTEC 620),

Bioinformatics (BTEC 640), Molecular Genetics and Biotechnology (BTEC 685/686), Advanced Research Methods (BTEC 688/689), and the capstone course, Internship in Biotechnology (BTEC 697). Each is briefly described; after each course, the instructor(s) are indicated in parentheses. BTEC 600 is usually co-taught by two instructors. The remainder of the courses is taught by a single instructor each semester. The laboratory courses (BTEC 685/686 and BTEC 688/689) are broken up into two sections with two instructors when there are a sufficient number of students.

Biotechnology Seminar (BTEC 600) exposes students to a wide array of groundbreaking research and the variety of job specializations in Bay Area biotechnology by bringing in speakers from across the industry who give seminars on their work and research. *(Dr. Gunn, Dr. Lai, Dr. Tzagarakis-Foster, Dr. Young)*

Career Development Seminar (BTEC 601) teaches fundamentals of career planning, job hunting, resume writing, and interviewing. Emphasis is placed on the value of networking. Many class activities are hands-on, such as participating in mock interview sessions. The course provides students with skills to obtain internships early, aiming to give students opportunities to perform multiple internships during the course of the degree. *(Dr. Young)*

Molecular Biology (BTEC 620) grounds students in the fundamentals of biology and biotechnology. It is designed to assure that all students have appropriately advanced understanding of genetic flow and biotechnological techniques. This course is taught in a partially 'flipped' format, with much of the lecture material delivered as recorded online videos. Class time is used instead for group problem solving projects and the presentation and discussion of primary scientific articles. Over 15 primary research articles are presented and analyzed in detail each semester. *(Dr. Lai)*

Bioinformatics (BTEC 640) teaches students to learn to understand, analyze and conceptualize the immense data sets generated in modern biotech in the age of "omics" technologies and high-throughput robotics. Student learn to navigate command line interfaces (UNIX) and program in the R language to complete projects involving next-generation-sequencing (NGS), including bacterial community and RNA-seq datasets. Ultimately, students design and complete a project they devise themselves. *(Dr. Zimmerman)*

Molecular Genetics and Biotechnology (BTEC 685/686) is the foundational laboratory course. Students use CRISPR to knockout a p53-tumor suppressor related gene in human tissue culture cells and analyze the effect of the knockout on cells' ability to perform apoptosis. The course ensures all students obtain a strong laboratory grounding (pipetting, safety, calculation and basic experimental design) by working through common recombinant DNA techniques, mammalian transfection and cell tissue culture, gel electrophoresis and western blotting.

Moreover, it introduces the more advanced biotechnological techniques such as qPCR, flow cytometry, and confocal microscopy. Using the cutting edge technology of CRISPR as the context for this training helps engage student excitement and bolsters student resumes. Students present their findings in group meetings during the semester. *(Dr. Lai, Dr. Young)*

In ***Advanced Research Methods (BTEC 688/689)***, students undertake a semester-long research project either of their own devising or one in collaboration with a company/academic lab outside of USF. Students write a grant-like research proposal and write a publication-like final paper at the end of the semester. In a sense, this course is structured like a micro-Ph.D.—giving students a chance to plan their own time, design and troubleshoot experiments. This gives them the opportunity to practice in a relatively low stakes environment the skills they'll eventually need to progress as they advance in their careers. Each student presents in multiple group research meetings and journal club meetings to improve their oral presentation skills. Over 10 companies or institutions outside of USF have participated in collaborative projects as a part of this class. One great benefit of this is that many students who work with a company as a part of a class project have received internship/job offers at the end of the semester. *(Dr. Lai, Dr. Young)*

In the ***Internship in Biotechnology (BTEC 697)*** course, students work at least 320 hours at a biotechnology/pharmaceutical company or research institute. Students produce written progress reports and oral presentations, including an end-of-semester internship presentation event which is attended by many biotech scientists and professionals from outside of USF. As the capstone class of the Biotechnology program, students usually take this course during their final spring semester in the program and the students use the biotech knowledge and skills that they have acquired from other courses of the curriculum. *(Dr. Lai)*

In addition to these required courses, one 4-unit elective class is required. Most students take one of two electives offered in the evening: ***Molecular Medicine (BIOL 605)*** or Disease, Physiology and Immunology (BTEC 623). Molecular Medicine (BIOL 605) covers drug discovery, drug development, and pharmacogenomics. Subjects emphasized include drug screening and optimization, drug targets, basic immunology including antibody structure/function, clinical trials, pharmacokinetics, and genome wide association screening with associated methods (SNP microarrays, NGS, RNA-seq). Course pedagogy is active learning based with case studies, flipped classrooms, and frequent class discussion. *(Dr. Young)*

Disease, Physiology and Immunology (BTEC 623) is physiology for biotechnology researchers – exploring normal human functioning to better understand the disease states biotechnologists seek to treat/cure. Cancer and infectious diseases are generally quite comprehensible to molecularly trained biotechnologists. This class seeks to help students understand more complex

diseases that require an appreciation of the function and interplay of tissues, organs and organ systems (e.g. diabetes). Emphasis is placed on the cardiovascular system and, because of its importance to biotech, immunology. Active learning pedagogy is incorporated in the course. *(Dr. Young)*

Less commonly, due to the constraints of working full-time, students satisfy their elective requirement by taking daytime offerings of the biology department including: Biology of Cancer, Immunology, Molecular Endocrinology, Animal Toxicology, Histology. The College of Arts & Sciences administration has been working to make it easier for graduate students to take courses in other programs for elective credit. In this past year, many of our students have opted to take Data Science courses as their electives, allowing them to complete the newly created 8-unit Foundations in Data Science certificate at the same time.

ii. Bioentrepreneurship Courses

The bioentrepreneurship curriculum has evolved over the program's history from MBA biobusiness classes taught in the School of Management to the current bioentrepreneurship courses taught in the College of Arts and Sciences, described below. In January 2018, Professor Gunn transitioned to the College of Arts and Sciences from the School of Management. At this point, a new regulatory course, Global and US Regulatory Affairs, was developed, to replace the previous Information of Biotech course, and a new Bioinnovation Management course was developed to replace the Business Teams and Small Group Dynamics course. With this transition, the PSM in Biotechnology program is no longer a multi-school program with all required courses being now taught in the College of Arts & Sciences with a BTEC designation.

Global & US Regulatory Affairs (BTEC 610) incorporates the study of U.S. and global regulatory requirements in the biopharmaceutical and biomedical device sectors. The primary focus is on pre-clinical development through Phase IV clinical trials and FDA filing/approval, identifying comparable actions in the EU/Japan, and other significant global markets. *(Dr. Gunn)*

Legal-Social-Ethical Biotech (BTEC 611) studies the ethical, social and legal impact of biotech, both in the US and globally. Includes HIPAA, GINA, the developed vs. developing world, Supreme Court decisions, national/global intellectual property, the orientation of organized religions, and the potential impact of synthetic biology. *(Dr. Gunn)*

Local-National-Global Biotech (BTEC 612) covers the global biotechnology industry, the US biotech landscape, and the impact of the San Francisco Bay Area – the largest biocluster – both nationally and globally. Focuses on the nature of biobusiness and significant bioclusters, while featuring lectures from local biotech professionals. *(Dr. Gunn)*

In ***Bioinnovation Management (BTEC 615)*** students develop skills in managing bioentrepreneurship projects in the bioscience and biomedical device fields. Students learn how to be responsive team members as well as communicative team leaders, setting weekly meeting agendas, conducting meetings, filing reports, dealing with nonperformance issues, and solving team puzzles. Also covered is sustaining innovation in organizations and team dynamics. *(Dr. Gunn)*

Bioentrepreneurship AGI (BTEC 619) is a one week academic global immersion course to a global biocluster. Students visit selected biotechnology-related corporations and organizations, meet key industry professionals, relate the biocluster to the global biotechnology industry and complete bioentrepreneurship research projects. The week-long trip is usually held during intersession (January) or at the start of summer (May). Previous destinations include Switzerland, England, Australia, Puerto Rico, San Diego, and Washington D.C.. Planned destinations for the upcoming AGI's include Ireland/Northern Ireland, Washington, DC and Switzerland. *(Dr. Gunn)*

Biotech's Response to the COVID-19 Pandemic (BIOL [BTEC] 680) was created to substitute for the required Bioentrepreneurship AGI course, required by all PSM students. In two successive sections in Spring, 2021, the course tracked the response of the global Biotechnology Industry to the COVID-19 Pandemic. This includes tracing the timeline of the pandemic, marking the first time that biotech could begin to address the Co-Vi-2 coronavirus, while focusing on testing, treatments and vaccine development, and reporting in with weekly updates. Students selected non-US countries and regions to individually investigate throughout the course, building a collective global picture of infection spread and technology development and dispersal. This course is being re-designed for offer in Spring, 2022 with the continued need for an AGI substitute. Needed changes to the course will focus on the now more-formalized corporate involvement in similar aspects of addressing the COVID-19 pandemic with additional efforts to bring in speakers from the field and reconsideration of textbooks and other materials. *(Dr. Gunn)*

An important feature of our program is our small class sizes. The large majority of students in each of our core classes are Biotechnology students, with a small number of students from other programs (like MS in Biology, MS in Information Systems, MS in Data Science) as possible additions. Typically our class enrollment numbers are:

1. science lecture classes: 15-20 students
2. science laboratory classes: 12-16 students
3. bioentrepreneurship classes: 15-20 students

We believe that maintaining small class sizes is essential to our program – this way students receive a lot of individual attention and personalized teaching. This is important particularly because our students come from different backgrounds

in terms of prior education and research backgrounds. This is also one of the key marketing features of our program that is attractive to potential students.

iii. Enrollment

There have been between 11 and 27 new students per year who have enrolled in the program. No transfer course credit is accepted in the program, even in the case of students who have earned a separate Master's degree. A few students that have previously taken an upper division Molecular Biology class and received a B or above, are allowed to waive the Molecular Biology core course. In such situations, students are required to take an additional 4 credit elective in its place. More details regarding the program's admissions process are included in Section G: Students below.

iv. Recruitment

The PSM in Biotechnology program takes advantage of a critical opportunity for the University of San Francisco: optimal proximity to the rapidly expanding biotechnology industry in the Mission Bay district of San Francisco and the very cradle of biotech, South San Francisco (still home of the first biotech company, Genentech).

There are Bay Area-based competitor Master's in Biotechnology programs like San Jose State University and San Francisco State University, but each approach the industry differently. San Jose State is more involved in South Bay Biotech—Palo Alto, Fremont, etc. San Francisco State has focused particularly, though not exclusively, on stem cell biology, one specific facet of biotechnology. Moreover, in recent years San Francisco State has emphasized small cohorts of less than 10 students per year. Northeastern University recently launched Biotechnology Master's programs at their San Francisco satellite campus.

Many other excellent Biotechnology Master's degree programs exist nationwide – at Johns Hopkins, Georgetown, Texas A&M, and the Keck Graduate Institute for example. The curriculum and tuition costs of these other programs are fairly similar to our program at USF. One major advantage that we have over these competitor programs is our location in the San Francisco Bay Area. The number of possible biotechnology companies that students can intern at while taking classes in our program dwarfs the number of biotechnology companies in almost every other part of the country except for the other two U.S. biotechnology hubs, Boston and San Diego.

Students are recruited to apply to the program by a variety of means. USF's Graduate Admissions has taken the lead in paid digital advertising including search engine (Google and Bing) keyword advertising, LinkedIn InMail campaigns, etc. Faculty have supported this effort by designing a "Drip" email campaign to prompt potential students that have expressed program interest.

Faculty also maintain the social media presence of the program (including Facebook, Instagram, Twitter, LinkedIn) and the program website. Graduate Admissions sends postcards to biology GRE test-takers and sends representatives to graduate and career fairs across California. Faculty perform recruiting site visits to regional colleges and companies, including UC Berkeley, California State East Bay, City College of San Francisco, and Genentech. They also create advertising brochures and posters and maintain a newsletter published each semester. Traditionally, the Program Director has led these marketing efforts. Many of responsibilities have recently been taken over by our newly hired Program Manager.

To increase visibility and increase enrollment yield, faculty stage community biotech events on campus, e.g. our panel discussion, “How to Get a Job in Biotech”, and “Biotech HR: Questions and Answers”. More informal social networking events are regularly staged (~3 per semester) by the faculty in San Francisco biotech hub neighborhoods, including Mission Bay and South San Francisco. Alumni, board members, and their network are invited to increase industry awareness of the program. One particular selling point of our program at USF for marketing purposes is the Bioentrepreneurship AGI course – few other Biotechnology programs have similar international trips to tour international bioclusters.

v. Advising

Student advising and informal career counseling in the program has recently been split between Dr. Lai, Dr. Tzagarakis-Foster and Dr. Young with each faculty member advising between ~10-20 students (combined 1st and 2nd year cohorts). These faculty additionally advise another 25-35 biology undergraduates. Faculty usually send out an advising letter to each student recommending classes for next semester. Students are encouraged to schedule one-on-one advising meetings once a semester, prior to registration.

