GRADUATE EDUCATION IN PHARMACY SCHOOLS AND COLLEGES

Trends in Research and Graduate Programs in Schools and Colleges of Pharmacy, Part 1: Programs

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Objective. To examine the landscape of research and graduate education nationally and within schools and colleges of pharmacy. This report is part 1 of a three-part series and focuses on graduate programs' research funding and science faculty composition and diversity.

Findings. Between FY2008 and FY2017, the number of full-time faculty members in schools and colleges of pharmacy increased 36%. The number of pharmacy schools with National Institutes of Health (NIH) awards increased by 15%, while NIH grants per faculty principal investigator (PI) increased by 31%. However, unadjusted for inflation, the mean NIH dollar amount per-faculty member PI increased just 14% and the mean NIH dollar amount per-school declined 7%, indicating that number of funded faculty outpaced dollars available. Proportionately, the percentage of science faculty members at pharmacy schools decreased from 47% to 43%. Only 15 public, research-intensive schools and colleges of pharmacy received more than half of the combined FY2017 NIH funding and total funding, while all other public and private schools and colleges of pharmacy shared the remaining funds. Interdisciplinary programs are developing slowly, and may help to diversify and increase future funding. Proportions of tenured and tenure-track positions are declining, but biological sciences and social and administrative sciences disciplines are growing and women faculty are making significant gains in these fields and at the assistant professor rank.

Summary. Research-intensive schools and colleges of pharmacy are best-positioned to lead the academy to reframe graduate education to build interdisciplinary team skills and attract more diverse funding and science faculty members.

Keywords: graduate, training, research, funding, trends

INTRODUCTION

The graduate education infrastructure in schools and colleges of pharmacy has been instrumental in producing scientists and leaders in academia, the pharmaceutical industry, federal government, non-governmental organizations (NGOs), and other science-based policy positions. Over the last two decades, the foundation of graduate education has been impacted by external and internal factors that have influenced its sustainability and accountability. This report series examines these factors in light of the significant increase in the number of schools and colleges of pharmacy, including current and emerging challenges and opportunities over the last 10 years that impact graduate students, science faculty members, graduate education, and research infrastructure in pharmacy schools; science faculty composition, including discipline

identity, rank, tenure status, gender, and race and ethnicity; factors that support and hinder a diverse environment in pharmacy schools; graduate enrollment, degrees conferred and gender, race, and ethnicity over the last 10 years; and graduate student experiences (mentoring, career navigation).

In 1998, American Association of Colleges of Pharmacy (AACP) Commission on the Future of Graduate Education in the Pharmaceutical Sciences was charged to examine two major questions: What are the numbers and abilities of PhD graduates needed in the pharmaceutical sciences, and what should be the nature of the education and training of PhD students in the pharmaceutical sciences? The report's major recommendations included: schools and colleges of pharmacy must offer students competitive research environments under supervision of highly qualified faculty mentors; pharmaceutical sciences faculty should be encouraged to engage in multi- or interdisciplinary research and graduate training programs within their own institution and with

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other faculty members within the university; graduate programs in the pharmaceutical sciences should establish, compile, and assess longitudinal databases of performance indicators to assess faculty, student, and program quality, and annually submit data for a common set of indicators to AACP; schools and colleges of pharmacy should provide “survival skills” (non-research) training to graduate students; and schools and colleges of pharmacy need to increase recruitment from non-pharmacy disciplines.¹ These recommendations are still timely, and should be considered appropriate for other “life sciences” disciplines that have emerged in schools and colleges of pharmacy over the last 10 years.

There have been significant changes to graduate education in schools and colleges of pharmacy. In 1993, nearly 40% of individuals who received their PhD two decades earlier were tenure-track or tenured faculty members. By 2008, this percentage dropped below 30%. The slope of this decline has remained steep.^{2,3} Notably, the anecdote that most PhD trainees go into academic research has been incorrect for decades. Even for students receiving their degrees in the early 1970s, the percentage never exceeded 50% (once postdoctoral training had been completed). Today, more PhDs work in non-academic science-related careers than within universities. Some of these careers involve science policy or regulatory functions rather than research.⁴ Overall, there is a very low rate of unemployment among biomedical PhDs,³ and trainees move to careers in nonacademic sectors at a high rate. However, new graduates who secure positions in the private sector or government agencies may have serious difficulties adapting to a non-academic culture. The largely unacknowledged challenge today for graduate programs in biomedical sciences is to provide job skills and core competencies⁵ that will support the majority of trainees pursuing careers in nonacademic sectors, without compromising their rigorous training in basic biomedical disciplines.

