Journal of the History of Biology (2007) 40:509–528
DOI 10.1007/s10739-007-9131-y

Beyond the Boss and the Boys: Women and the Division of Labor in *Drosophila* Genetics in the United States, 1934–1970

MICHAEL R. DIETRICH and BRANDI H. TAMBASCO
Department of Biological Sciences
Dartmouth College
Hanover, NH 03755, USA
E-mail: Michael.Dietrich@Dartmouth.edu

Abstract. The vast network of *Drosophila* geneticists spawned by Thomas Hunt Morgan's fly room in the early 20th century has justifiably received a significant amount of scholarly attention. However, most accounts of the history of *Drosophila* genetics focus heavily on the "boss and the boys," rather than the many other laboratory groups which also included large numbers of women. Using demographic information extracted from the *Drosophila Information Service* directories from 1934 to 1970, we offer a profile of the gendered division of labor within *Drosophila* genetics in the United States during the middle decades of the 20th century. Our analysis of the gendered division of labor supports a reconsideration of laboratory practices as different forms of work.

Keywords: division of labor, *Drosophila*, gender, genetics, Thomas Hunt Morgan, women

In the early 20th century, Thomas Hunt Morgan's network of *Drosophila* researchers transformed the science of genetics and made the *Drosophila* fruit fly into one of the most powerful genetic tools of the 20th century. Historians of genetics have justifiably spilled gallons of ink describing Morgan's group and its efforts.[1] Despite significant numbers of women within Morgan's group, however, the model accepted by most historians is one of the "boss and the boys."[2] This paper recovers part of the history of women within *Drosophila* genetics and analyzes the gendered division of labor within *Drosophila* laboratories in the United States that rendered women invisible yet indispensable.

[1] Allen, 1975, 1978; Carlson, 1966, 1981; Dunn, 1965; Harwood, 1993; Kohler, 1994; Sapp, 1987; Sturtevant, 1965.

[2] Kohler, 1994.

Using the geographical directories included in the *Drosophila Information Service* (*DIS*) bulletins from 1934 to 1970, we have been able to track changes in personnel within those *Drosophila* laboratories that reported their membership. The *Drosophila Information Service (DIS)* was begun by Calvin Bridges and Milislav Demerec in 1934. The purpose of the *DIS* was to promote open communication in a growing and increasingly dispersed field. Generally issued once a year, the *DIS* consisted of technical notes, short research notes, stock lists, and a directory of *Drosophila* laboratories and their workers. The directories were arranged geographically by country and then by state and city. Each laboratory reported its own staff as well as its current research interests. Staff lists included faculty, research associates, technicians, and students.[3] We focused our study on *Drosophila* workers in the United States, because we noticed that when many laboratories in the U.S. listed a woman her name was followed by either a "(Mrs.)" or a "(Miss)." This designation was not consistent, but it suggested that sex could be tracked through the *DIS* directories.

In this paper, we used information extracted from the *DIS* directories to analyze the division of labor with *Drosophila* laboratories in the United States from 1934 to 1970. Our data reveal a very clear division of labor among male and female workers in *Drosophila* genetics. Women were not excluded from tenure-track faculty positions, but were very strongly relegated to less prestigious positions as technicians or research assistants. Even when the field of *Drosophila* genetics experienced a significant period of growth after the Second World War, women experienced an uneven growth in their opportunities. While a glass ceiling never existed for women in United States, *Drosophila* genetics, there was certainly a sticky floor that prevented their proportional advancement in the field.

[3] The technical and research notes from the *DIS* have been retained by many libraries, but the directories were often discarded. As a result, finding a complete sample of the directories was a challenge. We have posted the geographic directories used for this paper at http://www.mendel.dartmouth.edu/fly/DIS/. These directories include information from many different nations in addition to the United States. Because labeling was absent and naming practices in other countries were less clear to us, we restricted our analysis to the United States.

Measuring *Drosophila* Genetics in the United States

The demographic data for workers in *Drosophila* laboratories in the United States was obtained from the geographic directories included in the *Drosophila Information Service*, Numbers 1–45 (1934–1970). *Directories* were not available for 1938, 1950, 1951, 1952, 1955, 1961, 1964, 1966, and 1969. We did not include information from geographic directories after 1970, because these later directories did not list all of the workers in *Drosophila* laboratories. *Drosophila* workers listed in the directories were counted and categorized first by sex, then by position.

Sex was often denoted in the directories by including a prefix of Miss or Mrs.[4] Entries without a prefix were sorted by first name. If the name was listed with only two initials and a last name, the person was counted as male. The independent sorting of a sample directory by R. C. Lewontin and J. F. Crow corroborated this convention. For the period from 1934 to 1970, sorting by use of initials was very reliable. Nevertheless, there were a number of individuals in each year that we could not judge, usually because no prefix was included and the name was ambiguous. These individuals constituted on average 3% of the total in each year (see Table 1). The numbers of male and female workers used here are only those we could determine using the prefix, the initials convention, or a clear male or female first name. We did not include those individuals who sex we could not determine in the totals used to calculate any proportions. Nevertheless, we freely acknowledge that our results are bound to include some errors and the results should be treated with caution. As we shall see, however, the differences between the sexes are frequently so great that they cannot be discounted as the result of any modest errors in counting and categorizing.[5]

Using the data extracted from the *DIS* directories, we first charted the growth of *Drosophila* genetics as a field by sex (Figure 1). Although

[4] Many of the women designated as married were spouses of men in the same laboratory group. Indeed within Morgan's group in the early decades of the century, his spouse Lilian worked as a research associate as did Phoebe Reed, Alfred Sturtevant's future spouse, and Helen Redfield, Jack Schultz's spouse. The *DIS* directory does not indicate whether or not these women were paid.

[5] The convergence of numbers of men and women in the early 1960s may be an artifact of a relative increase in the number of unknowns as compared to the number of unknowns after 1965.