Program policies and regulations are communicated to all students during a mandatory orientation event in August or January. During the August orientation event, we also arrange a visit to a local biotechnology company. Our Biotechnology students can participate in USF graduate associations like the Graduate Student Senate. Some of our current and former students present at and participate in our PSM Advisory Board meetings.

vi. Retention

The current graduation rate of students in our Biotechnology program is close to 90%. Of the 153 students in the first five cohorts of the program, 16 left the program for various reasons:

- 8 left for academic reasons (academically disqualified)

- 4 left because they found a job and decided not to continue in the program
- 4 left for personal/family reasons (usually needing to relocate out of the area)

Our graduation rate has exceeded the institutional graduation rate of 77%. We consider the number of students that left the program for academic reasons to be reasonable as we want to maintain high academic rigor. It would be optimal to minimize the number of students who get a job and choose to quit the program, but the rate at which this has been occurring (4 out of 153 students) is relatively low.

vii. Job placement

Arguably, the paramount measure of the success of the PSM in Biotechnology program is how many graduates obtain full-time employment in the biotechnology field. Strikingly, virtually all graduates of the program have done so. This number has been estimated yearly by informal correspondence with students during the months following graduation. A recent survey of all graduates of the program confirmed this (see Figure 1). It showed that 95.2% of program graduates (2012-2020) were employed full time in the field or pursuing Ph.D. studies related to biotechnology. This number was fairly consistent across cohorts.

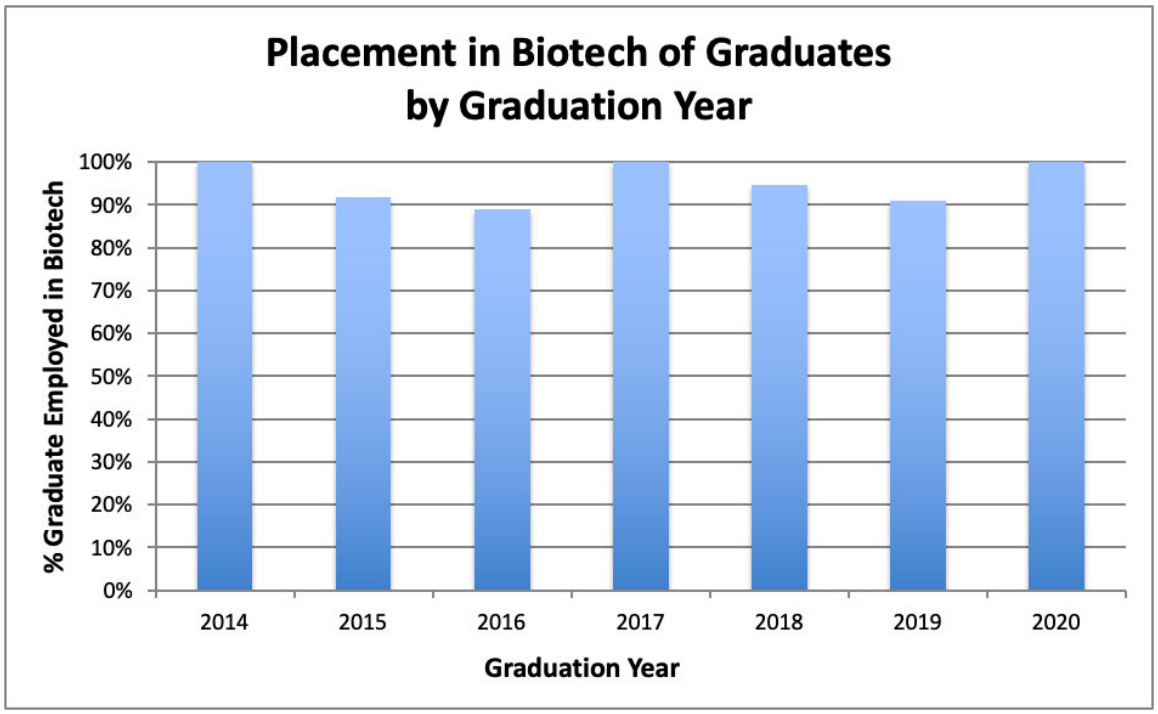


Figure 1. The percentage of graduates of each cohort employed in biotechnology or pursuing a Ph.D. in the biotechnology-related field was determined by survey of LinkedIn profiles. Of 153 program graduates, 3 students have pursued Ph.D. studies in a biotechnology related field.

An email survey performed in Spring 2018 indicated that graduates' jobs are also high quality, with strong salaries indicative of robust careers (see Figure 2), with

most students making between $70,000 and $100,000 a year between 0 and 4 years after graduation.

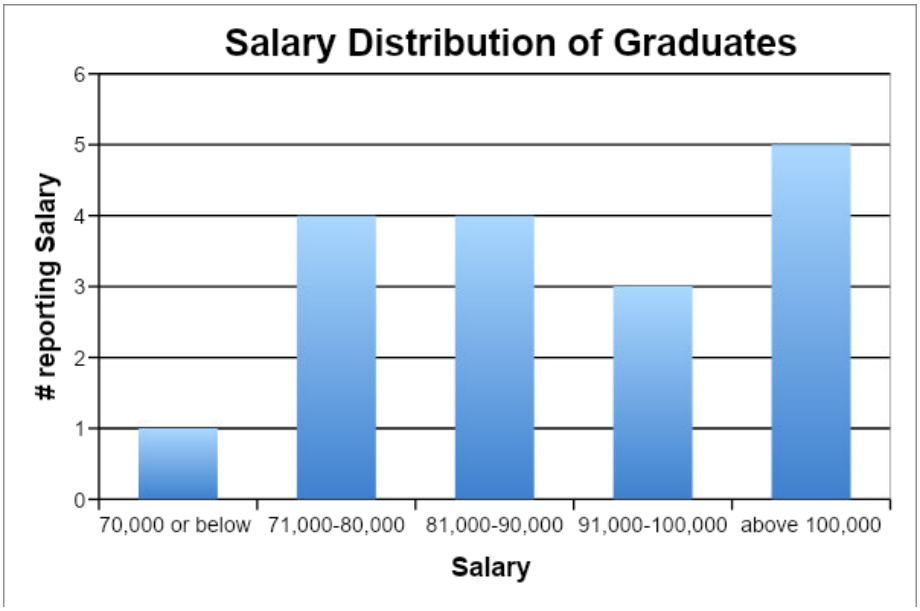


Figure 2: Salary Distribution of PSM in Biotechnology graduates. Salaries were determined by emailing all program graduates at time of survey (Spring 2018). 17 of 78 graduates responded with their current salary.

Moreover, PSM students have achieved significant success in the biotech community, with students being profiled in local and national media. (Mercury News-https://www.mercurynews.com/2018/12/24/flu-season-bay-area-scientists-working-toward-post-influenza-world/. Outside Magazine https://www.outsideonline.com/2395803/snakebite-antivenom-tim-friede.) Several of our graduates working at Distributed Bio appeared in the Netflix docuseries 'Pandemic', including Sarah Ives who was heavily featured (https://www.netflix.com/mx-en/title/81026143).

viii. Overall Academic Quality

The bioentrepreneurship courses in the PSM in Biotechnology program are unique to USF. Created and developed by Professor Gunn, they reflect the global biotechnology industry, and are pedagogically based on the peer-reviewed BIEM Model (Bioenterprise Innovation Expertise Model). These have been identified through Professor Gunn's research as the twelve driving disciplines required to drive cutting-edge science from the lab bench to a registered product. Further, they are annually updated with relevant biotech interviews with CEO's and CSO's in the biotech field as result of the new 40-45 new BioTech Nation NPR interviews each year conducted by Dr. Gunn. Student effort is based on the peer-reviewed educational pedagogy of "engaged analysis", also developed by

Dr. Gunn, and develops a sense of overall perception of the essentials of the bioenterprise.

The faculty continually strives for improvement, and the curriculum currently supports strong outcomes. The program is well designed with evening classes, career development priming, strong science and bioentrepreneurship training, feeding the ability of students to obtain internships and ultimately good careers.

D. Assessment of Student Learning

i. Program Learning Outcomes

Updated last in May 2019:

1. Review and evaluate concepts from multiple disciplines (biology, bioinformatics, business) within biotechnology.
2. Interpret and execute best practices in biotech-related lab techniques as well as exhibit an ability to assess the novelty of research and prioritize protocols.
3. Comprehend the need for ethics in science and technology-based business/research/industry.
4. Critically review scientific papers and demonstrate science communication skills necessary to attain professional-level employment in science and technology based research/industry.
5. Demonstrate effective teamwork, team leadership, business communication skills, and networking skills, including exposure to industry members in molecular biology and biotechnology based business/research/industry.

ii. Institutional Learning Outcomes vs. Program Learning Outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5
Institutional Learning Outcomes X Program Learning Outcomes	1. Review and evaluate concepts from multiple disciplines (biology, bioinformatics, business) within biotechnology.	2. Interpret and execute best practices in biotech-related lab techniques as well as exhibit an ability to assess the novelty of research and prioritize protocols.	3. Comprehend the need for ethics in science and technology based business/research/industry.	4. Critically review scientific papers and demonstrate science communication skills necessary to attain professional level employment in science and technology based research/industry.	5. Demonstrate effective teamwork, team leadership, business communication skills, and networking skills, including exposure to industry members in molecular biology and biotechnology based business/research/industry.
Institutional Learning Outcomes					
1. Students reflect on and analyze their attitudes, beliefs, values, and assumptions about diverse communities and cultures and contribute to the common good.			X		
2. Students explain and apply disciplinary concepts, practices, and ethics of their chosen academic discipline in diverse communities.	X		X	X	
3. Students construct, interpret, analyze, and evaluate information and ideas derived from a multitude of sources.	X			X	X
4. Students communicate effectively in written and oral forms to interact within their personal and professional communities.				X	X
5. Students use technology to access and communicate information in their personal and professional lives.		X			
6. Students use multiple methods of inquiry and research processes to answer questions and solve problems.	X	X			
7. Students describe, analyze, and evaluate global interconnectedness in social, economic, environmental and political systems that shape diverse groups within the San Francisco Bay Area and the world.			X		X

iii. Curricular Map – Courses vs. Program Learning Outcomes:

	PLO1	PLO2	PLO3	PLO4	PLO5
Biotechnology course Curricular Map 2018-19	1. Review and evaluate concepts from multiple disciplines (biology, bioinformatics, business) within biotechnology.	2. Interpret and execute best practices in biotech-related lab techniques as well as exhibit an ability to assess the novelty of research and prioritize protocols.	3. Comprehend the need for ethics in science and technology based business/research/industry.	4. Critically review scientific papers and demonstrate science communication skills necessary to attain professional level employment in science and technology based research/industry.	5. Demonstrate effective teamwork, team leadership, business communication skills, and networking skills, including exposure to industry members in molecular biology and biotechnology based business/research/industry.
KEY: I = Introductory; D = Developing; M = Mastery					
Courses or Program Requirement					
BTEC601: Career Preparation Seminar - seminar, 1 unit				I	I
BTEC610: Global and U.S. Regulatory Affairs - lecture, 2 units			D	D	D
BTEC611: Legal-Social-Ethical Biotech - lecture, 2 units			M	D	D
BTEC620: Molecular Biology - lecture, 4 units	I		I	I	
BTEC612: Local, National, Global Biotech - lecture, 2 units				D	I
BTEC615: Bioinnovation Management - lecture, 2 units				D	M
BTEC619: Bioentrepreneurship AGI - fieldwork, 2 units				D	M
BTEC685/686: Molecular Genetics and Biotechnology - lab, 4 units	D	I		D	
BTEC688/689: Advanced Research Methods - lab, 4 units		M		D	
BTEC640: Bioinformatics - lecture, 4 units	D	D			
BTEC600: Molecular Biology seminar - seminar, 1 unit				D	D
BTEC697: Internship in Biotechnology - fieldwork, 4 units		M		M	M
BTEC elective: lecture, 4 units	M			D	

The program learning outcomes that are applicable to each course are included in each course's syllabus.

iv. Annual Assessment Reports

Annual assessment reports from the 2016-2017 academic year and earlier had several areas of each report that were deemed as needing improvement or incomplete. These included:

a. Unorthodox and incomplete curricular maps
b. Rubrics used for direct assessment that needed more details and information
c. Failure to include data from the direct assessment of student assignments
d. Missing closing the loop analysis

Shown below is the summary produced by our USF Office of Assessment & Accreditation for our 2016-2017 assessment report:

> Summary
> *It is clear from this report that the PSM in Biotechnology has made efforts to start a rudimentary assessment process. There are significant flaws in the current assessment report that the college asks the program to address as it considers further assessment activities. The program should be sure to utilize the help of their Faculty Director for Curricular Development as they consider how to construct their curricular map and more effectively assess their program. The college and I look forward to your continued assessment and use of assessment results to improve student learning within your program.*

Starting in the 2017-2018 academic year, we implemented significant changes in the process that we use to assess student learning. In particular, we began performing direct assessment of student assignments in order to determine student achievement of our program learning outcomes.