Previous analyses incorporated into this report are based on biomedical research and graduate education reports released in the last 10 years, including the National Institutes of Health (NIH) *Biomedical Research Workforce Working Group*,³ the NIH’s Advisory Committee to the Director (ACD) *Working Group on Diversity in the Biomedical Research Workforce (WGDBRW)*,⁶ *A National Analysis of Minorities in Science and Engineering Faculties at Research Universities*,⁷ *The Path Forward: The Future of Graduate Education in the United States*,⁸ *Rising Above the Gathering Storm Revisited: Rapidly Approaching Category 5* from the National Academies,⁹ and the National Science Foundation (NSF)

Survey of Earned Doctorates (SED).¹⁰ Many of the scholarly reviews of graduate science education focus on a number of changes that need to occur to ensure its sustainability, accountability, and success.

Each year the AACP Research and Graduate Affairs Committee (RGAC) examines various aspects of research and graduate affairs within the Academy. The 2014-2016 RGAC’s Report¹¹ recommended a competency-based model of graduate education and postgraduate education (including both basic and clinical postdoctoral training) for pharmacy schools, and the 2016-2017 RGAC developed six domains of core competencies for graduate education in the pharmaceutical sciences.⁴ Building on that model, the 2017-2018 RGAC¹² was charged to focus on reducing barriers to recruiting and retaining diverse and successful graduate students. The committee reinforced the need for training students in professional, non-research “power skills,” including leadership and management, and personal and professional development. Following those earlier efforts, the 2018-2019 RGAC honed in on the need to expand collaborative research and leadership development opportunities.¹³

For this investigation, AACP institutional research data were mined regarding extramural research funding, graduate student enrollees, number of PhD degrees conferred, and faculty composition, including discipline, rank, tenure status, gender, and race/ethnicity. These data are reported annually by pharmacy schools and compiled, analyzed, and summarized by AACP. Per AACP’s statement entitled “Pharmacy Faculty Research Grant Data Collection: Process and Methodology,” research grant data are a combination of NIH and external funding, as follows: AACP annually requests from the NIH a complete report of NIH-funded research grants awarded to principal investigators at schools and colleges of pharmacy during the past federal fiscal year (October 1-September 30). The AACP staff populates the NIH research grant data into a report form and sends each report to the school or college’s CEO Dean of record for verification, modification, deletion, or addition based on their own funding record. The deans are then asked to report awards from other federal agencies and non-federal sources (nongovernmental organizations such as the Patient-Centered Outcomes Research Institute (PCORI), state-level agencies, associations and foundations, pharmaceutical industries, etc), as well as collaborative PI subcontracts (an investigator who received a flow-through NIH or other federal or nonfederal subcontract from the PI/project leader of a parent grant, which was awarded to another college or school within the same institution or from a different institution). The AACP verifies the submitted reports using uniform criteria to

validate that the grants are investigator-initiated, competitive, and peer-reviewed.

OBJECTIVE

The objective of this comprehensive analysis of graduate education infrastructure, aligned with pertinent insights and strategy from national reports on graduate education and biomedical research, is to inform change in the culture and structure of graduate programs in pharmacy schools into the future.

FINDINGS

Research and graduate education in pharmacy schools are financially supported by state investments, tuition revenue, and research grants and contracts. A 10-year composite overview of the AACP Institutional Research Data from schools and colleges of pharmacy from FY2008 to FY2017 is provided in Table 1. This is a collection of all external research funding data from the NIH and “other” external research awards. Between FY2008 and FY2017, there was a 31% increase in PI-only NIH dollars awarded to schools and colleges of pharmacy (from \$262M to \$343M) and a 41% increase in NIH total funding (from \$290M to \$410M). Because of a change in AACP’s methodology since FY2011, in which more types of non-federal funding (specifically industry funding and state agencies) are included in the totals, it is difficult to compare total research funding across the 10-year period. That said, there was still an impressive 97% increase in non-NIH funding (from \$97M to \$191M) and a 41% growth in total funding (from \$427M to \$601M) between FY2011-FY2017. This indicates a new and expanding research portfolio for schools and colleges of pharmacy, and displays the importance of diverse funding sources as a major driver in enhancing the research infrastructure within these institutions.