Table 1. Numbers of *Drosophila* Workers by Category in the United States, 1934–1970

Year	Male professor	Female professor	Male research associate	Female research associate	Male assistant	Female assistant	Sex unknown	Total male	Total female
1934	35	1	11	3	5	11	1	51	15
1935	36	3	13	3	8	10	2	57	16
1936	41	4	15	4	9	8	2	65	16
1937	42	4	25	7	22	15	3	89	26
1939	40	4	17	9	17	20	0	74	33
1940	41	4	9	6	14	17	0	64	27
1941	39	4	8	9	15	16	0	62	29
1942	40	6	10	3	17	12	0	67	21
1943	42	7	5	1	7	13	1	54	21
1944	43	5	2	1	3	17	1	48	23
1945	43	3	8	1	2	19	2	53	23
1946	45	5	10	3	4	19	3	59	27
1947	57	6	4	2	9	20	3	70	28
1948	61	6	13	5	12	27	4	86	38
1949	62	6	12	9	18	31	2	92	46
1953	66	5	21	7	29	49	6	116	61
1954	75	8	21	7	28	57	6	124	72
1956	89	10	26	12	35	70	18	150	92
1957	94	9	30	18	32	76	18	156	103
1958	111	8	36	19	38	84	14	185	111
1959	115	10	41	30	40	85	17	196	125
1960	104	9	40	19	44	107	25	188	135
1962	103	8	47	23	47	127	21	197	158
1963	113	9	54	34	72	154	26	239	197
1965	132	17	59	41	65	145	14	256	203
1967	132	17	59	41	65	145	5	256	203
1968	163	23	73	33	46	170	15	282	226
1970	232	37	76	41	46	170	29	354	248

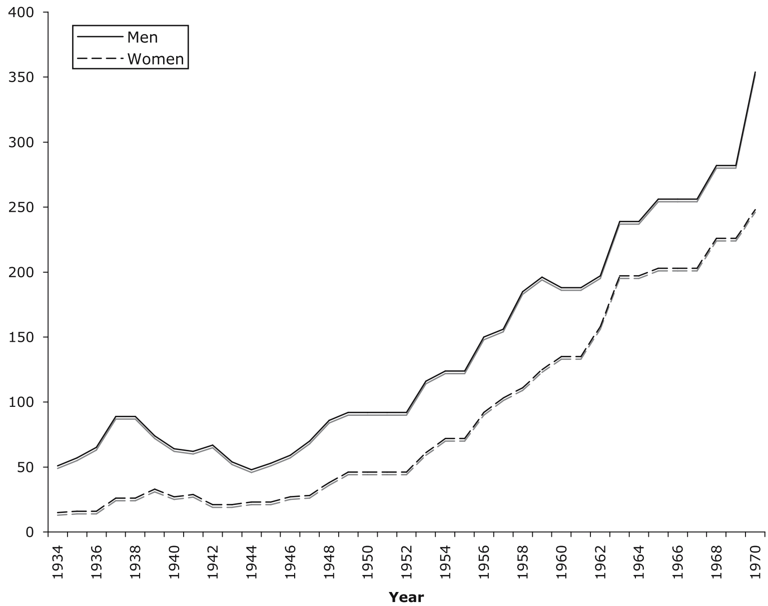

Figure 1. Numbers of Men and Women in *Drosophila* Genetics in the United States, 1934–1970. Data extracted from the *Drosophila Information Service* directories. See the text for an explanation of the methods used.

there were always more men overall than women, the proportion of men to women narrowed during the Second World War as more men became involved in the war effort. In terms of general demographic trends, the Second World War caused a significant dip in the number of both men and women doing *Drosophila* genetics. The decline was greatest for male assistants and both female and male research associates. The number of male professors remained nearly constant, while the number of female professor increased. During the post-war period, however, *Drosophila* genetics experienced steady growth as measured by the number of workers in the United States. Yet, while positions for women as research associates and assistants grew quickly, the number of women professors remained the same until the mid-1950s.

This same data set has also allowed us to demonstrate a very strong gendered division of labor (Figure 2). The wide variety of job titles provided in the *DIS* was grouped into three categories: Faculty, Research Associate, and Technical Assistant.[6] While the majority of men working in *Drosophila* genetics were Faculty, the majority of women were Technical Assistants. This gendered division of labor in American *Drosophila* genetics represents what Margaret Rossiter has labeled hierarchical segregation within science.[7] As scientific fields professionalized, some disciplines were associated with women; creating territorial segregation as fields such as home economics were understood as disciplines appropriate for women. Other fields were understood as more appropriate for men. If women were able to enter these fields, they experienced fewer opportunities for advancement and tended to be relegated to positions with less authority and prestige than their male counterparts. Certainly the disproportionate gendered division of labor in U.S. *Drosophila* genetics exemplifies the type of gender hierarchy identified by Rossiter.[8]

The handful of women in *Drosophila* genetics with faculty appointments suggests that there was a "sticky floor" rather than a "glass ceiling" operating in the United States in the middle decades of the 20th century. Women were not excluded from any employment category, but they certainly were not equally represented and did not have the same access to faculty appointments as men. We were able to verify the sex and career trajectories of all women listed in the faculty category by *DIS*. Between 1934 and 1970, we found only 36 women who held some faculty appointment. Before the Second World War, Catherine Beers

[6] The job titles were sorted into categories as follows: (1) the *Faculty* category includes Professor, Associate Professor, Assistant Professor, Adjunct Professor, Lecturer, Instructor, Assistant Instructor, Investigator, Visiting Professor, Scientific Director, Principal Geneticist, Director of Lab, Senior Geneticist US Department of Agriculture, Zoologist, Acting Director, Captain in US Army, Physicist, Research Supervisor, Acting Chairman; (2) the *Research Associate* category includes Independent Researcher, Visiting PhD, Associate, Associate Member, Fellow, Teaching Fellow, International Fellow, NRC Fellow, Doctoral Candidate, Researcher, Project Associate, Staff Scientist, National Research Fellow, Research Fellow, Research Biologist, Graduate Research Geneticist, Independent Investigator, Guest Investigator, Guggenheim Fellow, Research Chemist, Research Geneticist, Research Scholar, Women's Club Scholarship, Research, Gregory Fellow, Predoctoral Fellow, Junior Research Biophysicist, Visiting Scholar, Research Executive, Gosney Fellow, Visiting Investigator, Research Executive; (3) the *Technical Assistant* category includes Technician, Stock Keeper, Technical Assistant, Research Assistant, Curator of Stocks, Graduate Assistant, Undergraduate Assistant, Student Assistant, Experimentalist, Stock Custodian, Artist, Laboratory Attendant, Lab Helper, Preparator. In constructing these categories, we tried to make the Faculty category as inclusive as possible in order to not underrepresent women's advancement in this field.