For 2017-2018, we chose to assess PLO4 (Critically review scientific papers and demonstrate communication skills appropriate for professional level employment in science and technology based business/research/industry). We chose to assess student work from three different required classes in our program:

- BTEC 601: Career Preparation Seminar – job application cover letter assignment
- BTEC 688/689: Advanced Research Methods – journal club paper assignment
- BIOL 680: Bioentrepreneurship AGI – speaker presentation analysis written report

For each class, a Biotechnology faculty member (who did not teach the class) rated between 11 and 16 student assignments using one of the two rubrics below:

Criteria	Ratings			
	Weak (1-4)	**Satisfactory (5-6)**	**Good (7-8)**	**Excellent (9-10)**
Demonstrated ability to critically review scientific papers	Unable to distinguish between review article and primary scientific literature. Presentation disorganized or lacking important information. Missing or incomplete connection to other scientific articles. Poor understanding or interpretation of data from article.	Primary scientific literature paper chosen. Presentation organized but lacking key information in areas. Makes some connection to other scientific articles. Satisfactory understanding and interpretation of data from article is demonstrated.	Primary scientific literature paper chosen. Presentation organized but lacking but missing minor pieces of information. Makes some connection to other scientific articles. Complete understanding and interpretation of data from article is demonstrated.	Primary scientific literature paper chosen. Presentation well organized throughout. Makes many connections to other scientific articles. Complete understanding and interpretation of data from article is demonstrated.

Criteria	Ratings			
	Weak (1-4)	**Satisfactory (5-6)**	**Good (7-8)**	**Excellent (9-10)**
Demonstrate communication skills appropriate for professional level employment	Unprofessional demonstration of business communication skills. Disorganized presentation. Ineffective arguments made. Multiple grammar and spelling errors found.	Professional business communication skills demonstrated, but with areas of improvement. Presentation organized but with some rearrangement suggested. Arguments made effectively. Three or less grammar and spelling errors found.	Professional business communication skills demonstrated – meeting expectations of working business professionals. Presentation organized but with some rearrangement suggested. Strong arguments made. No grammar and spelling errors found.	Professional business communication skills demonstrated to the highest degree – as would be done by experienced working professionals. Presentation organized with strong arguments made throughout. No grammar and spelling errors found.

Ratings for the student work were high for each of the three assignments, ranging from 7.5 to 8.1 (out of 10), demonstrating successful achievement of PLO4.

It was challenging to do our assessment on PLO4 because so many classes in our program (12 of the 13) fulfilled PLO4 to some degree. PLO4 covered both science-based classes (ability to critically review scientific papers) and bioentrepreneurship classes (demonstration of professional communication skills). We decided that spitting PLO4 into two separate PLOs, one covering science-based classes (new PLO4) and one covering bioentrepreneurship classes (new PLO5) made sense:

- PLO4. Critically review scientific papers and demonstrate science communication skills necessary to attain professional level employment in science and technology based research/industry.

- PLO5. Demonstrate effective teamwork, team leadership, business communication skills, and networking skills, including exposure to industry

members in molecular biology and biotechnology based business/research/industry.

We submitted this update to the program PLOs to our curriculum committee in the spring of 2019 and they were officially approved and put into place in May 2019. Our USF Office of Assessment & Accreditation appreciated the improvements that we made to our assessment process, sent us a positive evaluation. The summary statement of the evaluation is included below:

Summary

It is clear from this report that PSM in Biotechnology has a clear and on-going assessment process that is established within its degree program. The program has considered previous suggestions from annual reports and taken action to respond to those comments. Well Done! Finally, the college acknowledges that your action plan to address results of your assessment is one of the best in the college.

For the 2018-2019 academic year, we assessed another of our Program Learning Outcomes, PLO2:

- PLO2: Interpret and execute best practices in biotech-related lab techniques as well as exhibit an ability to assess the novelty of research and prioritize protocols.

We again collected student work from three different biotechnology laboratory classes (BTEC640, BTEC685/686, an BTEC688/689) and rate the student achievement of PLO2 using the following rubric:

Criteria	**Ratings**			
	Weak (1-4)	**Satisfactory (5-6)**	**Good (7-8)**	**Excellent (9-10)**
PLO2: Interpret and execute best practices in biotech-related lab techniques as well as exhibit an ability to assess the novelty of research and prioritize protocols	Student unable to accurately or reproducibly perform biotech-related lab techniques. Struggles with the ability to assess the novelty of research and/or the prioritization of protocols.	Student demonstrates the ability to perform biotech-related lab techniques competently, but with minor accuracy or reproducibility errors. Able to assess the novelty of research and can prioritize protocols.	Student demonstrates the ability to perform biotech-related lab techniques competently and accurately. Able to assess the novelty of research and can prioritize protocols.	Student demonstrates expertise in performing biotech-related lab techniques and fluency with assessing novelty of research and prioritizing protocols.

Our Office of Assessment & Accreditation again gave us a positive review of this assessment in Spring 2020.

Summary

It is clear from this report that PSM in Biotechnology has a clear and on-going assessment process that is established within its degree program. We do

encourage you to consider modifying your curricular map to index student learning rather than just mark its presence in program courses.

The college and I look forward to your continued assessment and use of assessment results to improve student learning within your program.

Our assessment process for this most recent year changed as it was requested that we summarize the approaches to distance learning that our program implemented in the Spring 2020 semester after the COVID-19 pandemic hit. We provided a summary of the ways that distance learning was implemented and the pros and cons of distance learning in this most recent assessment report.

E. Faculty

Five full-time faculty members currently teach in the PSM in Biotechnology program. Associate Professor Cary Lai and Assistant Professor Brian Young teach science courses and are term professors. Tenure-Track Assistant Professor Naupaka Zimmerman teaches Bioinformatics. In the Bioentrepreneurship area, tenured Associate Professor Moira Gunn oversees all the bioentrepreneurship courses, in addition to teaching bioentrepreneurship courses. In addition to serving as Program Director or Associate Director, tenured Professor Tzagarakis-Foster teaches some seminar classes.

Of the five full-time faculty, 40% are tenured, 20% are tenure-track, and 40% are term. Other full-time faculty breakdowns include 80% Caucasian/20% Asian, and 60% Male/40% Female.

During a typical academic year, the teaching is as follows (number of credits for each class in parentheses):

- Dr. Young: BTEC 600(1), BTEC 601(1), BIOL 405/605 (4), BTEC 623(4), BTEC 685/686(4), BTEC 688/689(4): *50% of BTEC courses*
- Dr. Lai: BTEC 620(4), BTEC 685/686(4), BTEC 688/689(4), BTEC 697(4): *44% of BTEC courses*
- Dr. Gunn: BTEC 610(2), BTEC 611(2), BTEC 612(2), BTEC 615(2), BTEC 619(2): *28% of BTEC courses*
- Dr. Zimmerman: BTEC 640(4): *11% of BTEC courses*
- Dr. Tzagarakis-Foster: BTEC 601(1): *3% of BTEC courses*

The science faculty – Dr. Lai, Dr. Tzagarakis-Foster, Dr. Young and Dr. Zimmerman – each has more than a dozen years of experience in research science. They have authored numerous peer-reviewed scientific publications (10, 10, 7, 14, respectively), including papers in some of the most highly regarded journals (*PNAS*, *Genes and Development*, *Cell*, and *Science*). Both Dr. Lai and Dr. Young have several years of experience as drug development researchers in biotechnology: Dr. Lai at Genentech; Dr. Young at Sutro Biopharma. Dr. Lai,

additionally, has experience as Head of Commercial Operations at LakePharma, a Biotech Contract Research Organization. Dr. Zimmerman has authored software packages, provided instruction and leadership in the community based software project, carpentries.com, and taught computational workshops and intensives at UCSF, Stanford, UW Madison, Arizona State University, the University of Texas at Arlington and UC Davis.

The bioentrepreneurship faculty is led by tenured Associate Professor Moira Gunn, a former NASA computer scientist and entrepreneur, perhaps best known as the producer and host of public radio's Tech Nation and its regular segment, BioTech Nation. Each year, she interviews 40-45 biotech CEO's and CSO's, which is aired on the NPR Channel on SiriusXM, among other venues. Through over 750 biotech interviews, she has infused the development and experience of the global biotech industry into USF's bioentrepreneurship courses. Her book "Welcome to BioTech Nation … My Unexpected Odyssey into the Land of Small Molecules, Lean Genes, and Big Ideas" was named to the Best Book List of the Library Journal. In total, she has interviewed over 3,000 people in the area of innovation, and her global journalist connections are valuable in scheduling USF's unparalleled biotech AGI's. Besides designing, developing teaching the bioentrepreneurship courses, she has also participated in the development of the website, the brochure, the reviewing of applicants, and other recruitment activities. Her bioentrepreneurship research covers the biotech media sector as well as STEM attitudes in both science and non-science students. Dr. Gunn received an Honorary Doctorate in Science from Purdue University, and was awarded the National Science Medal for Distinguished Service by an Individual by the National Science Board/National Science Foundation for "far-reaching contributions to the public understanding of science and engineering in the United States".

Science teaching assignment decisions are made by the Program Director and Associate Director with the feedback and input of the Biotechnology faculty as a whole. Bioentrepreneurship teaching assignments are made by Professor Gunn in consultation with the Associate Dean for Sciences and the Program Director. For the most part, faculty schedules are similar to those envisioned in the original program design. The number and breadth of courses professors teach, including courses for other University divisions (see below), can be challenging. However, faculty know course assignments are equitable given existing resources. Extensive freedom is given to faculty in developing courses and experimenting with alternative methods of teaching. The small class sizes allow for the easy use of active learning techniques and student-centered classrooms in many Biotechnology classes. Many classes involve student presentations, group assignments, and collaborations with outside groups and companies. Teaching Effectiveness is measured in part by student teaching evaluations that are completed for each class. The Associate Dean for Sciences meets with each faculty member each year for an Academic Career Prospectus (ACP) meeting where teaching, research, and service are discussed.

In addition to teaching Biotechnology program courses, Dr. Lai, Dr. Tzagarakis-Foster, Dr. Young and Dr. Zimmerman each also teach undergraduate Biology classes. Dr. Lai regularly teaches Cell Physiology (4 credits), and in previous semesters has taught Virology and Biology of Cancer. Dr. Tzagarakis-Foster regularly teaches General Biology I (4 credits) and Endocrinology (4 credits). Dr. Young teaches Cell Physiology (4 credits), and General Biology I Lab (2 credits). Dr. Zimmerman teaches Seminar in Biology (for undergraduates and biology MS students) (1 credit), Ecology (4 credits), General Microbiology (4 credits), and Writing and Research Methods (1 credit).

Faculty are involved in extensive service to the program, department, college, university and community. Dr. Lai advises 25-35 Biology undergraduates, serves on the Biology Honors program committee, the Biology Awards committee, the Molecular emphasis review committee, Master's Thesis committees for Biology MS students, and served as faculty mentor to Dr. Young. He has been involved as a member in search committees for 6 different faculty and staff hires. He currently serves on the Honors College steering committee and has served in the past on the University's Distinguished Teaching Award committee and the College of Arts and Science Curriculum committee. He was part of the University's Honors College Admission Task Force and was a University core curriculum assessment reviewer.

Dr. Young, in addition to currently serving as Associate Program Director, has been involved in recruitment for the program, giving site visits at nearby universities and companies. He annually arranges incubator internship meet-up lunches in JLabs South San Francisco and the JLabs Mission Bay campus. He advises 25-35 Biology undergraduates each year, serves on the Biology Assessment committee, the Biology Exceptions committee, and has served on the Biology Awards committee. He served on the search committee for hiring a tenure track physiologist for the Biology department. He has served on the University committee to develop an Engineering department at USF and serves as the Pre-Pharmacy Student Organization faculty advisor.

Dr. Naupaka Zimmerman serves as an advisor for 40-50 Biology students, and serves as the Assistant Director of the Biology MS Master's program. He represents the Biology Department on the Harney space committee, involved in remodeling the building where the department is housed. He also serves on the Dean's Medal committee, and serves as webmaster for the International Association for Ecology (INTECOL) and the Early Career Ecological Section. He has served on the governing board of INTECOL, and currently serves on the governing board of the International Network of Next-Generation Ecologists. Moreover, he is heavily involved in the community-based Software and Data Carpentry organizations.