Although the total dollar amounts have increased substantially over 10 years, it has not been commensurate to the significant increase in the number of pharmacy schools and funded faculty members during the time period. From FY2008 through FY2017, the total number of schools reporting research awards increased 52% (63 to 96). However, the mean NIH funding per school actually decreased by 7% (\$4.6M to \$4.3M), and the mean total awards per school increased by 18% (\$5.3M to \$6.3M). Because of changes in AACP reporting, changes in the numbers of funded faculty members and funding awards can only be examined over the last seven years (FY2011-FY2017). In that period, the number of funded faculty members increased by 45% (998 to 1448) and NIH-funded faculty members

increased by 25% (698 to 874). However, the mean NIH funding per funded faculty member decreased 14% (\$330K to \$283K) and the mean total funding per funded faculty member decreased 3% (\$428K to \$415K). Although an increase in the number of funded faculty members potentially serves as a good indicator of the job market for biomedical science faculty members, the per-faculty dollar amounts demonstrate that available funding has not increased commensurately and, if it continues on the current trajectory, could hamper the establishment of strong research programs.

The vast majority of funded faculty members are at public institutions, although private schools and colleges have expanded their funded research in the last 10 years. In FY2017, 12% (173 out of 1448) of funded faculty members were at 35 private institutions. The proportion of NIH-funded faculty members to total funded investigators are 46% at private institutions (81 out of 173) and 62% at public institutions (793 out of 1275). The percent of NIH funding to overall funding is 57% (\$20M out of \$35M) for private institutions, and 69% (\$389M out of \$566M) for public institutions in the same time period. Proportionately, private pharmacy schools received just 5% of NIH funding (\$20M out of \$410M) and 6% of total awards (\$35M out of \$601M). Of note, just 15 public pharmacy schools received more than half of the combined FY2017 NIH funding and total funding, while the other 81 public and private schools shared in the remaining funds. Taken together, these data demonstrate the critical importance of diverse funding sources as a major driver in enhancing the research infrastructure in pharmacy schools, particularly at the largest research-intensive public institutions.

Emergence of New Disciplines and Interdisciplinary Graduate Programs

Extramural funding is critical to the success of graduate programs in schools and colleges of pharmacy. Along with school and university investments, these grant awards support graduate student stipends. The increase in the number of schools reporting research awards suggests that over the past 10 years there has been a significant increase in graduate education in pharmacy schools. An analysis of graduate programs (Table 2) indicates that pharmaceutical sciences/biological sciences is the most prevalent graduate program area, with 60 established programs across the United States. Pharmacology as a discipline is next with 26 programs, and pharmaceutical economics/health outcomes is the third most popular area with 21 programs. Table 2 presents a summary of interdisciplinary programs compiled as part of the March 2016 RGAC AACP Survey on Graduate Education, to which 72

Table 1. National Institutes of Health and Total Grant Funding for US Schools and Colleges of Pharmacy

Year	FY2008	FY2009	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017 ^c
# Pharmacy schools ^a	NA	NA	NA	124	129	130	133	135	138	142
# Full-time faculty ^b	4631	4957	5326	5586	5849	6040	6025	6303	6292	6319
# Funded schools	63	68	73	85	86	93	97	100	113	96
# Funded faculty	NA	NA	NA	998	950	1033	1049	1281	1467	1448
# Schools w/ NIH award	63	68	73	74	79	80	84	82	94	85
# NIH PI status only ^c	519	550	547	524	498	491	482	525	577	597
# NIH-funded faculty ^d				698	672	683	706	762	871	874
NIH PI-only funding	\$262.5M	\$320.3M	\$358.3M	\$274.5M	\$269.9M	\$265.3M	\$280.1M	\$294.7M	\$322.9M	\$342.9M
NIH total funding	\$290.2M	\$350.1M	\$401.3M	\$329.7M	\$327.0M	\$310.3M	\$342.4M	\$357.3M	\$384.1M	\$409.5M
All other funding	\$45.6M	\$80.8M	\$93.7M	\$97.0M	\$89.1M	\$120.1M	\$128.3M	\$195.3M	\$174.2M	\$191.5M
Grand Total	\$335.8M	\$430.9M	\$495.1M	\$426.7M	\$416.1M	\$430.4M	\$470.8M	\$552.5M	\$558.4M	\$601.0M
NIH \$ per PI only	\$505,874	\$582,325	\$654,995	\$523,896	\$542,060	\$540,381	\$581,180	\$561,247	\$559,548	\$574,310
NIH \$ per NIH-funded faculty	NA	NA	NA	\$472,367	\$486,638	\$454,319	\$485,056	\$468,847	\$441,037	\$468,542
Total \$ per funded faculty	NA	NA	NA	\$427,572	\$438,002	\$416,658	\$448,805	\$431,318	\$380,634	\$415,055
NIH \$ per funded school	\$4,606,519	\$5,148,214	\$5,497,919	\$3,878,970	\$3,802,570	\$3,336,559	\$3,530,408	\$3,572,615	\$3,399,495	\$4,265,685
Total \$ per funded school	\$5,330,167	\$6,336,961	\$6,781,815	\$5,020,196	\$4,838,390	\$4,628,040	\$4,853,567	\$5,525,182	\$4,941,501	\$6,260,419
% NIH PIs per funded faculty	NA	NA	NA	53	52	48	46	41	39	41
% NIH \$ of total \$ per funded school	86	81	81	77	79	72	73	65	69	68
% funded schools	NA	NA	NA	69	67	72	73	74	82	68

