

## Women in Medical Physics

We were honored to be invited to write this article, *Women in Medical Physics*, for the 50<sup>th</sup> anniversary issue of Medical Physics. Of course, our perspectives are only the briefest part of the story of women in our field. We look forward to many more important conversations as we continue on this journey toward equity for all genders.

To begin, we wish to state that the goal of equity, diversity, and inclusion efforts ultimately is not a diverse workforce for its own sake, it is workforce excellence. We aim for our field to excel in patient care, research, education, and outreach. Actively promoting and supporting diversity, including gender diversity, is one way in which we achieve excellence. We would also propose the deontological argument: *it is simply the right thing to do*. Below, we offer three individual perspectives on gender equity in medical physics.

*Kelly C Paradis, PhD*

In 2017, there was a panel session at the AAPM annual meeting in Denver, Colorado, about how sponsorship could promote diversity in the field of medical physics. One of the speakers celebrated the accomplishments of past women medical physicists and provided a few relevant statistics. One was that the percent of PhDs earned by women in physics had increased by a factor of four over the last 50 years. This was potentially even an understatement, as the percent had grown from about 3% in the late 1960's to about 18% in the late 2010's (although I note that the 2008 percentage is the same as the 2019).<sup>1</sup> But then I heard the speaker say, "women aren't a minority anymore [in medical physics] ... you're about equal, 50/50."

I wondered, could that be true? I thought about my undergraduate physics class, which was comprised of two women and fifteen men, my first graduate physics lab in which I worked directly with no other women at all, and then finally my current role as a medical physicist where finally not only were there other women but also several in leadership roles. I took a look at the most recent AAPM Professional Survey at the time (2016) and read "women continue to comprise 23% of the AAPM membership".<sup>2</sup>

This uncertainty about gender diversity in our field has remained in the back of my mind over the last several years since I first heard that AAPM talk. How can we improve if we don't know where we stand? In 2019, with Drs. Elizabeth Covington and Jean Moran, I co-authored "The state of gender diversity in medical physics"<sup>3</sup>, in which we examined the trajectory of women representation in AAPM, and the distribution of awards and leadership positions. We saw that only one woman had ever held an AAPM council chair position since they were created in the 1970s (in 2020 this increased to two women total), and that the journal Medical Physics had never had a woman Editor-in-Chief. We also saw that the percentage of women who had won association awards was less than the overall representation within the membership for all awards except the John R. Cameron Young Investigators Symposium Award. When the 2021 Journal Paper Award Recipients were announced on Twitter, I replied, "Congratulations to all the men winning awards named after other men (93% and 86%, respectively)".

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In Figure 1, we show the trajectory of the representation of women in AAPM over time, including all members, as well as Full, Resident, and Junior members individually. What we see is that the higher representation of women in residency has not translated (or is translating very slowly) into full membership. Could this be due to a lack of role models in training programs (in 2019, 7.5% of CAMPEP graduate program directors and 21.5% of residency program directors were women)?<sup>3</sup> Or because in 2021, women medical physicists ranked 7 of 8 workplace climate categories significantly lower compared to men?<sup>4</sup> Or is it because women experience discrimination and harassment in our field, “including those related to unequal compensation, discrimination against mothers, discrimination during the hiring process, gender-biased assumptions about behaviors or goals, communication biases, and overt and persistent sexual harassment”?<sup>5</sup> Clearly there is more work to do, and it is time to start focusing on the implementation of data-driven interventions rather than collecting more data about problems that we already know exist.

*Jean M. Moran, PhD*

From the start of my education, I have been acutely aware of gender inequity in the sciences, engineering, and medical physics. I distinctly remember my first Annual Meeting (Anaheim, California, 1994) while in my 2nd year at the University of Michigan. I was thrilled and nervous to present the work I had done with Dr. Benedick Fraass (William D. Coolidge Award Winner in 2013) and Dr. Mary Martel (AAPM President in 2007). I was excited to soak up new science and meet the scientists who wrote the books and articles I read. That first conference ultimately led to me joining the AAPM in 1995, lifelong friendships, and an unwavering commitment to our organization and profession. But I was an outlier as I counted few sessions with any women speakers, panelists, or moderators.