Dr. Gunn's research focuses on the dynamics of bioentrepreneurship, the role of media in the global biotechnology industry, and STEM attitudes and their impact. Dr. Tzagarakis-Foster studies a transcription factor involved in human development and breast cancer. Dr. Zimmerman's research involves using next-generation genomic technologies to study fungal endophytes as a way to advance our understanding of microbial ecology. Dr. Lai and Dr. Young are term appointments – while each has a strong research background, neither maintains a research program at USF.

The PSM in Biotechnology program has strong ties to the Biology department since several of the faculty that teach in the PSM in Biotechnology program are Biology department faculty. Still, it has been challenging to fully integrate the Biotechnology program - for example our Biotechnology students likely know very few of the Biology faculty who do not teach in the Biotechnology program. Increasing involvement of the current and future Biology faculty would be a great asset to the program. Further, additional ties to the related Chemistry department could also bolster the program. As the Chemistry department's Master's students often seek employment in the fields of biotechnology or pharmaceuticals, it makes sense for Chemistry and Biotechnology to establish stronger future connections.

F. Departmental Structure

Departmental Governance

The University of San Francisco's faculty is unionized, shifting responsibilities and prerogative associated in many universities with departmental chairs to the Dean's and Provost's offices. As such, though the PSM in Biotechnology program is housed within the Biology department and interacts with the Biology department chair, it generally works directly with the Dean's office of the College of Arts and Sciences. The program does not have formal bylaws or governing documents, besides the faculty of USF's contract with administration and the bylaws of the USF Biology department. The university contract mandates two types of full-time professors: tenure track professors with both teaching and research responsibilities and term professors that teach exclusively. Salary and benefits are the same for both. Tenured faculty, with the additional responsibility of a research program, enjoy the benefit of tenure security. Term positions are contracted for renewable terms, generally of one year, but in some cases as long as 5 years. All professors have a 30 credit unit load per year. Tenure/tenure track professors perform 18 units of teaching, 6 units of service and 6 units of research each academic year (Prof. Gunn, Prof. Tzagarakis-Foster, and Prof. Zimmerman). Term faculty perform 24 units of teaching and 6 units of service yearly (Prof. Lai and Prof. Young).

A Program Director leads the program with help from an Associate Director. The length of the term that the Program Director and Associate Director serve is not fixed. The original Program Director, Dr. Dever, served for six years, from 2012-2018. The Associate Director role was held by Dr. Tzagarakis-Foster and Dr. Lai during this period. The Program Director role has shifted between Dr. Lai and Dr. Tzagarakis-Foster since 2018. No fixed period has been determined for the term of the Biotechnology Program Director.

The Program Director and Associate Director together receive a total of 4 units of course release per semester, to be divided commensurate with duties. The current division of credit is 3 units to the Program Director and 1 unit to the Associate Director. The Director in Bioentrepreurship receives 1 unit of credit. The Program Director was responsible for the following duties during the 2020-2021 academic year:

- Admissions: Communicate with applicants, meet with prospects, review & decide applications, send registration instructions to incoming students, make sure all have registered correctly.
- Financial Aid/scholarships management: merit scholarship applications, decisions, coordinate scholarships with the Dean's office.
- New student orientation: coordinate and run orientation event at USF and social afterwards.
- Marketing of the Program: organize information meetings, manage social media, manage program website, manage LinkedIn and InMail advertising campaigns, confer with Grad Admissions on brochures/marketing, write newsletter (twice a year).
- Budget Management
- Social events coordination: manage and coordinate ~3 events spring semester.
- Assessment: annual program assessment submission
- Course scheduling management
- Directed studies: manage directed studies of advisees.
- Curriculum development & management for current students: develop and get approval of 4+1 program, develop curriculum and manage catalogue information, track elective courses, determine Molecular Biology course waivers, track degree requirements, substitution requests, notice to post graduation forms.
- Student Conduct Issues management: Academic probation, disqualification letters
- Internal relations engagement at USF: Meet with potential donors: attend grad program director meetings.

The Associate Director was responsible for the following duties during the 2020-2021 academic year:

- Admissions: make recruitment visits to nearby colleges and universities, make congratulation calls to recruited students, maintain automated admissions contact e-mails.
- Orientation: coordinate orientation program visit to local biotech company
- Scientific Advisory Board: manage Advisory Board membership and coordinate and plan annual Advisory Board meetings
- Marketing of the program: arrange community panel event
- Social events coordination: manage and coordinate 3 events fall semester, manage and coordinate summer social event, manage annual spring alumni reunion event.
- Industry/Internship Services: arrange internship matching events to Bay Area Biotech incubators.
- Directed studies: manage directed studies of advisees
- Graduating student/alumni surveying

There is a Scientific Advisory Board that helps to oversee and advise the program. The Advisory Board is made up of biotechnology industry professionals at Bay Area companies. Many are high-ranking officials, including CEO's, company founders, Directors, and Vice Presidents. Two (Cale Reid and April Ryles) are USF Biotechnology program alumni. The Advisory Board usually meets once a year in May where they help to make high level program decisions in areas including program governance, curriculum, and assessment.

Although the Scientific Advisory Board has been essential for the formation and continued development of this program, the level of involvement of each member has been very mixed. Some Board members contribute regularly throughout the year by giving seminars, serving as panelists, attending our program events, and assisting students looking for jobs. Others, we see only each year at the annual Advisory Board meeting.

Name	**Position**	**Company**	**Year started**
Richard Cutler Jr., Ph.D.	Executive Director	Nektar Therapeutics	2013
Roel Funke, Ph.D.	Senior Director	PACT Pharma	2020
Jacob Glanville, Ph.D.	CEO	Centivax	2013
Paul Hastings	CEO, Chairman	Nkarta, BIO	2019
Susan Kramer, Dr.PH	Executive Vice President	Concentric Analgesics	2012
Mike Lelivelt, Ph.D.	Principle Consultant		2020
Nicole Miller, Ph.D.	Molecular Diagnostics	Ultragenyx Pharmaceutical	2012
Ron Najafi, Ph.D.	Founder and CEO	Emery Pharma Services	2012
Michelle Nemits	Executive Director	Biocom Bay Area	2019

Rich Price, Ph.D.	Oncology Strategic Analyst	Genentech	2012
Cale Reid, PSM Biotech	Program Manager	Flatiron Health	2018
April Ryles, PSM Biotech	Regulatory Affairs Manager	Exelixis	2016
Reginald Smith, MBA	Principal Quality Assurance Professional	Abbott Diagnostics	2019
Jacinto Villanueva, Ph.D.	Director	Abcam	2012
Jeffrey Wallin, Ph.D.	Senior Director	Gilead Sciences	2013
Vince Wu, Ph.D.	Principal	VLW Associates	2016

Currently, faculty meetings are held monthly. During Biotechnology faculty meetings, issues such as admissions, student conduct and performance, class scheduling, program assessment, and program direction are discussed.

For 2020-2021, the PSM in Biotechnology program general operating budget was $72,765 and the student worker budget was $7500. These budget numbers have remained fairly constant over the last five years. General operating budget money is spent on lab equipment, lab supplies, and costs associated with orientation, socials, and panel events. Student worker budget goes to hire student teaching assistants and lab assistants. The amount of money provided by the College for our annual general operating budget has been sufficient to support the needs of our program. Normally, we have extra money in our budget at the end of the fiscal year ($10,000 - $20,000) that goes to the purchase of more expensive pieces of equipment such as pipettors, thermocyclers, incubators, a plate reader, etc.

G. Students

i. Admissions

Our program application consists of the following components:

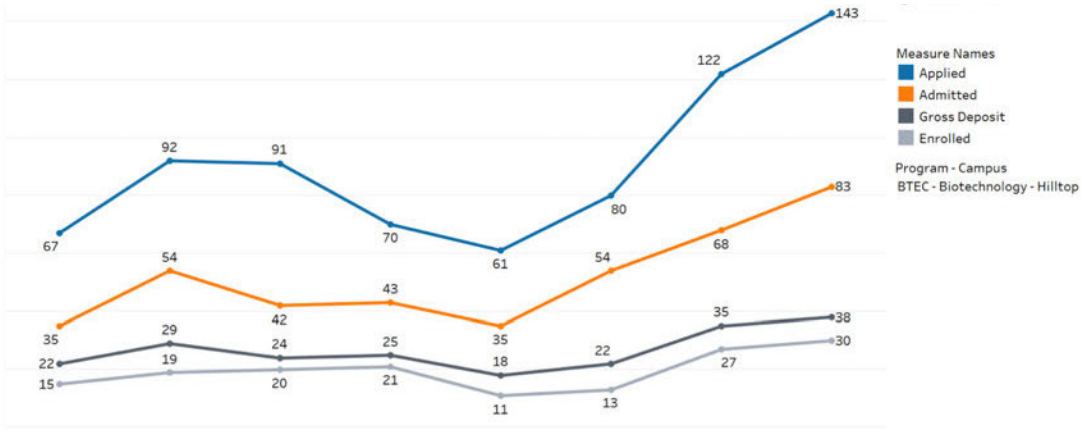
- Undergraduate transcripts
- GRE (general exam) scores
- Resume
- Statement of purpose
- Two letters of recommendation
- IELTS or TOEFL scores (international students)

Applications are primarily reviewed and rated by the Program Director and Program Manager. Sometimes other faculty members including the Associate Director will review applications as well, particularly for unorthodox or borderline applicants. The most important factors used to determine admissions and

awarding of merit-based scholarships are undergraduate school/GPA, GRE scores, and whether the applicant has significant research/work experience. We normally look for GPA of 3.0 or above and GRE scores in the 50th percentile or above. Admitted students over the past seven year have had an average GPA of 3.19 and average Quantitative/Verbal GRE percentile scores of 60%/ 58%. Independent lab research experience (for example working as an undergraduate in the lab of a faculty member) or biotechnology work experience is not expected, but is considered advantageous. Additionally, for international students, their IELTS or TOEFL scores are used to determine admissions as well. We look for IELTS scores of 7.0 or above and TOEFL scores of 90 or above.

Most of the admitted students are between 0-3 years out of undergraduate (many go straight from completing their undergraduate degree in May or June to beginning in our graduate program the next August). Most of the students were Biology or Biology-related majors (Biochemistry, Biotechnology, Bioengineering, etc.). A smaller percentage of students are science, non-Biology majors, including Chemistry, Chemical Engineering, and Kinesiology. Students who are non-science majors are considered for admission if they have taken at least one year of college-level Biology and one year of college-level Chemistry. Very few non-science majors apply though.

Each academic year, there are two rounds of admissions – admitting students to start in each fall and spring semester. Usually the amount of students that apply, are admitted, and enroll is 5 to 10 times higher for the fall vs. the spring (we have had between 0 and 3 students enroll in different years in the spring). The enrollment charts shown below only include the data for fall applicants for simplicity.



	Summer & Fall 2013	Summer & Fall 2014	Summer & Fall 2015	Summer & Fall 2016	Summer & Fall 2017	Summer & Fall 2018	Summer & Fall 2019	Summer & Fall 2020
Applied	67	92	91	70	61	80	122	143
Admitted	35	54	42	43	35	54	68	83
Gross Deposit	22	29	24	25	18	22	35	38
Melt	8	11	4	4	7	9	8	8
Enrolled	15	19	20	21	11	13	27	30
Budget	12	13	20	20	22	22	22	22
Denied	26	34	49	22	22	20	46	45
Admit Rate %	52.2%	58.7%	46.2%	61.4%	57.4%	67.5%	55.7%	58.0%
Yield %	42.9%	35.2%	47.6%	48.8%	31.4%	24.1%	39.7%	36.1%

Figure 3. Fall Admissions data from 2013 through 2020. Data is from USF's Center for Institutional Planning and Effectiveness (CIPE).

As shown in Figure 3, we saw a steady increase in newly enrolled students from the time the program was launched in 2012 (11 new students) until 2016 (21 new students). We then had two poor admissions years in 2017 (11 new students) and 2018 (13 new students). We missed by a wide margin the goal set for our program by the University of 22 new students for each of these years. The admissions yield rates dropped from an average of around 45% to 31.4% and 24.1% during these two years.

Year	Goal number new students	Actual number new students
2012-2013	12	11
2013-2014	12	15
2014-2015	20	19
2015-2016	20	20
2016-2017	20	21
2017-2018	22	11
2018-2019	22	13
2019-2020	22	27
2020-2021	22	30
2021-2022	26*	24

* Our student goal was increased from 22 to 26 students per year when we hired our Program Manager in 2021.