[7] Rossiter, 1982; Scheibinger, 1999.

[8] Rossiter, 1997.

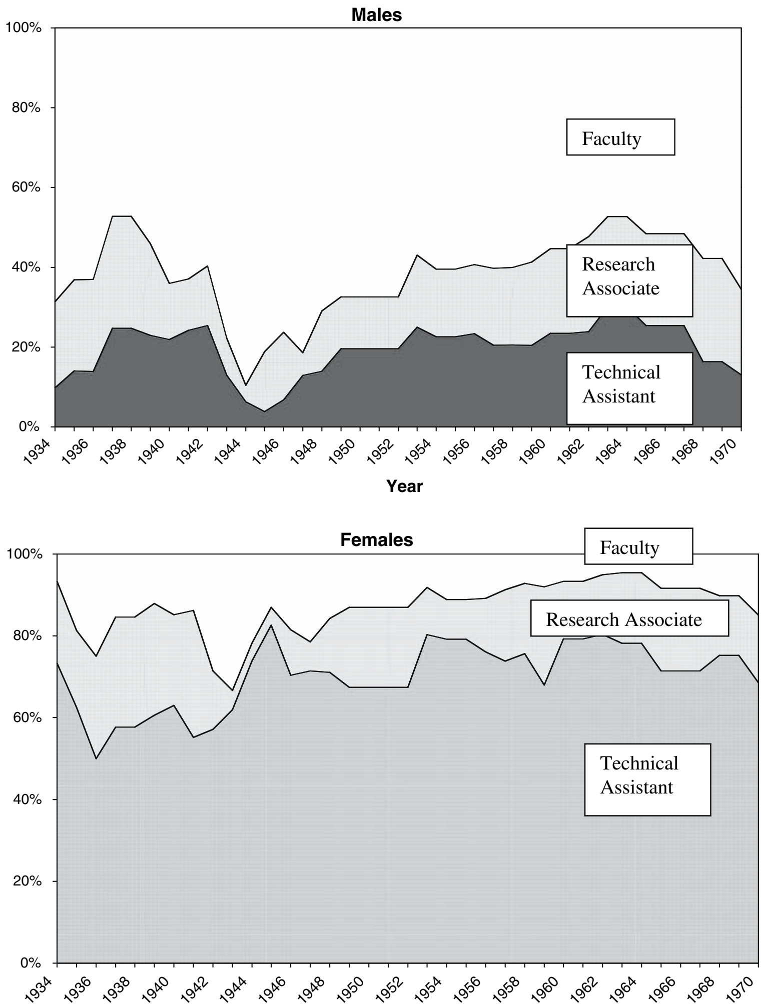

Figure 2. Division of Labor within U. S. *Drosophila* Genetics, 1934–1970. Changing percentages of men and women by category. Note that because of the small number of women in faculty positions before and during the Second World War, small changes in numbers of women result in large proportional changes.

held a faculty position at the University of Southern California, Ruth Howland worked at New York University, Sarah Bedichek Pipkin taught at North Texas Agricultural College, and Margaret Haydon and Louise Wilson both taught at Wellesley College. Compared to many other women in *Drosophila* genetics at the time, these women were exceptions in that they had faculty appointments. Yet, the careers of women, such as Sarah Bedichek Pipkin, for instance, exemplify the kinds of pressures affecting the majority of women in their field.

Born in 1913 Sarah Craven Bedichek was the daughter of noted Texas naturalist, Roy Bedichek. Indeed, both of her parents had college educations and both taught at some point during their lifetimes in local secondary schools.[9] The family's attitude toward women's education and employment was not that of the domestic ideal typical of the time. Roy Bedichek encouraged his spouse Lillian's career and intellectual pursuits, and, when their son married, Roy commended that he find an intelligent young woman.[10] Sarah Bedicheck was encouraged to attend college and in 1933 received a B.A. in Zoology from the University of Texas, Phi Beta Kappa.[11] Working with J.T. Patterson and H.J. Muller, she earned her PhD in 1937.

Doctorate in hand, Bedicheck returned to her families' home in Denton, Texas and taught anatomy and physiology at the Texas State College for Women, now the Texas Women's University. Within a year, she won a Rockefeller fellowship to do post-doctoral research at Kings College, University of London with the eminent British geneticist, J.B.S. Haldane. As a guest in the Department of Biometry, Bedicheck demonstrated that multiple gene sex-determination was correct with a series of experiments using the triploid *Drosophila melanogaster*.[12] At end of her fellowship year, she returned to Texas, where she was appointed to the faculty at North Texas Agricultural College, later named the University of Texas at Arlington. In 1938 she also married Alan Collins Pipkin.[13]

At the North Texas Agricultural College, Pipkin continued her studies of triploids and chromosome balance. During this time, her husband Alan attended and graduated from Tulane Medical School with a PhD in Entomology. In 1942, Pipkin resigned her position and joined her husband as his career took them to California, Beirut, Arkansas, Hawaii, Panama, and Maryland. Between 1943 and 1947, Pipkin had three sons and still seemed to find time for research and writing. While in Beirut after WWII, Pipkin taught biology and zoology at the Catholic University of Beirut, wrote a laboratory manual, and eventually taught a Medical Genetics course for the American