^a #pharmacy schools obtained by AACP from institutional member lists from July of each year; includes regular and associate member schools. Survey from FY11 on included associate member schools, but AACP cannot confirm if associate member schools were included in FY08-FY10.

^b Full-time faculty obtained from AACP's Full Time Faculty Trends Dashboard <https://www.aacp.org/research/pharmacy-faculty-demographics-and-salaries>. The full-time faculty numbers may not match FTE data from FY2011-15 research funding reports due to changes in AACP's collection methods for research data.

^c AACP limited federal grant search to the following agencies: FIC, NCATS, NCCAM, NCI, NCRR, NEI, NHGRI, NHLBI, NIA, NIAID, NIAMS, NIBIB, NICHD, NIDA, NIDCD, NIDCR, NIDDK, NIEHS, NIGMS, NIH, NIMH, NIMHD, NINDS, NINR, NLM, OD.

^d For those years available (FY11-FY17), total calculated from institutional rankings file, NIH tab (includes PI grants and collaborative subgrants).

^e FY16 and FY17 data include funding of students, staff and trainees as well as faculty/administrators due to a change in AACP's collection method for research grant data.

Table 2. Discipline-Specific and Interdisciplinary Graduate Programs in US Schools and Colleges of Pharmacy

PROGRAM TYPE	Number of Programs
DISCIPLINE-SPECIFIC	
Pharmaceutical Sciences/Biological Sciences	60
Pharmacology/Toxicology/Experimental Therapeutics/Clinical and Experimental Therapeutics	26
Pharmaceutical Economics, Policy Outcomes, Health Outcomes Research, Pharmaceutical Health Services Research	21
Medicinal Chemistry	17
Chemistry, Chemical Biology, Pharmaceutical Chemistry	3
Drug Discovery	2
Biological and Medical Informatics	1
Biophysics	1
Pharmacognosy	1
TOTAL	132
INTERDISCIPLINARY	
Biomedical Sciences (Engineering: chemical, biochemical)	14
Neuroscience	9
Structural Biology (Cancer biology, biochemistry, Chemical biology, computational)	7
Molecular, Cellular Life Sciences (Molecular bioscience)	5
Toxicology	2
Epidemiology/Gerontology	2
Bioinformatics	1
Public Health	1
TOTAL	41

schools and colleges responded.¹¹ Interdisciplinary programs were defined as those graduate programs that include more than one college or school within a university, with partnerships typically being between pharmacy and medicine, engineering, or nursing. The RGAC survey found 41 interdisciplinary programs; the most prevalent areas of focus were biomedical sciences, structural biology, and molecular/cellular life sciences. The majority were partnerships or collaborations with schools and colleges of medicine.

Studies by Porter and colleagues^{14,15} found that science as a whole is becoming more interdisciplinary, albeit with small steps drawing mainly from neighboring fields (eg, pharmaceutical sciences faculty members collaborating with faculty members from medicine and engineering). Likewise, over the last decade, federal funding agencies have emphasized new approaches to improving the synergy and interactions among multi- and interdisciplinary research teams through dedicated, high-impact, interdisciplinary science grants (eg, NIH RC2 awards that support high-impact ideas for new fields of investigation) and other instruments, including training grants to stimulate integrative science (eg, NSF's Integrative Graduate Education and Research Grants [IGERTs]). Graduate programs are evolving to become more interdisciplinary and align with related fields in order to sustain and strengthen their competitiveness.