The low level of enrollment of new students in the 2017 and 2018 years was a strong concern to the University administration. As a result, the Dean's office informed program leadership of the danger of the program closing or of faculty lines being eliminated. Early in the consideration process, odds of Dr. Young's faculty line being continued were estimated at only 50%. This was quite disappointing in light of the strong placement success of the program and the central importance of biotechnology to the economy of the Bay Area and the state of California. Paradoxically, the thriving state of biotech in the current strong economy likely contributes to this, with greater demand for employees depressing enrollment in graduate programs (according to reports from the administration this has been a University wide trend, affecting many programs). As many of the program professors do not possess tenure, this represents a potential challenge to retaining quality faculty and poses a threat to program sustainability as the economy cyclically waxes and wanes.

Encouragingly, the number of incoming students in 2019 and 2020 has spiked up to 27 and 30, as we have been able to easily surpass our goal of 22 new students during these years. We implemented many changes to our admissions and marketing processes which likely helped us to exceed our admissions goals. In particular, we implemented a 'high touch' approach for students expressing interest in the program and students accepted for admission. For example, a concerted effort was made for multiple faculty to call and congratulate admitted students and every admitted student was encouraged to make class visits and attend one or more of our panel or social events.

Another improvement in terms of admissions has been our ability to bring in 4+1 Biology/Biotechnology students, with the launch of this program in 2019. The number of new 4+1 students over the past three years has ranged from between 3 and 8. Hopefully, for years to come the 4+1 program will provide a steady supply of USF Biology major undergraduates who enter the Biotechnology program. Traditionally, only a small number of our incoming Biotechnology students (1-2 per year) completed their BS at USF. The 4+1 program will likely increase this number to 5-8 students from USF annually.

Year	number of new 4+1 students
2019-2020	6
2020-2021	3
2021-2022	8

ii. Scholarships

Our PSM in Biotechnology program awards partial merit-based scholarships to some of the students who apply and are admitted to our program. These scholarships are usually awarded at the time of admission to the most highly qualified applicants in order to help entice them to choose to come to USF over other graduate programs that they have been admitted to. Scholarship decisions

are made by our admissions committee primarily based upon the applicants undergraduate GPA, GRE scores, and research/work experience.

The university allocates each graduate program an annual budget for merit based financial aid. Each program usually uses these funds to maximize the number of students in the program. The amount of annual merit based financial aid allocated to the Biotechnology program is a specific percentage of the projected revenue that the College of Arts & Sciences receives from tuition from the Biotechnology students. Programs that project to bring in more students annually receive more scholarship money. Additional discretionary scholarship funds from the Dean's office are available in some cases.

Additional scholarship money can be awarded to admitted students from other sources. For example, the College of Arts & Sciences Graduate Admissions Office can use scholarship money to recruit international students specifically from 10 target countries, Brazil, Chile, Colombia, Italy, Kenya, Mexico, Norway, Peru, Turkey and the United Kingdom. The goal of this additional scholarship money is to recruit international students from a set of countries which traditionally have had low representation in the USF graduate student body. These targeted country scholarships are usually in the amount of $7500 for one year. We have had five Biotechnology students receive this targeted country scholarship during the past seven years (3 from Mexico, one from Brazil, and one from Colombia).

It is likely that the merit-based scholarships that we award improve our admissions yield numbers substantially. While the $5000 annual scholarships cover only about 20% of the students' overall tuition cost, awarding at least some scholarship money can definitely result in a well-qualified applicant choosing to come to USF over a competitor program. With a larger pool of scholarship money available each year, we could improve our admissions yield numbers further – we have approached some potential donors about sponsoring scholarships with the help of USF's Development office.

Students in our program do occasionally also receive scholarships or funding from outside the university. Two of our current students have received full scholarships – one from the Parasol Foundation and one is a Gates Millennium Scholar. Some of our students also receive tuition reimbursement from their employers as well. We have had students who come into our program with biotech jobs already at employers such as Genentech, Merck, Bio-Rad, Thermo Fisher, and Pfizer. Many of these large employers will pay for at least part of the tuition cost of our PSM program – less than 20% of our students fall in this category. The large number of San Francisco Bay Area biotechnology professionals that would like to earn their Master's degree and can receive tuition benefits from their employer represent a huge market of potential new students. We are actively considering new strategies to market our program to these working, biotechnology professionals.

iii. Alumni and job placement

The mission of the PSM in Biotechnology program is to prepare our students for careers in the biotechnology industry. As previously discussed, we have been very successful in this regard – our success rate of moving students into the biotechnology field has been excellent. Very few of the students enter our program with prior biotechnology experience and almost all are employed full-time in permanent biotechnology positions when they graduate from our program. The graduating students not working at biotechnology companies are most often employed in academic research labs (most frequently at UCSF) or have entered Ph.D. programs.

To give a more granular perspective on the success of our program, we present here outcomes for two cohorts in deeper detail. Below is a list of the 2014 Biotechnology graduates (the first graduating class from our program). 14 of the 15 students listed below are currently working at a biotechnology company. The one exception is a student who completed his Ph.D. at U.C. Berkeley after our program and is now a postdoctoral fellow at UCSF. Many of the students entered in lower level positions, most frequently Research Associate I, and have been promoted since to Senior Research Associate, Scientist, or Senior Scientist. Most of the former students have changed companies at least once since graduating. Perhaps most notably, only 2 of these 15 students were working in the biotechnology industry when they entered the program.

Student (2014 graduate)	**Current employer**	**Job Title**
[redacted]	Lyell Immunopharma	Senior Research Associate
[redacted]	Pivot Bio	Scientist I
[redacted]	Boehringer Ingelheim	Clinical Supply Scientist II
[redacted]	Bio-Rad Laboratories	Research Associate II
[redacted]	PACT Pharma	Process Development Scientist
[redacted]	Fluidigm	Product Specialist III
[redacted]	10X Genomics	Production Supervisor
[redacted]	BioMarin Pharmaceutical	Senior Research Associate II
[redacted]	Emeryville Pharma	Director of Quality Assurance
[redacted]	Gritstone Oncology	QC Analyst II
[redacted]	Bio-Rad Laboratories	Senior Scientist
[redacted]	UCSF	Postdoctoral Fellow
[redacted]	Roche	Senior Scientist
[redacted]	Exelixis	Senior Associate, Regulatory Affairs
[redacted]	Natera	Clinical Laboratory Associate

All of these students took positions following graduation in the San Francisco Bay Area, and all of them continue to live in the Bay Area. The companies they work at are located throughout the Bay Area, including in San Francisco, South San Francisco, East Bay, and on the peninsula.

As an example of our more recent employment trends, below is a list of all of the students in a recent graduating class, students who graduated in May 2020. 11 of the 12 students currently work at a biotechnology company. One student works at a recruiting firm. 4 of the 12 graduated students are still at the same employer that they did their internship with. All of the students are in permanent, full-time positions. Only one of these twelve students came into the program with prior biotechnology experience. For a complete list of all of the internship employers, current employers and position titles for each of the students in the five graduating classes of the program, see Appendix ii: Internships and Jobs.

Student (2020 graduate)	Internship employer	Current employer	Job Title
[redacted]	Felix Biotechnology	Bristol Myers Squibb	Quality Control Associate I
[redacted]	Distributed Bio	Distributed Bio	Scientist
[redacted]	Cepheid	Harpoon Therapeutics	Research Associate
[redacted]	Intrexon	Kelly Science	Scientific Recruiter
[redacted]	Distributed Bio	Distributed Bio	Project Manager
[redacted]	Encoded Therapeutics	Clara Foods	Research Associate
[redacted]	10X Genomics	10X Genomics	Production Associate
[redacted]	Distributed Bio	Loxo Oncology	Senior Research Associate
[redacted]	Intrexon	Mammoth Biosciences	Senior Research Associate
[redacted]	GALT	Federation Bio	Research Associate II
[redacted]	Indie Bio	Indie Bio	Bioengineer
[redacted]	StemPharm	Abcam	Research Associate

The employment prospects of students in our program are excellent. Over the past seven years of the program, students have increasingly been able to begin interning at companies earlier in the program and have been able to do multiple internships in many cases. Many students will begin interning during their first year in the program and most all are working by the summer in between their first and second year. Almost all of these industry internships are for pay, usually for $20-$35 per hour. Part of this improvement over the last seven years is that our program at USF has built many more contacts with employers, particularly biotechnology San Francisco Bay Area companies. We now have alumni students that work at most of the large biotechnology companies in the area and at many small and mid-sized biotechnology companies as well. The majority of internships which students find come from a direct connection from our program.

H. Staff

Our Biotechnology program is supported by the following USF staff members:

- **Luwei Xie: Program Manager** (Biotechnology PSM and Energy Systems Management MS)
- **Sandra Hakanson: Program Assistant** (Biology undergraduate, Biology MS, Biotechnology PSM)
- **Peter Baketa: Biology lab manager** (Biology undergraduate, Biology MS, Biotechnology PSM)
- **Matt Helm: Instrumentation Specialist**
- **Jeff Oda: Instrumentation Specialist**

Luwei Xie joined as our first PSM in Biotechnology Program Manager in February 2021. Luwei splits his time - 50% dedicated to our PSM in Biotechnology and 50% to USF's MS in Energy Systems Management program. Luwei normally dedicates Tuesdays, Thursdays and half of Wednesdays to our Biotechnology program. He is responsible for multiple aspects of the marketing, admissions, recruiting, administration, outreach, and support for our Biotechnology program. Some of Luwei's specific responsibilities are:

- First point of contact for admissions inquiries. Admissions marketing and participation in direct outreach such as graduate college fairs, webinars, and open houses.
- Supervision and participation in all aspects of the admissions process. Includes helping review, rate, and catalog new applications, coordinating interviews and campus visits, and distributing decision notifications and scholarship offers.
- Program marketing direction and coordination
- Assist with the organization and participation in student events such as orientation, socials, panels, and graduation events.
- Current student advising

Sandra Hakanson is a full-time Program Assistant for the Biology department. The Biology Program Assistant manages the Biology department office and interacts directly with current students, prospective students, staff, faculty, and other visitors to the office. The Program Assistant handles administrative duties for the department such as coordinating events and meetings, managing faculty hiring searches, ordering, and processing invoices. The Biology Program Assistant does assist with the Biotechnology program, but spends less than 20% of their time doing so. The remainder of their time (80%+) is spent supporting the Biology undergraduate major and MS in Biology program.

Peter Baketa is the full-time Lab Manager for the Biology department. His responsibilities include preparing, setting up, and taking down each section of our Microbiology, Anatomy, and Physiology undergraduate labs. Additionally, he does laboratory course ordering, oversees lab cleaning and maintenance, and trains/supervises student workers who help with all of these activities. Peter helps maintain the Biotech labs, but all of the setup and takedown of these labs is done by the professors who teach each lab. General lab maintenance, such as periodic cleaning and removal of biohazard and chemical waste, is done or overseen by the Lab Manager. Around 10-20% of the Lab Manager's time explicitly supports the Biotechnology labs.

Matt Helm and Jeff Oda both serve as staff Instrumentation Specialists. In this role, they maintain the instrumentation in the science teaching labs at USF. This includes training students and faculty to use equipment, performing equipment maintenance and coordinating repairs, and assuring lab safety. Most frequently Matt Helm and Jeff Oda assist Biotechnology program classes with training and support for use of the confocal microscope and flow cytometer. Both of these staff members support all of the science departments at USF, including Biology, Chemistry, Physics and Astronomy, Kinesiology, and Environmental Science. Because their responsibilities are spread out over so many departments, they spend only a small percentage of their time (<10%) assisting the Biotechnology program specifically.

Annually, we have a budget of approximately $7,000 that can be used to pay student workers. We hire Biotechnology students for jobs such as:

- Teaching assistant (TA) each year for BTEC 688/689. Because of the intensive nature of this lab course, having a TA is very helpful.
- Occasional TA for larger than normal courses. For example, this year we hired student TA's for BTEC 640 which had a large class size of over 30 students.
- Student ambassadors that assist with program social media, meeting with admitted students, and program events
- Student lab assistants that help with lab maintenance and making media and pouring plates for labs

I. Diversity and Internationalization

i. Gender Diversity

The overall percentage of female students in the Biotechnology program has been 55% and the percentage of male students has been 45%. Over the past seven years, the percentage of women varied quite a bit from year to year, from a low of 38% in 2013 to a high of 61% in 2021 (see Figure 4).

It is notable that the percentage of women in our program is over 50% and our goal is to keep this percentage close to or above 50% in future years. The lack of women in STEM majors in college and fields professionally has been well documented. Our Biotechnology program at USF and programs like ours provide an excellent way to decrease the gender imbalance in a growing STEM field.