9 Bedichek, 1998, pp. 439–441, xiv.

10 Bedichek, 1998, p. 235.

11 Bedicheck, 1998, p. 440.

12 Bedicheck, 1998, p. 150; James F. Crow to Michael R. Dietrich, 6/4/2003, personal communication.

13 Bedichek, 1998, p. 440.

University of Beirut School of Medicine. Her research on seasonal fluctuations in Lebanese species of *Drosophila* was supported by a grant from the Rockefeller Foundation and contributed to an important literature on the population genetics of natural populations. Her results were published in *Molecular and General Genetics* in 1952 and *The American Naturalist* in 1953.[14] Pipkin maintained her research program despite her itinerate life by securing appointments, usually as a research associate, at a variety of institutions including Howard University, the Gorgas Memorial Laboratory in Panama, and John's Hopkins University. She ended her career with a faculty appointment at Howard University beginning in 1967, where she was promoted to full professor in 1970. While working in Panama and at John's Hopkins in the 1960s, she continued her work on population fluctuations and added new lines on inquiry regarding species introgression and feeding habits of tropical *Drosophila* species.[15] At Howard, she followed the growing molecularization of genetics with a research program focused on the genetics of dehydrogenases including alcohol dehydrogenase.[16] She died in 1977 in Washington DC.[17]

Like many women in science, Pipkin's career trajectory was not a seamless progression from student to faculty member. Although one of the few women to obtain faculty positions before the 1970s, Pipkin also subordinated her career to her marriage and her family. Indeed where other notable women in *Drosophila* genetics found the research associate category to be the most that they could achieve in terms of an appointment, Pipkin used the flexibility of a research appointment to maintain her research interests while meeting her domestic expectations.[18] Only after her three children had left home did Pipkin return to her research full time and then seek an appointment as a faculty member. It is worth noting, however, that when Pipkin was appointed at Howard in 1967, it was becoming much more common for women to enter the tenure track in *Drosophila* genetics.

From 1945 to 1970, *Drosophila* genetics grew steadily as a field. Both men and women benefited from this growth in that the number of both grew at almost the same rate during this period. However, the overall growth rates do not address the hierarchical segregation within the field.

[14] Bedichek, 1998, pp. 265, 281–283; Pipkin, 1952, 1953.

[15] Pipkin, 1965, 1968a, 1968b; Pipkin et al., 1966.

[16] Pipkin, 1968a, 1968b, 1969; Pipkin and Hewitt, 1972; Pipkin et al., 1972, 1973.

[17] Bedichek, 1998, p. 442.

[18] Many of the women active at the beginning of *Drosophila* genetics had appointments as Research Associates (Kohler, 1994).

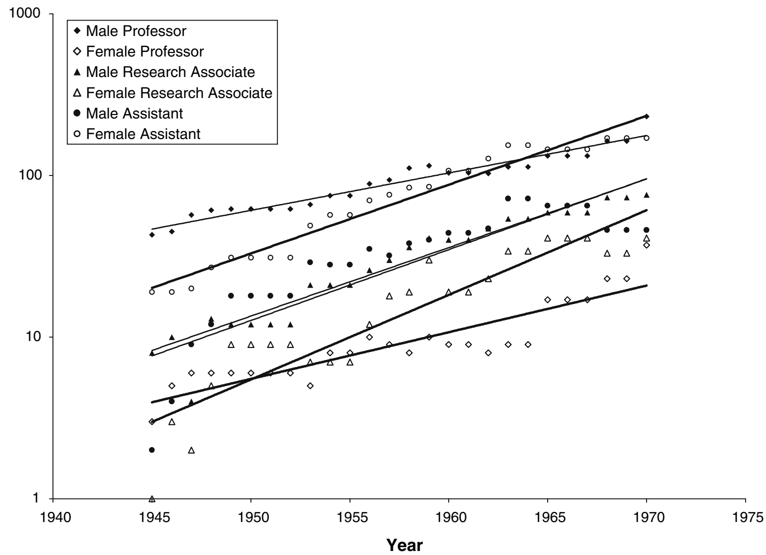

Figure 3. Growth in U.S. *Drosophila* Genetics, 1945–1970. Rates of growth for Male and Female Faculty, Research Associates, and Assistants. Dashed lines represent male trends. Solid lines represent female trends.

Margaret Rossiter has argued that during times of growth within science, hierarchical segregation should diminish as expansion creates new opportunities.[19] The data we have collected allows us to revisit the Rossiter thesis, albeit for only a subfield of genetics.[20]

When growth rates for *Drosophila* genetics are examined by category (faculty, research associate, and technical assistant) and sex (male and female), women show notably higher rates of growth only in the research associate and assistant categories (Figure 3). From 1945 to 1970, female faculty grew at close to the same rate as their male counterparts. The rate of growth in faculty positions was less than that of the other categories. So, while growth did correspond to greater opportunities for women, those opportunities still reflected hierarchical segregation within the field. In the post-war period, it was much easier for women to enter *Drosophila* genetics as technical or research assistants. This is not to say that women necessarily wanted to be research assistants. In a letter on behalf of his research assistant, Gertrude Heidenthal, Curt Stern inquired about the possibility of teaching positions for her from L. C. Dunn, a well-known

[19] Rossiter, 1978.

[20] Rossiter (1997) addresses the differences among different fields in science.

geneticist at Columbia University. Evidently, Stern and Heidenthal recognized that assistantships had "no permanency or future." Yet Stern did not think that Heidenthal had the "ambition to go into one of the top positions." Teaching at "any decent small college" was deemed the appropriate path for Heidenthal in 1941.[21] Heidenthal went first to Wellesley College and then by 1946 to Russel Sage College. She published two papers from her doctoral research with Stern, but at Wellesley her research shifted to a new organism, *Habrobracon*, a parasitic wasp.[22] *Habrobracon* was a good system for studying the genetic effects of radiation dosage, which was a topic of growing importance during the Cold War. In collaboration with L. B. Clark at nearby Union College, Heidenthal's research was supported by the Rockefeller Foundation and the Atomic Energy Commission.[23] While Heidenthal did teach as a small women's college, she continued a modest research program, albeit not with *Drosophila*.