While celebrating 50 years of publishing *Medical Physics*, I am dismayed that only two women have received our highest honor recognizing a career of excellence in medical physics: the William D. Coolidge (WDC) Gold Medal - Edith Quimby (1977) and Maryellen Giger (2015). A handful of other women have been recognized with the Marvin M.D. Williams (MMDW) Professional Achievement Award and/or the Edith H. Quimby (EHQ) Lifetime Achievement Award - Ann E. Wright (MMDW: 1991), Melissa Martin (MMDW: 2009, EHQ: 2015), Marilyn Stovall (EHQ: 2007, MMDW: 2013), Jean M. St. Germain (MMDW: 2015), Priscilla F. Butler (MMDW: 2020), Mary L. Meurk (EHQ: 2000), Azam Niroomand-Rad (EHQ: 2006), Caridad Borrás (EHQ: 2013), and Ellen D. Yorke (EHQ: 2019). When considering the next 50 years of our field, I would like to see equity in a range of opportunities to support excellence in our field:

- mentorship and sponsorship that results in equitable distribution of awards
- rates of women and men applying for and receiving grants in medical physics<sup>6,7</sup>
- leadership in research, teaching, clinical and other environments.

Within our organization, I have spoken with numerous physicists (women and men) who disagreed with me that we have an equity problem. Finally, the dialogue is changing beyond pointing to a few successful women as an argument against inequity. The completion of the 2021 AAPM Equity, Diversity, and Inclusion Climate Survey<sup>4</sup> along with the creation of the AAPM Equity, Diversity, and Inclusion Committee (EDIC) are important steps forward. The Women’s Professional Subcommittee (created in 2010) continues its work through its newsletter, proposing content each year for our

annual meeting, and the ever-popular Women's Luncheon (initially led by Nicole Ranger). The Work Group on Science Council Equity Diversity and Inclusion is developing guidelines to encourage equitable membership in Science Council groups. New initiatives will continue to be created.

I am heartened by these more substantial efforts towards equity. We are learning more from quantitative and qualitative research from training<sup>8-10</sup> through professional positions and an ever-expanding content of thoughtful presentations at AAPM meetings. But are we doing enough? Could we do more? While we started with an Ad Hoc and then the formal EDIC, our sister organization, ASTRO, voted to create a Healthcare Equity, Diversity, and Inclusion Council (within ASTRO, "Councils" are high level groups just under the Executive Committee, similar to AAPM's structure). Just as equity and excellence will strengthen our field for medical physicists as individuals, we also want equity and excellence for our patients too. I hope that the ongoing efforts today will result in meaningful change. I hope that all will agree that we need to strive to achieve equity in recognition of excellence. I eagerly hope for a day when equity is achieved, and more than 11 women are professionally recognized for their scientific, educational, and professional contributions to medical physics.

*Kristi R. G. Hendrickson, PhD*

In my rural Midwestern high school, there were several young women in the only physics class, as anyone planning to go to college (about 20% of the senior class) would usually take all science courses offered. In my introductory physics courses in my small, liberal arts college, there were many women, but fewer than 20% of them graduated with a physics major in my cohort year. I was the only woman in my first-year graduate courses; the only woman in my PhD lab group; and most often the only woman in the room, even if it was just a coffee break. I was the first and only woman hired as physics faculty in my first position after graduate school, which I left to transition to a medical physics career. I kept going because I had wanted to be a physicist ever since junior high, but it was lonely, discouraging, and at times depressing. In hindsight, I see that I was not able to be my best and achieve to my highest potential because of the unwelcoming environment. The bias and discrimination was at times direct and obvious, more often tacit and subtle, but always there. The lack of peers, mentors, and role models that looked like me made a difference.

In Figure 2, graduation data from the National Science Foundation (NSF) and the National Center for Education Statistics (NCES)<sup>11</sup> are overlaid with data from the Commission on Accreditation of Medical Physics Education Programs (CAMPEP). From 1966-2018, the NSF and NCES collected and published graduation data by major and included gender information. The yellow (highest) line in Figure 2 is the percentage of women who earned a bachelor's degree in any major in the year indicated. The blue line is the percentage of women earning a bachelor's degree in physics. An increasing number of bachelor's degrees in physics were awarded over the period shown in the figure, with 9283 total physics bachelor's degrees awarded in 2018. The bachelor's degree in physics is an entry-level degree into the field of medical physics, along with other science, technology, engineering, and mathematics (STEM) majors. Since approximately the year 2000 or over the past 20 years, the percentage of physics degrees earned by women has been decreasing, after a fairly steady rate of increase over the prior 40 years.

From 2014-2021, CAMPEP collected gender data on the entering classes of all CAMPEP-accredited graduate and trainee programs. These programs include master's degrees, doctoral degrees, and

residency programs in medical physics. The percentage of entering MS and PhD students who identify as women increased, perhaps one might say dramatically increased, over the first half of the data collection period. Although it has leveled off or decreased in the second half (Figure 2 and Table).