Science faculty members at schools and colleges of pharmacy are critical for supporting science-based courses in the pharmacy curriculum, as well as supporting the research portfolio and curriculum of the graduate programs. The two major department identities for many schools are pharmaceutical sciences and social and administrative sciences, and there are several common research disciplines: the longstanding medicinal/pharmaceutical chemistry/pharmacognosy, pharmaceuticals/pharmacy, and pharmacology/toxicology disciplines, and more recent disciplines of biological sciences/biomedical sciences and social and administrative sciences.

For this investigation, science disciplines were defined by the AACP categories of biological/biomedical sciences, medicinal/pharmaceutical chemistry/pharmacognosy, pharmaceuticals, pharmacology/toxicology and social and administrative sciences. The number of science faculty members at schools and colleges of pharmacy by self-reported discipline and gender in FY2008 and FY2017 are presented in Table 3. Although as previously mentioned there was a 52% increase in number of schools and colleges reporting institutional research awards and a 36% overall increase in full-time faculty members, there was only a 22% increase in the number of science faculty members (from 2,072 to 2,521) during the same time period. In FY2008, science faculty members represented

Table 3. AACP Science Faculty by Rank, Discipline, and Gender

FY2008		Provost	Dean	Assoc Dean	Asst Dean	Professor	Assoc Prof	Asst Prof	Instructor	Lecturer	Total
Biological/Biomedical Sciences	M	–	1	3	1	19	20	39	4	1	88
	F	–	0	1	1	6	9	24	4	0	45
Medicinal/Pharm. Chem/ Pharmacognosy	M	–	12	12	3	197	104	104	0	3	435
	F	–	2	1	2	21	29	34	0	0	89
Pharmaceutics	M	–	10	15	7	141	109	98	13	1	394
	F	–	4	3	2	29	39	54	5	3	139
Pharmacology/ Toxicology	M	–	16	21	5	147	110	96	4	0	399
	F	–	1	3	3	33	48	51	1	1	141
SAS	M	–	11	25	8	65	62	48	2	0	221
	F	–	2	5	10	22	33	47	2	0	121
Total	M	–	50	76	24	569	405	385	23	5	1537
	F	–	9	13	18	111	158	210	12	4	535
FY2017											
Biological/Biomedical Sciences	M	1	5	4	4	45	52	72	3	2	188
	F	0	0	2	1	16	33	55	0	0	107
Medicinal/Pharm. Chem/ Pharmacognosy	M	0	12	27	5	195	149	98	1	0	487
	F	0	2	3	2	35	35	34	0	3	114
Pharmaceutics	M	2	11	19	2	138	138	87	1	3	401
	F	1	3	3	2	46	48	60	4	2	169
Pharmacology/ Toxicology	M	0	12	27	5	144	139	87	5	0	419
	F	0	2	6	6	45	67	55	1	4	186
SAS	M	2	17	21	10	71	64	54	4	0	243
	F	0	2	15	12	39	50	85	3	1	207
Total	M	5	57	98	26	593	542	398	14	5	1738
	F	1	9	29	23	181	233	289	8	10	783

approximately 47% of the total faculty members in pharmacy schools (2072 out of 4455). Ten years later, the number of science faculty members declined to 43% of total faculty members (2521 out of 5886). Over the past 10 years, across all schools and colleges of pharmacy, there has been a 22% increase in the number of science faculty members and a 42% increase in the numbers of practice faculty members and faculty members of other disciplines. However, the number of schools and colleges reporting research awards has outpaced available funding, such that the per-school mean of NIH funding decreased (-7%) and the per-school mean total funding only modestly increased (18%) over the 10-year period.