Women's Work in *Drosophila* Genetics

While the data from the *Drosophila Information Service* directories reveal important gender differences within this field, they also highlight significant features concerning the nature of work and the division of labor within *Drosophila* genetics. The *DIS* directories provide a range of job titles from Professor to Research Assistant to Stock Keeper to Student, which we grouped into categories of Faculty, Research Associate, and Technical Assistant. We have demonstrated a significant difference in the distribution of genders across these categories, but does this also correspond to a real difference in the way work was distributed in *Drosophila* laboratories?

We do not have systematic information about how different labs in the United States organized and distributed their work. Indeed information about life in mid-century *Drosophila* laboratories is very difficult to find. As a result, our analysis of the division of labor will be based on what we can infer from job title information and from our analysis of Aloha Hannah-Alava's experience as a *Drosophila* researcher at the University of California, Berkeley beginning in 1942.

21 Curt Stern to L. C. Dunn, 4/22/1941. Curt Stern Papers. American Philosophical Society, Philadelphia, PA.

22 Stern and Heidenthal (1944) and Stern et al. (1946).

23 Heidenthal, 1945, 1952, 1953, 1960, 1962; Heidenthal et al., 1955.

As Robert Kohler has argued, the success of *Drosophila* as a model organism for genetics is a result of its easy adaptation to the laboratory setting, its relatively short life cycle, and the social network and norms that accompanied this emerging biotechnology.[24] Work within a *Drosophila* laboratory would typically involve maintaining fly stocks (cleaning fly bottles, preparing media and food, breeding flies every 2 weeks, etc.), performing experiments (breeding experiments typical of classical genetics would involve controlled mating of sometimes hundreds of flies, progeny would have to be sorted and counted), cytogenetic analysis, classification of different species and varieties, data collection, reporting of results, training, recruiting, and grant writing. Different laboratories would divide these and other tasks among their members in many ways. Evidence from the DIS directories suggests, however, that *Drosophila* work may have had some fairly typical divisions of labor and that these divisions of labor were gendered.

Perhaps because most historians of science are themselves academics, scientific work has often been considered in terms of the production of scholarly articles and books. While publications are very significant outcomes of research, they offer only a partial view of the practices that constitute scientific work. Indeed, they emphasize intellectual work over manual labor.[25] For present purposes, if we were to use publications as a measure of scientific work, we would over estimate the contribution of male workers. Using information from the DIS directories, we calculated the ratio of men to women working in *Drosophila* genetics in all categories in any given year sampled. We sampled the directory at 5-year intervals beginning in 1935. We then used the Flybase Reference database, which includes every commonly known reference to work on *Drosophila*, to find any publications by any person listed in the DIS directories for the year in question.[26] We then calculated the ratio of male to female publications and compared these to the male to female ratio for workers (see Figure 4). Although there is considerable variation in the publication ratio, the ratio of workers was always much less than the ratio of publications. Using publications to measure contribution to laboratory work will thus systematically underestimate the labor of women. It is important to note that the Flybase Reference database includes research notes as well as journal articles and books. Many technicians, who were predominantly female, frequently published technical notes in the *Drosophila Information Service*. If we

[24] Kohler (1994).

[25] Rose, 1983; Schiebinger, 1999.

[26] Flybase Reference. http://flybase.bio.indiana.edu/refs/

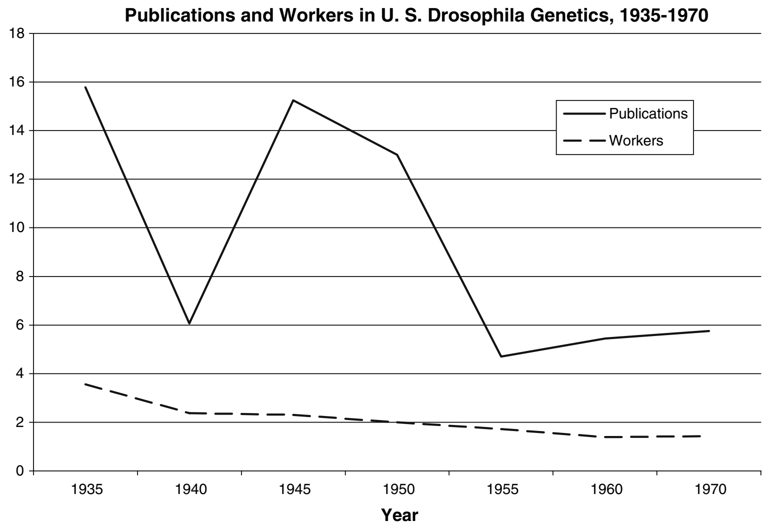

Figure 4. Proportions of Male to Female Workers and Publications in U.S. *Drosophila* Genetics, 1935–1970. See text for an explanation of methods and sources.

counted only refereed journal articles and books, the publication ratio would have been much higher.[27] That said, we do not wish to imply in any way that women in *Drosophila* genetics did not make significant intellectual contributions, either as assistants or as faculty members.

Technical assistants or technicians have been noted for their invisibility because of their notable absence from most forms of scientific publications. Conventions that judge the contributions of technicians as worthy of acknowledgement, but not of authorship, have been bolstered with arguments about the originality of author's contributions or the sustained involvement of authors in all stages of a project.[28] Given that the vast majority of technicians in *Drosophila* genetics were women, sexism could have made their exclusion from authorship seem easy and even natural during the mid-20th century. Certainly emphasizing authorship will tend to produce a skewed picture of laboratory work and an under-appreciation of the contributions of predominantly female technical assistants.