Why this leveling off or drop in percentage of physics undergraduate degrees and medical physics degrees earned by women? Are we to accept this as normal or as good as it can get? Dr. Ann Nelson in her commentary “Diversity in Physics: Are you part of the problem?” says “The reasons for underrepresentation are complex, but they are not subtle.”<sup>12</sup> The experiences of women in physics, like other STEM fields, include bias, harassment, and discrimination as part of the educational environment, which also lacks mentors and role models that can support and encourage women who experience these obstacles. Two important factors are recognition, where women can see themselves as physicists, and competency beliefs, where women come to understand that they are capable of doing physics. Dr. Nelson concludes in the same article, “Addressing the covert and overt racism and the unwelcoming culture in most physics departments is a great place to start correcting the problem.” She enumerates later in the article that our efforts need to include “...explicit and continual effort to encourage, mentor, and support all young physicists, to create a welcoming climate in your department, and to promote the hiring of diverse faculty members.”

The American Physical Society has created Step Up, a national program targeted at high school physics teachers with researchers and professional societies to combat the decreasing number of women earning physics degrees through culture change and empowerment of women to pursue physics in college.<sup>13</sup> Their goal is 50% physics bachelor’s degree attainment by women by 2025, that is, equal representation by women in physics. The curriculum that they have created helps all students to understand the current conditions for women in physics based on current statistics and documented experiences of the unwelcoming culture. By directly addressing the covert and overt, as Dr. Nelson points out, these women can see themselves as “physics people” and are armed with the tools to persist in a science they enjoy. Medical physics can do the same.

This special anniversary issue of *Medical Physics* is celebrating our remarkable history and future as a field. We have noted in each of our personal narratives that there is more to be accomplished for women in medical physics. All of us play a role in creating the climate in our workplaces and educational and training environments and determine the atmosphere of our volunteer-lead professional organizations. The recognition of the contributions of women in science and education should be acknowledged on a par with the impact of those contributions. *Medical Physics*, as our premier scientific journal, can take a further step to support equity and diversity beyond its Editorial Board by welcoming publication of the needed rigorous studies of our profession.

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Figure Captions:

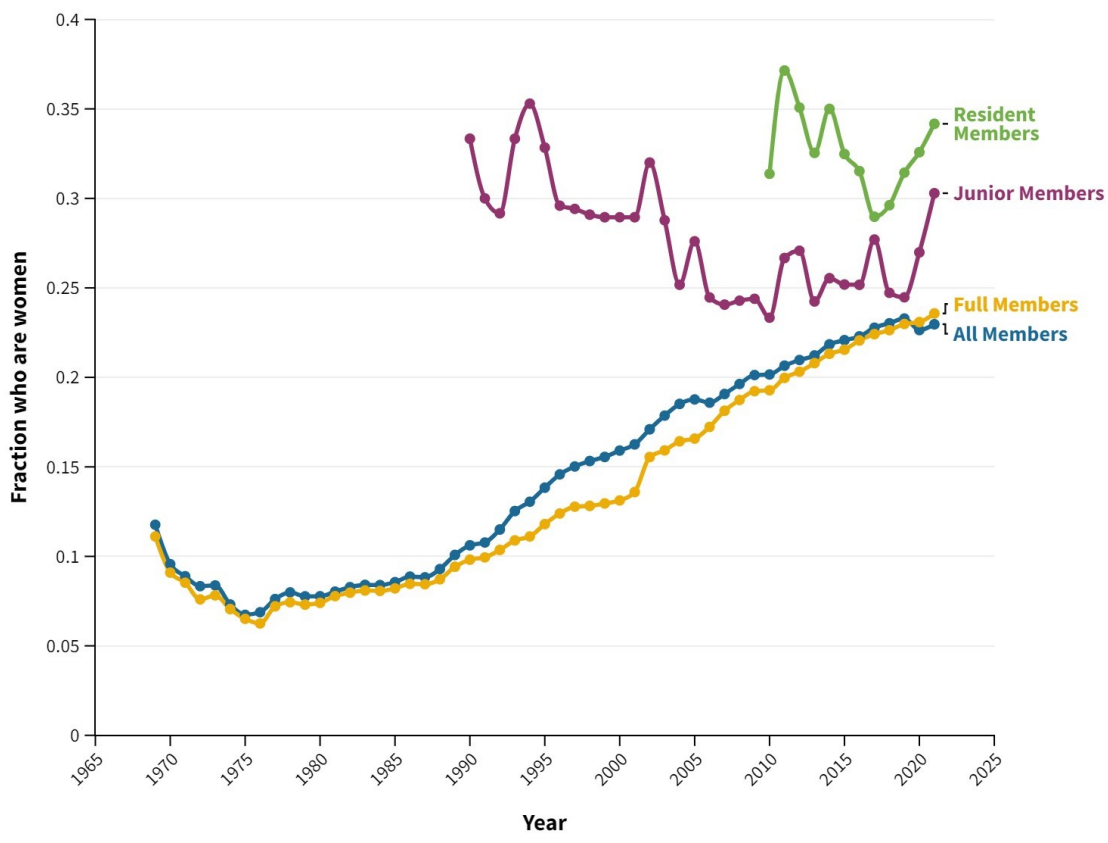


Figure 1: Fraction of APM Memberships held by women over time for all members and three subcategories: Full, Resident, and Junior.