In terms of discipline focus, there has been a concerted effort by pharmacy schools to enhance recruitment of faculty members within the biological sciences. Since FY2008, the number of faculty members within this discipline has more than doubled (122%, from 133 to 295). According to AACP data, biological sciences has been the discipline with the lowest number of faculty members across all ranks. The significant increase would appear to align with the perceived focus of schools on increasing their NIH portfolio of awards in the life sciences. The historic science disciplines in pharmacy schools are medicinal chemistry, pharmaceuticals, and pharmacology (Table 3). Together the number of faculty members in these three disciplines increased by 179 (11%) in 10 years (from 1,597 to 1,776). The number of faculty members in medicinal chemistry increased 15%; pharmaceuticals, 7%; and pharmacology, 12%. The number of faculty members in social and administrative sciences, another emerging discipline, increased by 32% (to 108 faculty members). This increase points to the academy's expanding research portfolio and efforts in epidemiology, health outcomes, and pharmacoeconomics. These results clearly indicate that discipline identity in schools and colleges of pharmacy has changed over time. This could be partially explained by the fact that many scientists practice multidisciplinary approaches to research questions and no longer see themselves as members of a specific discipline.

In FY2017 the greatest proportion of senior faculty members, ie, professors, were in medicinal chemistry (30%), followed by pharmaceuticals (24%) and pharmacology (24%), while only 8% of senior faculty members were in biological sciences and 14% were in the social and administrative sciences. Since FY2008 there has been a 122% increase in biological sciences professors and a 32% increase in social and administrative sciences professors. However, in FY2017 both of these disciplines together only represented about 22% of the science faculty members who had achieved the rank of professor (171 out of 774). At the other end of the spectrum,

assistant professors have the highest faculty count in biological sciences and social and administrative science among the science disciplines. Further, both disciplines have had significant increases in assistant professors between FY2008 and FY2017: 64 and 44 positions, respectively. These results suggest a strategic recruitment focus of these two disciplines. Biological sciences and social and administrative science are emerging disciplines within schools and colleges of pharmacy based on percent increases and the high number of assistant professors in these areas.

Trends in Gender, Rank, and Tenure of Science Faculty Members by Discipline

Nationally there has been a significant influx of female scientists into academia over the last 10 years, according to the SED report.¹⁰ As observed with other professional schools, pharmacy has also witnessed a significant increase in female scientists.¹⁰ In pharmacy schools, the number of female science faculty members increased by 46% (from 535 to 783) between FY2008 and FY2017 (Table 3). During this same period, the number of male science faculty members increased by 13% (1,537 to 1,738). In social and administrative sciences, the percentage of female faculty members increased from 35% in FY2008 to 46% in FY2017; female faculty members in pharmacology increased from 26% to 31%; medicinal chemistry, from 17% to 19%; biological sciences, from 34% to 36%; and pharmaceuticals, from 26% to 30%. The changing proportion of female faculty members also reflects some progress, increasing from 26% in FY2008 to 31% in FY2017. The total number of male faculty members was higher than female faculty members in each discipline in FY2008, ranging in proportion from 1.8:1 in social and administrative sciences to as high as 4.9:1 ratio in medicinal chemistry, and an overall ratio of 2.9:1. Ten years later, in each discipline the ratio of male to female faculty members decreased, with a range of 1.2:1 to 4.3:1, and an overall ratio of 2.2:1, which indicates that there is room for improvement.

These data also provide insight on recruitment and promotion trends over the last 10 years. With the increase in female faculty members, assessment of promotion and faculty rank by gender provides a perspective on faculty progression and academic success. There has been a robust increase in the number of female faculty members among the five science disciplines in each faculty rank since FY2008, increasing by 46% compared to an increase of 13% for male faculty members. Female faculty members gained 248 positions across all ranks; 79 at the assistant professor level, 75 at the associate professor level, and 70 at the professor level. There were only 13

Table 4. Gender Diversity of Faculty Members in Academic Medicine and Pharmacy in the United States

	Professor		Associate Professor		Assistant Professor		Instructor	
	M	F	M	F	M	F	M	F
Medicine, Basic Sciences ^a								
Anatomy	420	159	268	131	272	179	44	50
Biochemistry	815	238	411	174	461	246	72	50
Microbiology	614	192	362	170	345	251	31	42
Pathology (Basic Science)	386	170	255	180	353	385	36	49
Pharmacology	611	170	295	151	364	213	69	52
Physiology	526	139	258	101	253	155	51	36
Other Basic Sciences	1765	690	1043	666	1450	1151	156	213
Total	5137	1758	2892	1573	3498	2580	459	492
Female faculty members, %		25		35		42		52
Pharmacy, Sciences ^b								
Biological/Biomedical Sciences	45	16	52	33	72	55	3	0
Medicinal/Pharm. Chem/Pharmacognosy	195	35	149	35	98	34	1	0
Pharmaceutics	138	46	138	48	87	60	1	4
Pharmacology/Toxicology	144	45	139	67	87	55	5	1
Social Administrative Sciences	71	39	64	50	54	85	4	3
Total	593	181	542	233	398	289	14	8
Female faculty members, %		23		30		42		36