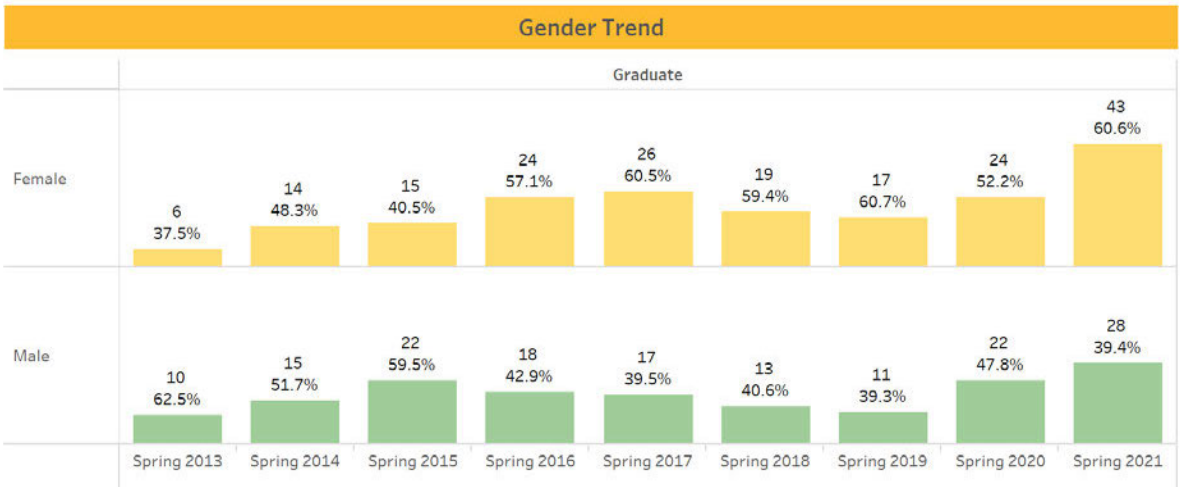


Figure 4. Gender trends in the program. The percentage of currently enrolled female and male students over the past 9 years is shown. Data is from USF's Center for Institutional Planning and Effectiveness (CIPE).

ii. Ethnic Diversity

The percentage of USF Biotechnology students in different ethnic categories over the life of the program is as follows:

Ethnicity	USF Biotech	San Francisco Bay Area
White	35%	42%
Asian	33%	23%
Hispanic or Latino	15%	10%
Unknown	7%	11%
African-American	5%	7%
Multi Race	4%	5%
Pacific Islander	1%	1%
Native American	0%	1%

The level of diversity of our student body has been good. Overall, our program's diversity mirrors that of the San Francisco Bay Area well, with a small overrepresentation of Asian and Hispanic students and a small underrepresentation of White, African-American and Native American students. The diversity levels change quite a bit from year to year, as would be expected in

a small program, but we don't see consistent changes in the trends over time (see Figure 5). We would like to maintain this level of diversity in the program with possibly increasing the number of African-American and Native American students in the program. We have recently added our first African-American Scientific Advisory Board member, Reginald Smith. He has already met with our program to discuss ways in which we can attract more African-American students to apply.

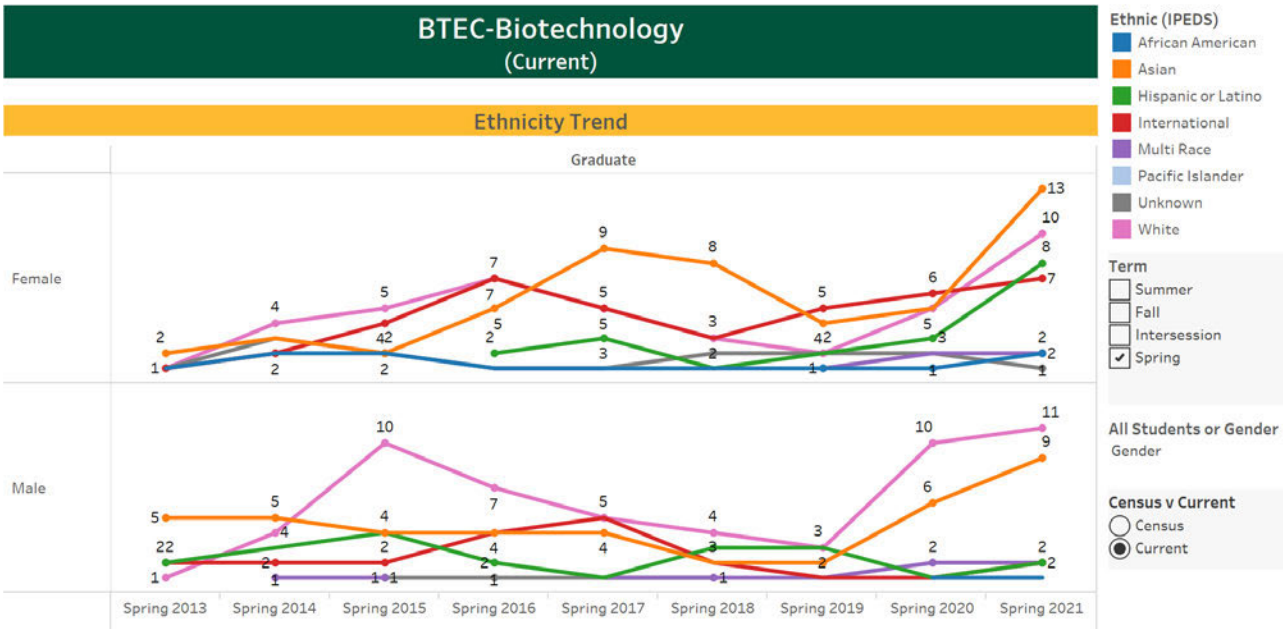


Figure 5. Ethnicity trends of enrolled Biotechnology over the past 8 years. Data is from USF's Center for Institutional Planning and Effectiveness (CIPE).

iii. Number of International Students

Over the past nine years, approximately 20% of the students in our program have been international students (non-U.S. citizens or permanent residents) and 80% have been domestic U.S. students (U.S. citizens or permanent residents). The percentage of international students has varied from a low of 6% in 2013-14 to a high of 27% in 2015-16 (see Figure 6).

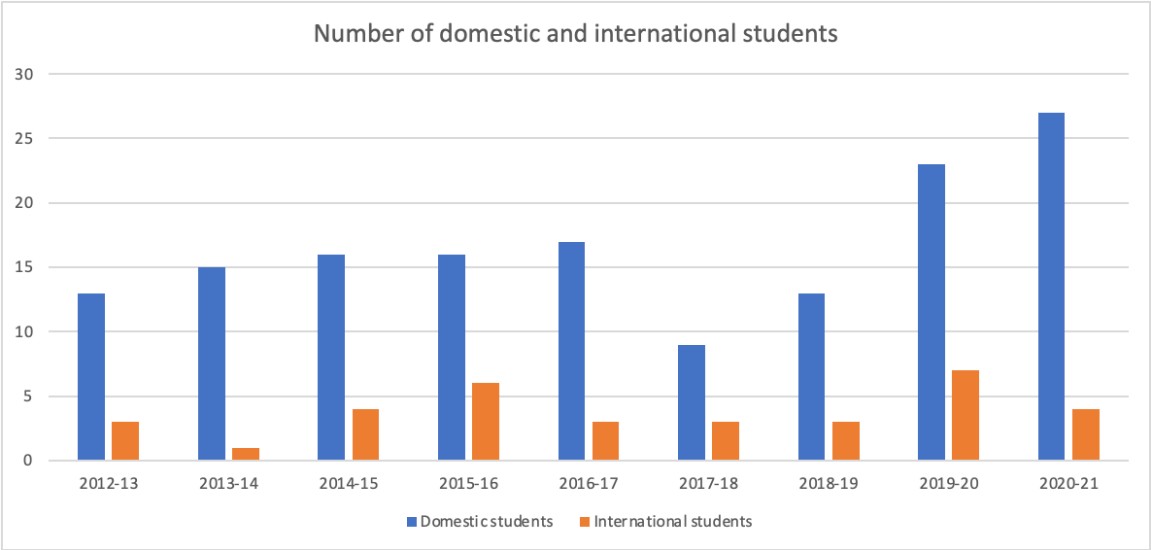


Figure 6. Number of domestic vs. international Biotechnology students over the past 8 years. Data is from USF's Center for Institutional Planning and Effectiveness (CIPE).

The most common country of origin of international students in our program is India – almost half of all of the international students are from India. The other international students come from a wide range of countries in Asia, North America, South America, and Europe. The next two most represented countries are China and Mexico – about 10% of our students come from each of these countries (see Figure 7). In terms of applicants, India dominates as well – approximately half of all international applicants are from India. It is unclear to us why we get many more applicants from India than any other country—we do not market our program to one specific international program over any other.

Figure 7. Countries of origin of the International Biotechnology students. Data is from USF's Center for Institutional Planning and Effectiveness (CIPE).

iv. Challenges for International Students

Overall, our domestic students have done better in our program than our international students. Over the past seven years, 8 of the 122 domestic students (6.6%) have been on academic probation at least once. In comparison, 4 of the 30 international students (13.3%) have been on academic probation at least once. In general, our international students have had more difficulty securing internships and permanent positions in the field of biotechnology as well.

Some challenges that our international students face:

- Taking classes in English for the non-native English speakers
- Growing accustomed to the style of classroom and level of participation expected in a U.S. classroom
- For F-1 foreign student visa holders, the inability to work off campus at biotech companies during their first year in the program
- F-1 visa students are able to work on CPT status beginning the summer after their first year. Following graduation, students can work up to three years on their OPT status as we are a STEM-certified program. Some employers are hesitant to hire an F-1 visa student who will eventually need to be sponsored for a work (H-1B) visa, which can make finding employment after graduation more challenging.
-

Our international students do add to our program in terms of adding diversity and more different perspectives within our classrooms. Over the next few years of our Biotechnology program, we generally expect the percentage of international students to remain in the same range (15-20%). Our program could benefit from increasing the diversity of the countries which these international students come from – for example increasing the numbers of students from Europe (3 students over the last 7 years), South America (2 students over the last 7 years), and Africa (0 students over the last 7 years).

v. Diversity of Faculty

The gender diversity of the full-time faculty that have taught in the program in the last seven years (62% female) is similar to the gender diversity of the students in the Biotechnology program. Currently, the full-time faculty teaching in the program is only 40% female though. Only one of the faculty is non-white and there are no faculty from traditionally underrepresented minority groups such as Hispanic or African American. If we expand the faculty to add a new full-time faculty member in the next few years, it would be ideal to recruit a faculty member from one of these groups.

J. Technology and Informational Resources

i. Instruments for Equipment and Teaching

All full-time faculty in the program receive their choice of laptop or desktop from the University. All computers are on a three-year replacement cycle. There is a standard suite of software provided by the University and the program can purchase any special software required. The computing needs of the Biotechnology program faculty are satisfactorily met. For teaching, the program pays for a single floating license to the Geneious Prime bioinformatics software.

Most faculty use an online course management system (Canvas) for their classes to share lecture slides and class assignments, to make course announcements, and as an online grade book.

The Bioinformatics class that all students are required to take also makes use of GitHub (a code-sharing website) for assignment distribution and submission. That class also makes use of a large Linux server housed in a shared server room in the Lo Schiavo Center. It is powerful enough to allow several dozen students to run analyses in parallel, and includes 1.5 TB of RAM, dual 22 core Intel Xeon processors, and a 32 TB RAID 10 for working with large datasets.

ii. Distance Learning or Online Learning

Before 2020 (pre-pandemic), the PSM in Biotechnology program did not have any distance learning or online programs. Most of the laboratory courses that are key components of the program could not be transferred to an online only format. For the second half of the Spring 2020 semester and the entire Fall 2020 semester, classes were switched to fully online and remote due to the COVID-19 pandemic. Most faculty taught in a synchronous format utilizing Zoom. In the Spring 2021 semester, we received special permission to hold our lab classes in person and we hosted our BTEC 685/686 and BTEC 688/689 lab classes on campus. In Fall 2021, most of our science classes (lectures and labs) are being held in-person on campus whereas most of our bioentrepreneurship classes will be held remotely.

iii. Library

The faculty members rarely use the library's physical holdings (books, periodicals, etc.). Faculty do routinely access scientific journals that can be downloaded from the USF Gleeson library journal finder website. The collection of journals that the USF libraries can access is somewhat limited – articles from recent years of major journals are usually available, but many specialized journals cannot be found. Additionally, the website navigation to get to the correct

journal article is somewhat cumbersome, requiring multiple clicks to navigate to the correct journal, volume, issue, and then paper. Many other institutions and universities have a one-click access system where papers can be downloaded directly from PubMed searches, speeding the process. Faculty members use few library resources otherwise, except to put textbooks on reserve for example. The Biotechnology program's library liaison, librarian Claire Sharifi, has been a useful resource – she conducts in class tutorials on using journal search software and directly assists students with performing literature searches and retrieving full-length versions of articles.

iv. Other - Vehicles

University vehicles are used on occasion to bring students to orientation events and on company tours. The vehicles available for Program use are owned by the College of Arts & Sciences and can be reserved by faculty members. The vehicles include Sprinter vans with a capacity of 12 and Suburbans with a capacity of 9. The Sprinter vans were used for most trips in the past, until this year it was decided that a commercial driver's license would be required to drive these. The Suburbans are usable, but their smaller capacity and lack of reliability make them poorer options. The College of Arts & Sciences is in plans to purchase new and replacement vehicles.