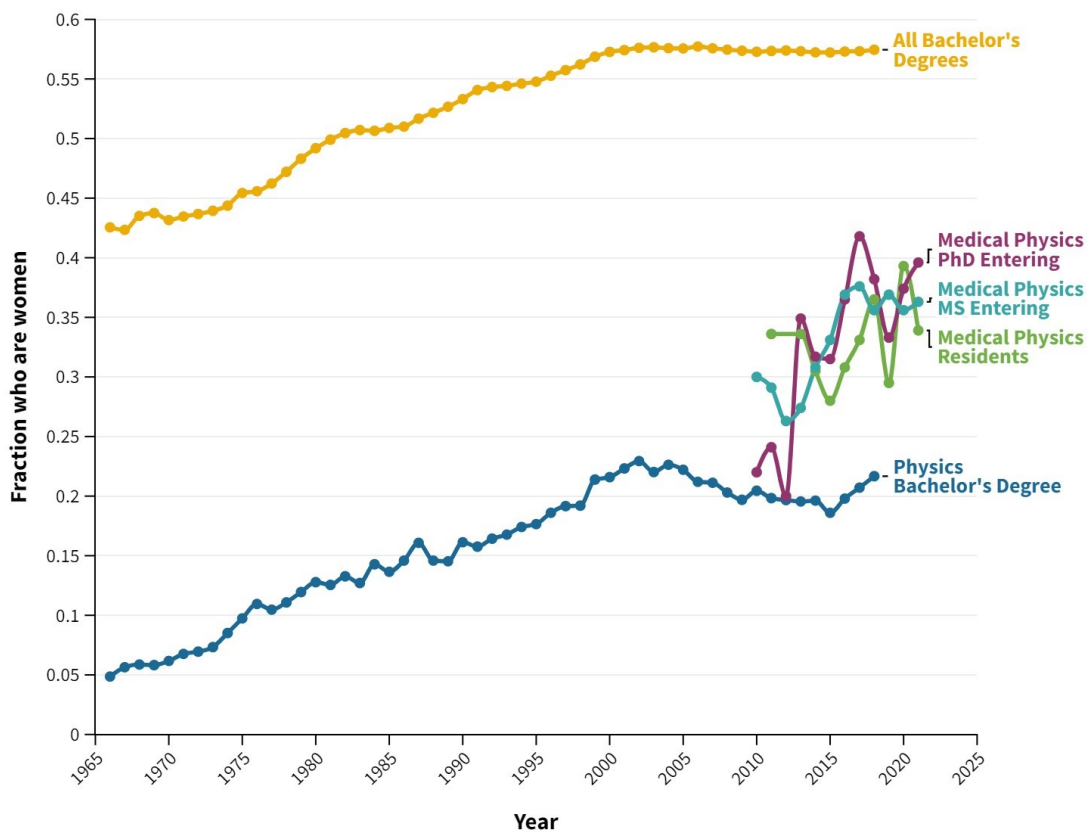


Figure 2: Fraction of all and physics bachelor's degrees earned by women over time, compared with the fraction of women entering graduate and resident medical physics programs.

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Table: Percentage (Number) of Women Entering Graduate Degree Programs  
and Residencies in Medical Physics

Year	MS	PhD	Certificate	Residency
2010	30.0% (NA)	22.0% (NA)	NA	NA
2011	29.1% (51)	24.1% (20)	NA	33.6% (42)
2012	26.3% (31)	20.0% (9)	NA	NA
2013	27.4% (48)	34.9% (30)	30.8% (8)	33.6% (42)
2014	30.8% (57)	31.7% (39)	NA	30.5% (43)
2015	33.1% (54)	31.5% (35)	NA	28.0% (40)
2016	36.9% (75)	36.5% (42)	11.6% (14)	30.8% (49)
2017	37.6% (77)	41.8% (46)	43.6% (17)	33.1% (79)
2018	35.6% (78)	38.2% (47)	22.0% (11)	36.5% (65)
2019	36.9% (76)	33.3% (40)	34.7% (17)	29.5% (54)
2020	35.6% (88)	37.4% (58)	39.2% (20)	39.3% (81)
2021	36.4% (87)	39.6% (53)	30.5% (18)	33.9% (64)