^a Association of American Medical Colleges, Faculty Roster: U.S. Medical School Faculty, Table 13: U.S. Medical School Faculty by Sex, Rank, and Department 2017. <https://www.aamc.org/data/facultyroster/reports/486050/usmsf17.html>. Medicine Basic Sciences departments included Anatomy, Biochemistry, Microbiology, Pathology (Basic Science), Pharmacology, Physiology, Other Basic Sciences.

^b Pharmacy science faculty include AACP disciplines of Biological/Biomedical Sciences, Medicinal/Pharmaceutical Chemistry/Pharmacognosy, Pharmaceutics, Pharmacology/Toxicology, and Social Administrative Sciences.

female associate deans from science disciplines in FY2008, and that number more than doubled to 29 by FY2017. By rank, the increases in number of male faculty members included 13 assistant professors, 137 associate professors, and 24 professors (total of 174 positions), as well as 22 additional associate dean positions (from 76 to 98). In FY2008 the proportion of female to male science faculty members at the assistant, associate, and full professor levels were 35%, 28% and 16%, respectively, and 26% overall. At the same rank order, in FY2017 the proportion of female faculty members were 42%, 30%, and 23%, respectively, and 31% overall. Despite a

significant increase in the number of women faculty members at each rank over the last 10 years, the overall percentage of female faculty members changed by 5% (from 26% to 31%), and the proportion of male to female pharmacy science faculty members was still more than 2:1.

The Association of American Medical Colleges¹⁶ data on US medical school faculty members provides insight on the trends in gender representation in academic medicine among the basic science departments (identified as anatomy, biochemistry, microbiology, pathology (basic science), pharmacology, physiology, and other basic

Table 5. Faculty Tenure Status and Gender

Tenure status	Gender	FY08	FY17	Change within Status, %
Tenured	M	879	964	10
	F	219	295	35
Tenure-Track, Nontenured	M	357	381	7
	F	140	224	60
Nontenure Track or Nontenure Institution	M	247	389	57
	F	153	258	69
Total	M	1483	1734	17
	F	512	777	52

sciences). In 2017, 25% of professors in academic medicine basic science departments were female compared to 23% of women pharmacy science faculty. The percent of women associate professors in medicine was 35% compared to 30% for women associate professors in pharmacy (Table 4). Women assistant professors in medicine and pharmacy were identical at 42% in both disciplines. The percent of female science faculty members in schools of medicine and the 10 year trend were relatively in line with similar assessments for female science faculty members in pharmacy.

The number of science faculty members between FY2008 and FY2017 by tenure status and gender are presented in Table 5. There was an increase of 269 tenured and tenure-track faculty members (17%, from 1,595 to 1,864) and an increase of 247 science faculty members in the non-tenure track or at nontenure institutions (62%, from 400 to 647). Science faculty members in the non-tenure track or at nontenure institutions represented 20% of pharmacy science faculty members at schools and colleges of pharmacy in FY2008, growing to 26% in FY2017. Women faculty members represented 20% of tenured science faculty members in FY2008 and 23% in FY2017. The proportions were slightly higher for tenure track female faculty members, improving from 28% to 37% in 10 years. Female science faculty members in the non-tenure track or at nontenure institutions showed minimal gains in equity (from 38% in FY2008 to 40% in FY2017).

Comparing the number of female faculty members in the United States working in the life sciences in tenured and tenure-track positions with the number in schools and colleges of pharmacy, pharmacy is trailing behind the national benchmarks. Women are achieving more than 50% of the life science degrees, although their representation in tenure or tenure-track positions is approximately 33%. The number of tenured faculty members at pharmacy schools are lower but similar to the number of tenure-track faculty members.¹⁷ Whether examining discipline representation, tenure status, or rank, the increasing numbers of female faculty members are positive in each of these sectors. There is a sustained trend in gender diversity of science faculty across the Academy. Overall, there have been significant positive changes in the demographics for pharmacy faculty members, but there is still more to be done to achieve equity for female faculty members. Furthermore, gender diversity seems to be more realized than racial diversity within the Academy (racial diversity is discussed in detail in part 3 of this series).