The Technical Assistant category spans a range of positions with the *Drosophila* laboratory. Some titles, such as Stock Keeper, Curator of

[27] We did not try to parse the relative contributions to articles with multiple authors, which are increasing during this time period. Each author on a multi-author article was scored as having written an article.

[28] Macrina, 2005; Russell et al., 2000; Shapin, 1989.

Stocks, or Stock Custodian, point toward the important task of keeping the laboratory's lineage of flies alive, clearly labeled, and genetically stable. As *Drosophila* genetics progressed before the Second World War, researchers began to depend on specific varieties of flies produced in the laboratory. For many kinds of experimental work, it was not efficient or in some cases possible to simply collect flies from a banana on a windowsill. Different varieties had known genetic constitutions and even designed sets of markers and chromosomal inversions that made them effective assay tools for mutational analysis.[29] Keeping stocks viable also required attention to temperature and general cleanliness. Mite infections can devastate a laboratory's collection of flies. A meticulous stock keeper and a diligent janitorial staff were indispensable, if the biotechnology known as *Drosophila* was to remain functional.

In addition to the expected title of Assistant or Technical Assistant, the Technical Assistant category is also populated with titles such as Artist, Laboratory Attendant, Experimentalist, and Preparator. While Artists were probably tasked with preparing figures for publications, the other titles in this category are not as specific. Since many fly labs were involved in both teaching and research, Technical Assistants could have been charged with preparing research protocols as well as classroom demonstrations or student laboratory exercises.

A more nuanced understanding of the division of labor within a *Drosophila* laboratory is possible by focusing on the career and experience of Aloha Hannah Alava. In 1913, Aloha Hannah was born in rural Montana. Her mother taught at the local school and Aloha also became a rural schoolteacher for 4 years before attending the University of Montana. Alava's interest in genetics was not encouraged by the Chairman of the Zoology Department who refused to recommend her for graduate school, claiming, "That is an impossibility. I have three young men to place in graduate school and since I grade by the curve, you can never expect more than a B." A young Botany instructor had a different perspective and helped Alava get into the graduate program at the University of Oklahoma. Her interest in illustration drew her toward cytology and cytogenetics at Oklahoma, where she completed a Masters degree in 1942.[30] The Chairperson of the Zoology Department was eager to place students at top schools for their doctorates. He pushed a skeptical Alava to apply to Berkeley, Columbia, and Chicago.

[29] We are referring to H. J. Muller's stocks of balanced lethals, which he designed to detect the effects of radiation. Carlson, 1981.

[30] Aloha Hannah Alava to Michael R. Dietrich, August 18, 1994. Personal Correspondence.

In response to her application, the Chairperson of the Zoology Department at Berkeley informed her that they were looking for "men with a straight A record." Alava assumed that his was a rejection until a letter came from Richard Goldschmidt asking her to join his laboratory group as a Cytological Assistant.[31] Goldschmidt had been a Director at the Kaiser Wilhelm Institute for Biology in Berlin-Dahlem before he had been forced to leave by the Nazis. He arrived at Berkeley in 1936 and set up a *Drosophila* laboratory whose research focused on physiological genetics and homeotic mutants.[32]

Alava arrived in the summer of 1942 to a Zoology Department almost emptied by the war effort – only three graduate students and assistants remained after the rest enlisted, went to Medical School, or to work in war related industry. Alava replaced Masou Kodani, who, as a Japanese-American, had been interred despite Goldschmidt's efforts to find a new position in the Eastern United States where he and his family would not be imprisoned.[33] Goldschmidt's group had a number of graduate students that were employed as teaching assistants. Alava joined another woman, Leonie Kellen, a German refugee who had been a graduate student at Berkeley and was later hired by Goldschmidt as his Research Assistant and Stock Keeper. Goldschmidt also employed Priscilla Hutchinson as a technician. Hutchison was trained as a nurse, but, as an African American woman in the mid-1930s, she had had difficulty finding employment in the Bay Area. Goldschmidt hired her upon his arrival at Berkeley. Alava comments that Goldschmidt could never teach Hutchinson how to count flies. This would have involved her in more of the experimental life of the lab, but would have also increased her workload. Alava was Hutchinson's direct supervisor and did not try to regulate her hours or alter her duties, which she performed flawlessly.[34]

The Goldschmidt laboratory had three rooms in the Life Sciences Building, so Goldschmidt, Kellen, and Alava occupied separate rooms.[35]

[31] Aloha Hannah Alava to Michael R. Dietrich, January 23, 1995. Personal Communication.

[32] Dietrich, 2003.

[33] Goldschmidt himself was listed as an Enemy Alien at this time and placed under curfew and travel restrictions.

[34] Aloha Hannah Alava to Michael R. Dietrich, February 6, 1995. Personal Correspondence.

[35] Aloha Hannah Alava to Michael R. Dietrich, February 6, 1995. Personal Correspondence.

Even when they were working on the same project, such as their analysis of the homeotic mutant Podoptera, they did their bench work independently.[36] Their individual contributions were written up separately and then combined by Goldschmidt for final publication.[37] Goldschmidt kept regular hours; arriving at 9am and leaving at 4pm. Alava and Kellen, however, tended to work late into the evening, since both had permission for night work during the war. A shortage of graduate students during the war also meant that the Zoology Department needed Teaching Assistants. Kellen, who wanted to teach, jumped at the opportunity, while Alava was more reluctant. From 1942 to 1945 they both worked half time as a Research Assistants and half time as a Teaching Assistants. Research for their doctoral theses and Leonie's duties as the Stock Keeper were added on to these other obligations.