K. Facilities

Within the Biology department, within which the Biotechnology graduate program is housed, there are shared equipment rooms (a microscopy center and a tissue culture suite) that house a range of advanced equipment, including: a Zeiss AxioObserver Wide-field Fluorescence Microscope, a Zeiss LSM700 Laser Scanning Confocal Microscope, a BD Accuri C6 Flow Cytometer, and a Hitachi TM3000 Scanning Electron Microscope and associated image- capture and computer resources. Shared teaching and research equipment relevant to the program also include two BioRad qPCR machines, two large and one small BioRad gel imagers, numerous culture incubators (including several with carbon dioxide control), a QuBit 3 fluorometer, and six Biosafety cabinets for sterile culture work. Within the last 2 years, the Biology Department has also purchased an Illumina iSeq high-throughput sequencer and a Tecan Infinite M Plex fluorescence/absorbance/luminescence plate reader. Both of these are significant resources that enable new types of analyses in both teaching and research. See Appendix iii: Equipment and Instruments for a complete list of the equipment available to the Biotechnology program and the location of each piece of equipment. Overall, we believe the program has access to an excellent set of equipment, allowing many advanced molecular and cell biology based experiments to be performed.

The Biotechnology PSM program was originally located in the Harney Science Center (HR). In August 2013, USF opened the John Lo Schiavo, S.J. Center for Science Innovation (LCSI). At this time, most of the Biotechnology courses were moved to the new LCSI building. This new, 'green' modern science building is exclusively designed for teaching, and includes multiple wet labs, lecture rooms, and computer science and multi-use rooms. Biology, and thus the Biotechnology program, shares the use of this new building with Chemistry, Computer Science, Environmental Science, and Physics. The Harney Science Center continues to house Biotechnology faculty offices, the Biology department office (HR256), shared equipment rooms, and Dr. Zimmerman's research laboratory.

Below is a table detailing the capacities and general uses of the lab rooms and the other teaching spaces used by Biotechnology program classes:

Teaching space in the Harney Science Center and the John Lo Schiavo, S.J. Center for Science Innovation that is utilized by the Biotechnology Program classes.		
Room number	Maximum Student Capacity	Room use
LSG04	16	BTEC 685/686 and BTEC 688/689 laboratory classroom
LSG04A	-	BTEC 685/686 and BTEC 688/689 laboratory prep room
LS205	16	BTEC 685/686 and BTEC 688/689 laboratory classroom
LS204	-	BTEC 685/686 and BTEC 688/689 laboratory prep room
LS103	40	Seminar and lecture classroom
LS209	25	BTEC 640 (Bioinformatics) classroom
LS303	40	Seminar and lecture classroom
HR252	-	Tissue culture and equipment suite
HR314	-	-80˚C freezer room
Malloy LL4	40	Bioentrepreneurship classroom

The teaching spaces in LSCI are well suited in terms of set-up and design for our courses. For example the LSG04 and LS205 laboratories have projections screens and whiteboards that are used for lecturing and bench space that is set up well for groups working on experiments. LS103 is an excellent seminar space and lecture classroom – we also normally hold our panel events in LS103 with the receptions in the adjoining Getty Study area. Throughout the LCSI building, there are numerous study spaces that our students use for independent and group study sessions. While sufficient for our current needs, the amount of Biotechnology teaching lab space in LCSI is limited which could restrict the future growth of our program.

The Harney Science Center (HR) is an old building in need of renovation. The administration is in the fundraising and design stage of the Harney renovation project, which should begin in the next 3-5 years. The Harney renovation should not dramatically affect the Biotechnology program directly – faculty offices and shared equipment spaces will be relocated during this process, but

Biotechnology program classes in Lo Schiavo should continue in the same rooms as usual.

L. Conclusion

Our PSM in Biotechnology program has been successful in achieving our mission over the first nine years of the program at USF: *providing motivated students with the knowledge and skills needed to successfully enter a career in the biotechnology industry*. Our students get excellent experience and training both in the classroom and through internships outside of the classroom, many of which are arranged with the assistance of USF faculty. Over the history of the program, 95% of the students land a full-time position at a biotechnology company within 3 months of graduation and their career trajectory in this growing field following graduation is bright.

We have a small number of faculty and staff that are involved in the program. Currently, we have five full-time USF faculty that regularly teach at least one required course in the program. As our Biotechnology program grows in size in terms of students, it will be essential to add new faculty and staff as well as to continue to strengthen and grow the program.

M. Comprehensive Plan for the Future

i. Admissions challenges

Over the first four years of the program (2012-2016), we met our admissions goals, bringing in at least the projected number of new students each year. The next two, we were short of our admissions goals – in 2017 we brought in 11 new students (22 projected) and in 2018 we brought in 13 new students (22 projected). We saw a bounce back in enrollment in 2019 with 27 new students coming in Fall 2019 (22 projected) and 30 new students coming in Fall 2020 (22 projected). In Fall 2021 we came close to meeting our goal with 24 new students (26 projected).

Meeting our projected number of new students each year is essential for our program – if we consistently miss our admissions goals, we may lose a staff or faculty line and eventually, the program could even be closed. If we consistently exceed our admissions goal, we may add a new staff and/or a new faculty line.

It is hard to know for certain why our admissions numbers were low in 2017 and 2018 and then high in 2019 and 2020. Many changes were made in 2019 including a change in the Program Director and Associate Director along with many new program marketing and admissions processes implemented. In addition, there were improvements on the PSM in Biotechnology external (marketing) website as well as the incorporation of the newly designed

bioentreprenuership courses, which has likely helped to attract more students to our program. It is important for us to identify and continue what is working well to meet our admissions goals in future years. Some ongoing points for consideration:

- Introduction of our new 4+1 Biology B.S./Biotechnology P.S.M. program should hopefully provide us with a steady stream of USF undergraduates who enter our program, assisting our admissions. We hope to bring in 5-8 USF Biology students into the program each year through the 4+1 program.

- We hope to further target biotechnology professionals who already work in industry as students for our program. Currently, less than 20% of our entering students have biotechnology industry experience. There are a very large number of biotechnology professionals currently working in the San Francisco Bay Area that may be interested in earning their Master's degree. Many of these potential students can also receive partial or full tuition reimbursement through their employer. Raising our profile with these students, however, has been difficult. We hope to solicit advice and feedback from reviewers about how we could best target these students.

- One of the biggest deterrents for potential new students is the high cost of housing in San Francisco. Many out-of-state students choose programs in other parts of the country because of the high cost of living here. Our program and other graduate programs at USF, will work with our administration to increase the availability of on-campus graduate student housing options. Alternatively, we could receive money from corporate or individual donors that could fund student scholarships.

- Ultimately, our program faces a marketing challenge. However, with USF's current push to increase graduate enrollment university-wide, our College of Arts and Sciences Graduate Admissions office has limited 'bandwidth' to devote to our small program. While this is understandable, it has led to faculty shifting their priority away from their expertise to fill the marketing gap. This is less than optimal considering biotech faculty have little marketing training or experience. One solution we have considered is to see if additional funds can be made available to us to hire an outside marketing professional. However, we would also like to solicit advice and feedback from our outside reviewers about how best to proceed.

Our long-term plan is to address all of these marketing and admissions challenges, and to not just consistently meet our currently projected admissions numbers (now at 26 new students per year), but to exceed them. We believe that it is possible to consistently bring in 26 to 32 new PSM students each year, in addition to the 5 to 8 new 4+1 students each year.

ii. Increased Biotechnology Program Faculty and Staff

If we are able to continue to meet or exceed our projected admissions numbers, we would like to increase the number of Biotechnology program faculty and staff.

- Addition of one new Biotechnology program faculty line. Adding new faculty that teach a number of courses in our Biotechnology program would increase our opportunity to expand and diversify our curriculum, allowing us to add new electives and areas of concentration. The new faculty could add new biotechnology experimental expertise in areas that we are currently weaker at – for example in the use of laboratory robotics, small-molecule drug discovery, or pharmacokinetics/pharmacodynamics. Adding a new science tenure-track faculty member could be beneficial as our Biotechnology program students could get training by working in their research lab before getting an internship in industry. This could be particularly beneficial for international F-1 visa students who cannot work off campus during their first year at USF. Ideally, the new faculty would be an underrepresented minority, expanding the diversity of faculty to better match the make-up of the students in the program. Furthermore, if the cohort size continues to grow in future years, additional sections of core classes will need to be created and staffed and the addition of a full-time faculty line will help with course coverage.

- An alternative way of growing the Biotechnology program without adding new Biotechnology faculty or staff would be to increase the ties between Biotechnology and other departments/programs at USF. For example, we can bring in other faculty from Biology, Chemistry, Environmental Science, or Computer Science to teach an elective or core course for our students. The introduction of the undergraduate Engineering major at USF may offer this possibility as well. A new Engineering faculty member with biomedical engineering experience could teach a course in this area to our Biotechnology students.

iii. Curriculum Updating

Over the last two years, we have made several curriculum changes such as adding new courses like BTEC 610: Global & U.S. Regulatory Affairs, BTEC 615: Bioinnovation Management, and BTEC 623: Disease, Physiology, and Immunology. Two new AGI immersion trip locations have been approved – trips to Ireland/Northern Ireland and New Zealand. We will continue to modify and update our program's curriculum over the next few years with the following goals:

- The biotechnology industry is rapidly growing and changing. It is essential for our program to keep pace with these changes with classes that cover

the most cutting edge technologies and experiments. We will seek to utilize our Scientific Advisory Board to its fullest to help us keep up with these changes. Our Scientific Advisory Board has played an important role in shaping our program's curriculum to date, but the Board could be more actively involved in our program.

- Currently, many of our courses serve as stand-alone units. Connecting what is covered in many of the required courses would improve the cohesiveness of the program and student learning. For example, we can introduce a next-generation sequencing module that is covered in our bioinformatics, bioentrepreneurship, and molecular biology lab classes – highlighting this technology from a different perspective in each course.

- Our program curriculum is currently quite fixed – students in each cohort take almost all of the same classes with little specialization based upon student interest. We would like to introduce new concentrations, allowing students to specialize in areas such as bioentrepreneurship or bioinformatics. This would likely require additional full-time faculty as part-time faculty with the proper experience may be difficult to find and too high turnover can be an obstacle to maintaining a permanent new concentration.

iv. Modification of Internship Coordination

Our Biotechnology program has been very successful in helping to match students with internships at biotechnology companies. The large majority of our students are first connected to a company where they intern at through faculty in our Biotechnology program. This process of internship matching has been somewhat ad hoc, however. For example, employers contact our faculty about available internships at different times of the year. Internships vary quite a bit in terms of hours, training provided, and the quality of the experience.

A more standardized internship experience would be beneficial to our students, our faculty, and the employers. The Master's in Data Science program at USF has an established practicum program that can be used as a model (https://www.usfca.edu/arts-sciences/graduate-programs/data-science/practicums). Some features of the Data Science practicum program:

- Practicums begin for all students at the same time (mid-October) and have the same duration (9 months)

- Employers who would like to participate are pre-screened and participate in pitch sessions at USF to tell all of the students about their company

- Students order their top choice companies by preference, and matching is done by the practicum director to optimize the number of students who match with one of their top choices.

The Keck Graduate Institute (KGI) has a Team Master's Project program for Biotechnology Master's students that can also be used as a model (https://www.kgi.edu/about/corporate-partnerships/team-masters-project-a-corporate-opportunity/overview/).

Students would benefit from a more tightly coordinated internship program like these. They would know when they are starting and ending their internship and know that they are guaranteed to be matched/placed with a company. One of the biggest concerns that our prospective and incoming students have is how and when they will find their internship – having an organized matching program would alleviate many of these concerns and could be an important admissions draw to our program.

Currently, exploring such expansion is beyond the capacity of existing faculty, considering how labor intensive setting up a coordinated internship program with dozens of employers will be, particularly for the first time. However, the addition of a Program Manager and/or an additional faculty member may make exciting program improvements possible. This would allow USF to leverage the current success of the program, expanding university funding, student opportunity, and benefit to the local biotech community.

Appendix i. Course Schedule

36 Units are Required for completion of the PSM degree. Below is the program of study for full-time students in the program beginning in the Fall.