DISCUSSION

There are significant internal and external factors that impact the recruitment, retention, and success of science

faculty members in schools and colleges of pharmacy. These include the timeline associated with training for a faculty position, pursuit of research funding to support laboratories and trainees, the role of tenure, and the challenges in increasing diversity among graduate faculty members.

The challenges of attaining a tenure-track faculty position are often exacerbated by the general expectation that a candidate have significant research experience acquired through postdoctoral training to enhance their research skill set. Obtaining these experiences can require an additional three to six years after completion of a PhD. Upon securing a tenure-track faculty position, the expectation for obtaining external funding, usually federal, is explicit. Thus, science faculty members must develop and sustain their research funding and laboratory in order to achieve tenure and to maintain their research programs.

Although the institutional research dollars for pharmacy schools, specifically funds from the NIH, have increased significantly since FY2008 (Table 1), the landscape of funding in terms of competitiveness and sustainability continues to be challenging to navigate.^{2,18} This is especially acute for junior science faculty members. According to the NIH Biomedical Research Workforce Report,³ the percentage of NIH grant holders with independent R01 funding who were under the age of 36 years has fallen sixfold (from 18% to 3% of all funding recipients) over the last 30 years. Complicating this is the minimal increase in federal research funding opportunities during a time when both medical schools and pharmacy schools are increasing the number of biomedical scientists on their faculty. This clearly results in an unsustainable, overly competitive environment that may substantially impact the ability for growth in the biomedical sciences and reduce research dollars that support science faculty trainees. Junior faculty members, even those with significant research potential, tend to be trapped in the milieu of endless unscored grants or poorly scored resubmissions, resulting in professional frustration and career stagnation. This not only impacts their success as science faculty members, but also presents a career in academia in a negative light to graduate students and postdoctoral trainees.

Today, only 14% of faculty members with a PhD in the life sciences hold tenure or tenure-track faculty positions five years after graduation,¹⁹ and scientists pursuing an academic career face a significantly elongated path to achieving tenure. In most instances, tenure is dependent on the faculty member being awarded a federal grant (NIH, NSF, etc) for which they are the principal investigator. Today the average age of a first time R01 awardee is 42 years.²⁰ This timeframe may exceed the "tenure" clock; thus, attaining tenure may be elusive. In

line with these findings, the tenure-track position as a career destination has decreased and a review of tenure status of science faculty members in schools and colleges of pharmacy is needed.

Some of the most encouraging data observed during this analysis was the growth and representation of women science faculty members in pharmacy. As stated before, there has been an increase in female science faculty members who are tenured or on a tenure track.²¹ However, in 10 years the total tenured and tenure-track science faculty members increased by 269, nearly equal to the total of 247 nontenure-track science faculty members or those at nontenure institutions (Table 5). This same trend has been reported across academia where the number of tenure-track positions has not increased with the number of new PhD graduates.²² Although the proportion of science faculty members in non-tenure track positions and at nontenure institutions to total science faculty members has grown from 20% to 26% between FY2008 and FY2017, the percent of tenured science faculty members has slightly declined over the past 10 years from 55% to 50%, and the percent of tenure-track faculty members has declined from 25% to 24%.

SUMMARY

Increases in institutional research funding over the last 10 years indicate an expanding research portfolio for schools and colleges of pharmacy, with diverse (ie, non-NIH) funding sources as a major driver in enhancing the research infrastructure. However, a decrease in the average amount of research dollars allocated per faculty member could hamper opportunities for individuals to establish and maintain strong research programs.

Graduate programs have evolved beyond the traditional programs of pharmaceuticals, pharmacology, and medicinal chemistry to include interdisciplinary programs that are increasingly aligned with departments or schools of medicine and engineering. With the advent of niche areas and more translational/interdisciplinary areas, pharmacy schools may need to redefine or expand disciplines to cover areas that are now relevant to the pharmaceutical sciences.

Trends in the rank, gender, and discipline of faculty members in schools and colleges of pharmacy indicate that number and proportions of female scientists in biological sciences and social and administrative science are increasing in pharmacy schools. However, the overall percentage of female faculty members in pharmacy schools has only increased by 5%, and the proportion of male to female pharmacy science faculty is still more than two to one overall. Further investigation into what motivates female scientists to enter academia,

as well as what is essential for them to overcome the perceived challenges and obstacles to maintaining academic careers as women.

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