Although Kellen was the designated Stock Keeper, Alava remembers that "never a day when by that I was not some how involved with the stocks." Indeed, Alava's duties included "making new stocks of a newly found gene mutation or new combinations of genes; rescuing the "mutant" from a contaminated stock; pinch-hitting in taking care of the stocks when someone else was ill or on a vacation; and in one case having the care of some hundreds of stocks as one of my "minor" jobs to say nothing about the thousand of virgin females I collected for "the Professor" and for others – to mention only one, for the laboratory courses in genetics."[38] Presumably, Kellen's position as Stock Keeper would have involved answering inquires about the stocks (Drosophilists often exchanged flies) and maintaining the stocks. Stock maintenance involved creating a breeding program that preserved the particular genetic constitution of the flies in the laboratory. These breeding programs could be fairly straightforward if the mutants in question were homozygous in the stocks. Some of the homeotic mutants with which the Goldschmidt lab worked, however, required selection for the mutant phenotypes as well. Priscilla Hutchinson did the day-to-day tasks of cleaning fly bottles, mixing up media, and creating new fly bottles. Although Goldschmidt had had a male Stock Keeper before Kellen got the job, Alava recalled that "at least during my time – stock keeping just

[36] Aloha Hannah Alava to Michael R. Dietrich, June 16, 1995. Personal Correspondence.

[37] Goldschmidt et al., 1951. Leonie Kellen married Geoerge Piternick in 1946 and took his name.

[38] Aloha Hannah Alava to Michael R. Dietrich, August 30, 1995. Personal Correspondence.

wasn't to the taste of men, and women were more inclined to do this tedious, tiresome, and thankless job without complaining."[39]

When the war ended and the "boys came home," the women in the Goldschmidt lab were not displaced from either their positions as Teaching Assistants or Research Assistants. According to Alava, the returning men used GI Bill funding to finish their graduate degrees and then moved on. Moreover, by the end of the war, Kellen and Alava were doing publishable research and Aloha was certain that they would not have been "replaced by an untrained male, just because he was a male."[40]

Alava earned her PhD in 1946. Because he knew he would retire soon, Goldschmidt arranged for her to have a post-doctoral position with the Nobel Prize winning geneticist H. J. Muller at Indiana University. There Alava worked as a cytogeneticist examining the changes in the banding patterns of salivary gland chromosomes that had been subjected to X-ray radiation.[41] When her Post-doc was done, she returned to Berkeley to work with Curt Stern, Goldschmidt's successor at Berkeley and his former Assistant from Berlin. At Berkeley, she was once again a Research Assistant. After being passed over twice for faculty positions at Berkeley, Aloha Hannah married Reino Alava, a Finnish botanist, and moved to Finland where she was a Research Fellow and helped establish the genetics laboratory at Turku University.

Among the many interesting features of the Goldschmidt lab during the Second World War was that the female Assistants were not excluded from research and publication. In fact, research worthy of publication and so of a doctorate was expected. Both Kellen and Aloha continued experimental research and publishing for the rest of their careers, although Kellen became much more involved in teaching. The manual labor of caring for stocks and preparing experiments was added to the mental labor of researching. Goldschmidt, himself, also engaged in laboratory work, including the counting and classifying of flies after an experimental cross, but it is very unlikely that he engaged in any stock keeping or custodial duties. As "the Professor," Goldschmidt was much more involved in the public presentation of laboratory results, whether in print or as talks at various meetings. In contrast, Priscilla Hutchinson

[39] Aloha Hannah Alava to Michael R. Dietrich, August 30, 1995. Personal Correspondence.

[40] Aloha Hannah Alava to Michael R. Dietrich, August 30, 1995. Personal Correspondence.

[41] Aloha Hannah Alava to Michael R. Dietrich, October 14, 1994. Personal Correspondence.

avoided learning tasks that would have drawn her any further into the research of the fly lab. Her work was focused on the material infrastructure necessary to allow the lab to function. Within the Goldschmidt, lab there were important differences in the degree to which different members of lab engaged in the mental work of research and publishing and the manual work of experimentation and maintenance of a *Drosophila* laboratory.

Although Aloha Hannah Alava's recollections shed light on only a single *Drosophila* laboratory for a relatively short period of time, they do support the claim that the division of labor suggested by the job titles in the DIS directory corresponds to actual differences in a laboratory. Moreover, the division of labor with the *Drosophila* laboratory seems to be gendered with maintenance and care-taking tasks disproportionately assigned to women. The sticky floor evident in relative inability of women to move into faculty positions is supported in Alava's case, but, significantly, being a Research Assistant did not mean that Alava was excluded from the kind of high-prestige intellectual labor associated with research faculty. Women like Alava and Kellen were doing it all, while predominantly male faculty members could focus their efforts on research and publication.

Conclusion

Using a data from the *Drosophila Information Service* directories, we have documented important differences in the roles that men and women played in *Drosophila* laboratories in the United States from 1934 to 1970. The demographic profile reconstructed from the directories provides a much fuller picture of scientific life in that it captures almost all of the individuals involved in the daily production of knowledge in a laboratory setting. Including technicians, assistants, and associates draws our attention away from the products of research (theses, articles, and books) toward the range of tasks involved in scientific work.[42] Given the disproportionate number of women involved in the work of *Drosophila* research that are not represented as authors, this richer understanding of the production of scientific knowledge is essential if the indispensable work of women is to be recognized and appreciated.

[42] Gerson, 1983; Strauss, 1985.

Acknowledgements

We would like to gratefully acknowledge the assistance of Aloha Hannah Alava, Kathy Cottingham, J. F. Crow, Evelyn Fox Keller, R. C. Lewontin, Jing Lin, Mark McPeek, and the anonymous reviewers for this journal, as well as the Women in Science Program at Dartmouth College. This research was presented at the International Society for the History, Philosophy, and Sociology of Biology in Vienna, Austria in July 2003.

References

Allen, G. E. 1975. "The Introduction of Drosophila into the Study of Heredity and Evolution: 1900–1910." *Isis* 66: 322–333.

Allen, G. E. 1978. *Thomas Hunt Morgan, the Man and His Science*. Princeton: Princeton University Press.

Bedichek, J. G. 1998. *The Roy Bedichek Family Letters*. Denton, TX: University of North Texas Press.

Carlson, E. A. 1966. *The Gene: A Critical History*. Ames: Iowa State University Press.