Fall, Year 1:
BTEC 601— Biotech Career Prep Seminar (1 unit), T 4:35-5:50 pm
BTEC 620—Molecular Biology* (4 units), MW 4:45-6:25 pm
BTEC 610—Global and US Regulatory Affairs (2 units), 1st half T or R 6:30-10:10 pm
BTEC 611—Legal-Social-Ethical Biotech (2 units), 2nd half T or R 6:30-10:10 pm

Spring, Year 1:
BTEC 685/686—Molecular Genetics and Biotechnology (4 units), MW 5:30-9:45 pm
BTEC 615—Bioinnovation Management (2 units), 1st half T or R 6:30-10:10 pm
BTEC 612—Local, National & Global Biotech (2 units), 2nd half T or R 6:30-10:10 pm

Summer, Year 1:
BTEC 619—Biotech Industry Immersion** (2 units)

Fall, Year 2:
BTEC 640—Bioinformatics (4 units), MW 4:45-6:25 pm
BTEC 688/689—Advanced Research Methods Lab (4 units), MW 6:45-10:30 pm

Spring, Year 2:
BTEC 600—Molecular Biology Seminar (1 unit), T 4:35-5:50 pm
BTEC 697—Internship in Biotechnology+ (4 units)
Elective++ (4 units)

*Students who have already taken an upper-level Molecular Biology class may forgo the Molecular Biology requirement with permission from the Program Director.
**Students must complete the Immersion course in order to graduate – it is offered once per year during intersession or after spring semester.
+Students may not enroll in the Capstone Internship course until completing BTEC 688/689. Prior internships may be completed but these do not qualify for BTEC 697.
++At least one Biotechnology elective will be scheduled on Tuesday/Thursday evenings. Other elective options may include Master's in Data Science, MBA, or other science courses.

Appendix ii. Internships and Jobs

COHORT	INTERNSHIP	CURRENT EMPLOYER	JOB TITLE
1	Thermo Fisher Scientific	Lyell Immunopharma	Senior Research Associate
1	Boehringer Ingelheim	Boehringer Ingelheim	Clinical Supply Scientist II
1	Natera	Fluidigm	Product Specialist III
1	Blood Systems Research Institute	10X Genomics	Production Supervisor
1	LakePharma	BioMarin Pharmaceutical Inc.	Senior Research Associate II, Cellular & Molecular Biology
1	NovaBay Pharmaceuticals	Emeryville Pharma	Director of Quality Assurance
1	Bio-Rad Laboratories	Bio-Rad Laboratories, Inc.	Senior Scientist
1	Geneweave Biosciences	Roche	Senior Scientist
1	BioMarin	Exelixis	Senior Associate, Regulatory Affairs
1	Natera	Natera	Clinical Laboratory Associate
1.5	Pivot Bio	Pivot Bio	Scientist I
1.5	Elysium Therapeutics	Bio-Rad Laboratories	Research Associate II
1.5	UCSF	PACT Pharma	Process Development Scientist
1.5	MiNDERA Dx	Gritstone Oncology	QC Analyst II
1.5	UCSF	UCSF	Postdoctoral Fellow
2	Acerta Pharma	Kartos Therapeutics	Senior Scientist
2	CytomX	Arcus Biosciences	Research Associate
2	LakePharma	Distributed Bio, Inc.	Director of Strategic Partnerships
2	Bayer	Dow AgroSciences	Senior Computer Systems Validation (CSV) Specialist
2	Distributed Bio	Skyhawk Therapeutics	Associate Scientist
2	Distributed Bio	Stanford University	Bioinformatics Analyst
2	BioMarin	Oncternal Therapeutics	Director, Program and Alliance Management
2	Distributed Bio	Distributed Bio	Director of Internal Engineering
2	BSRI	Navy	
2	BSRI	Tenaya Therapeutics	Senior Research Associate
2	Plexxikon	Plexxikon, Inc.	Director, Business Development
2	LakePharma	Invitae	Automation Engineer
3	Stanford University School of Medicine	Stanford University School of Medicine	Ph.D. student
3	BioMarin Pharmaceutical	BioMarin Pharmaceutical	Senior Manager
3	Encoded Genomics	Insitro	Scientist I
3	Amgen	Thermo Fisher	Manufacturing Supervisor
3	Linkage Biosciences	BioWatch	Biological Scientist
3	EpiBiome	BioMarin Pharmaceutical	Senior Research Associate I
3	OncoMed Pharmaceuticals	Amunix	Scientist
3	California Transplant Donor Network	Donor Network West	Tissue Donation Coordinator
3	FibroGen	Midwestern University	Research Specialist
3	Amgen	Amgen	Associate Scientist
3	PLOS	Flatiron Health	Product Manager
3	BioMarin Pharmaceutical	Epic	Technical Services
3	Carrot Sense	Deep Labs	Data Analyst Engineer
3	Amgen	Harpoon Therapeutics	Research Associate
3	Distributed Bio	BioMarin Pharmaceutical	Senior Research Associate
3	Genentech	Genentech	Senior Project Coordinator
3.5	Roche Molecular Systems	GeneWEAVE	Senior Scientist
4	Encoded Genomics	Encoded Genomics	Senior Research Associate
4	Distributed Bio	UCSF	Staff Research Associate I
4	U.C. Berkeley	University of Texas at Dallas	Ph.D. student
4	Amgen	Nkarta Therapeutics, Inc	Senior Research Associate II
4	Amgen	Atreca	Senior Research Associate
4	Encoded Genomics	Maze Therapeutics	Senior Research Associate
4	EpiBiome	BioMarin Pharmaceutical	Clinical & Reg Affairs Associate
4	Ab Initio	Thermo Fisher	Scientific Account Manager
4	Distributed Bio	Distributed Bio	Senior Scientist
4	Genentech	Guardant Health	Clinical Research Associate

4	CytomX	EpiCypher	Research Associate III
4	EpiBiome	Novogene	Marketing Supervisor
4	Timmerman lab, UCSF	Quest Diagnostics	Research Associate
4	Annexon Biosciences	Annexon Biosciences	Senior Research Associate
4	Amgen	Synthekine	Scientist
4	Cero Therapeutics	Nkarta Therapeutics	Research Associate
4	Counsyl	Pear Therapeutics	Design Assurance Engineer
4.5	Ab studio	Applied Molecular Transport	Project Manager
4.5	Ab Initio	Zymergen	Research Associate
5	BioMarin	BioMarin	Portfolio Analyst
5	Distributed Bio	Genentech	Researcher
5	Distributed Bio	EpiCypher	Research Associate III
5	Distributed Bio	Distributed Bio	Senior Scientist
5	Roche Molecular Systems	Thermo Fisher	Clinical Affairs
5	Denali Therapeutics	Denali Therapeutics	Research Scientist
5	Haystack Sciences	ChemPartner	Associate Scientist
5	Distributed Bio	Genentech	Senior Scientific Researcher
5	UCSF	Gilead Sciences	Clinical Trial Management Associate
5	USF	University of Vermont	Lab Research Technician
5	UCSF (regulatory)	Loyola Law School	JD candidate
5	UCSF (contracts)	Exelixis	Corporate Counsel, Contracts
5	OncoMed	SanBio	Process Development Associate III
5	Nkarta Therapeutics	Nkarta Therapeutics	Senior Clinical Research Associate
5	Encoded Therapeutics	Encoded Therapeutics	Scientist I
5	Viewpoint Therapeutics	Zymergen	Research Associate
5	Genentech	CytomX	Senior Research Associate
5.5	Denali Therapeutics	Distributed Bio	Scientist
6	UCSF, Rosenblum lab	Applied StemCell	Project Manager
6	Distributed Bio	Cero Therapeutics	Senior Research Associate
6	Control Panel/Droplet	Kit.com	Senior Laboratory Technician
6	JUUL	Tenaya Therapeutics	Research Associate II
6	UCSF clinical	Tricada	Clinical Trial Assistant
6	Alector	TrueBinding	Associate Scientist II
6	Control Panel/Droplet	Guardant Health	Clinical Laboratory Associate II
6	Genentech	Genentech	Senior Scientific Researcher
6	Distributed Bio	Distributed Bio	Scientist
6.5	Haystack Sciences	Nektar Therapeutics	Research Associate II
7	Felix Biotechnology	Bristol Myers Squibb	Quality Control Associate I
7	Distributed Bio	Distributed Bio	Scientist
7	Cepheid	Harpoon Therapeutics	Research Associate
7	Intrexon	Kelly Science	Scientific Recruiter
7	Distributed Bio	Distributed Bio	Project Manager
7	Encoded Therapeutics	Clara Foods	Research Associate
7	10x Genomics	10x Genomics	Production Associate
7	Intrexon	Mammoth Biosciences	Senior Research Associate
7	StemPharm	Abcam	Research Associate
7	Indie Bio	Indie Bio	Bioengineer
7	Distributed Bio	Loxo Oncology	Senior Research Associate
7	GALT	Federation Bio	Research Associate II
8	USF	BioSpyder	Research Associate
8	Centivax	Centivax	Scientist
8	Distributed Bio	Distributed Bio	Associate Scientist
8	SafeTraces	Apton Biosciences	Research Associate
8	Celltheon	Celltheon	Research Associate
8	PACT Pharma	PACT Pharma	Production Specialist
8	PACT Pharma	PACT Pharma	Research Associate
8	Distributed Bio	Distributed Bio	Bioinformatics Assistant
8	Annexon Biosciences	Annexon Biosciences	Research Associate
8	CODA Therapeutics	CODA Therapeutics	Research Associate
8	Spotlight Therapeutics	Spotlight Therapeutics	Research Associate II
8	DNAlite	DNAlite	Research Associate
8	BioPharma Connections	Nkarta Therapeutics	Intern
8	Distributed Bio	Nurix	Research Associate
8	Charles River Laboratory	Charles River Laboratory	Project Management Specialist

8	Sinopharm	Sinopharm	QC Specialist
8	Denali Therapeutics	Denali Therapeutics	Clinical Trial Assistant
8	Thermo Fisher	Thermo Fisher	Formulation Scientist
8	Benchling	Benchling	Account Executive
8	Reddit	Reddit	Specialist
8	BioPharma Connections	Roche	Intern
8	Applied StemCell	Applied StemCell	Marketing Associate
8	Vaxart	Vaxart	QC Analyst I

Harney 252 Cell Culture Core Facility

Zeiss PrimoVert Inverted Microscope
Bio-Rad TC20 Automated Cell Counter
Sorvall ST8 Centrifuge
Heraeus Hera Cell 240 Tissue Culture Incubator (x2)
5' Thermo 1300 Series A2 Tissue Culture Hood
4' Thermo 1300 Series A2 Tissue Culture Hood
6' Labconco Purifier Class II Biosafety Cabinet
Bio-Rad ChemiDoc XRS+ Molecular Imager
Bio-Rad C1000 Thermal Cycler with CFX96 Real-Time System
TECAN Infinite M Plex Plate Reader
Nexcelom Bioscience Cellometer Mini
Bio-Rad C1000 Thermal Cycler
Qubit 3.0 Fluorometer
illumina iSeq 100
Eppendorf 5804R Centrifuge

Harney 224 Microscopy Suite

Zeiss LSM 700 Laser Scanning Confocal Microscope
Zeiss Observer.D1 Wide Field Fluorescence Microscope
Keyence BZ-9000 Fluorescence Microscope

Harney 213 Research Lab with shared equipment

Sage Science Blue Pippin
Agilent Technologies 4200 TapeStation
Bio-Rad T100 Thermal Cycler (x2)
Qubit 4 Fluorometer

LS 204 Biotech Prep Area

Heraeus Hera cell Tissue Culture Incubator
Baker SterilGuard III Advance Biosafety Cabinet
Leica DMIL LED Inverted Microscope
Bio-Rad T100 Thermal Cycler
Beckman Coulter Avanti J-E Centrifuge

LS 205 Biotech teaching lab

Bio-Rad C1000 Thermal Cycler with CFX96 Real-Time System
Bio-Rad iMark Microplate Reader

BD Accuri C6 Flow Cytometer
Bio-Rad ChemiDoc MP Imaging System
Eppendorf 5402 Centrifuge
Thermo Scientific Nanodrop Lite Spectrophotometer
Amersham GeneQuant pro
Eppendorf 5418 Centrifuge (x3)
Thermo Max Q 4450 Incubating Orbital Shaker

LS G04 Biotech teaching lab

Sorvall RT7 Centrifuge
Baker SterilGuard III Advance Biosafety Cabinet
GE NanoVue plus
VWR Incubating Orbital Shaker
Eppendorf 5414D Centrifuge
Bio-Rad iMark Microplate Reader
Bio-Rad Gel Doc EZ Imager
Bio-Rad T100 Thermal Cycler
Bio-Rad Model 16K Microcentrifuge (x2)