Carlson, E. A. 1981. *Genes, Radiation, and Society*. Ithaca: Cornell University Press.

Dietrich, M. R. 2003. "Richard Goldschmidt: Hopeful Monsters and Other "Heresies"." *Nature Reviews Genetics* 4: 68–74.

Dunn, L. C. 1965. *A Short History of Genetics*. McGraw-Hill Publishing, Inc.

Gerson, E. 1983. "Scientific Work and Social Worlds." *Knowledge: Creation, Diffusion, Utilization* 4: 357–377.

Goldschmidt, R., Hannah, A. and Piternick, L. 1951. "The Podoptera Effect in *Drosophila melanogaster*." *University of California Publications in Zoology* 55: 67–294.

Harwood, J. 1993. *Styles of Scientific Thought: The German Genetics Community, 1900–1933*. Chicago: University of Chicago Press.

Heidenthal, G. 1945. "The Occurrence of X-ray Induced Dominant Lethal Mutations in *Habrobracon*." *Genetics* 30: 197–205.

Heidenthal, G. 1952. "X-ray Induced Recessive Lethals in *Habrobracon*." (Abstr.) *Genetics* 37: 590.

Heidenthal, G. 1953. "A Comparison of X-ray Induced Dominant and Recessive Lethals in the First Meiotic Metaphase Eggs and in Sperm of *Habrobracon*." (Abstr.) *Genetics* 38: 668.

Heidenthal, G. 1960. "Genetic Effects of X-rays and Cathode Rays on Oocytes of *Habrobracon*." *Genetics* 45: 633–639.

Heidenthal, G. 1962. "Embryonic Lethals Induced by X-ray Irradiation of the First Meiotic Metaphase Ocytes of *Habrobracon*." *Genetics* 47: 685–693.

Heidenthal, G., Clark, L. B. and Gowen, J. W. 1955. "Comparative Effectiveness of Roentgen Rays of 124 kv and 50 Mev on *Habrobracon* eggs Treated in the First Meiotic Metaphase." *American Journal of Roentgenology and Radium Therapy* 74: 677–685.

Kohler, R. 1994. *Lords of the Fly: Drosophila Genetics and the Experimental Life*. Chicago: University of Chicago Press.

Macrina, F. 2005. *Scientific Integrity: An Introductory Text with Cases*, 3rd ed. American Society for Microbiology Press.

Pipkin, S. B. 1952. "Seasonal Fluctuations in *Drosophila* Populations at Different Altitudes in the Lebanon Mountains." *Molecular and General Genetics* 84: 270–305.

Pipkin, S. B. 1953. "Fluctuations in Drosophila Populations in a Tropical Area." *The American Naturalist* 87: 317–322.

Pipkin, S. B. 1965. "The Influence of Adult and Larval Food Habits on Population Size of Neotropical Ground-Feeding Drosophila." *American Midland Naturalist* 74: 1–27.

Pipkin, S. B. 1968a. "Introgression Between Closely Related Species of Drosophila in Panama." *Evolution* 22: 140–156.

Pipkin, S. B. 1968b. "Genetics of Octanol Dehydrogenase in Drosophila metzii." *Genetics* 60: 81–92.

Pipkin, S. B. 1969. "Genetic Evidence for a Tetramer Structure of Octanol Dehydrogenase of Drosophila." *Genetics* 63: 405–418.

Pipkin, S. B. and Hewitt, N. E. 1972. "The Effect of Gene Dosage on Levels of Alcohol Dehydrogenase in Drosophila." *Journal of Heredity* 63: 331–336.

Pipkin, S. B., Ogonji, G. O. and Agbede, O. O. 1972. "Probable Evolutionary Mechanism Underlying Octanol Dehydrogenase Isozyme Patterns in the Genus *Drosophila*." *Journal of Molecular Evolution* 2: 56–71.

Pipkin, S. B., Rhodes, C. and Williams, N. 1973. "Influence of Temperature on *Drosophila* Alcohol Dehydrogenase Polymorphism." *Journal of Heredity* 64: 181–185.

Pipkin, S. B., Rodriguez, R. L. and Leon, J. 1966. "Plant Host Specificity Among Flower-Feeding Neotropical Drosophila (Diptera: Drosophilidae)." *The American Naturalist* 100: 135–156.

Rose, H. 1983. "Hand, Brain, and Heart: A Feminist Epistemology for the Natural Sciences." *Signs* 9: 73–90.

Rossiter, M. 1978. "Sex Segregation in the Sciences: Some Data and a Model." *Signs* 4: 146–151.

Rossiter, M. 1982. *Women Scientists in America: Struggles and Strategies to 1940*. Baltimore: Johns Hopkins University Press.

Rossiter, M. 1997 "Which Science? Which Women?" Osiris 12: 169–186.

Russell, N. C., Tansey, E. M. and Lear, P. V. 2000. "Missing Links in the History and Practice of Science: Teams, Technicians and Technical Work." *History of Science* 38: 237–241.

Sapp, J. 1987. *Beyond the Gene: Cytoplasmic Inheritance and the Struggle for Authority in Genetics*. New York: Oxford University Press.

Schiebinger, L. 1999. *Has Feminism Changed Science?*. Cambridge, MA: Harvard University Press.

Shapin, S. 1989. "The Invisible Technician." *American Scientist* 77: 554–562.

Stern, C. and Hiedenthal, G. 1944. "Materials for the Study of Position Effect of Normal and Mutant Genes." *Proceedings of the National Academy of Sciences* 30: 197–205.

Stern, C., Schaeffer, E. and Hiedenthal, G. 1946. "A Comparison Between the Position Effects of Normal and Mutant Genes." *Proceedings of the National Academy of Sciences* 32: 26–33.

Strauss, A. 1985. "Work and the Division of Labor." *The Sociological Quarterly* 26: 1–19.

Sturtevant, A. H. 1965. *A History of Genetics*. New York: Harper and Row.