Long term impact of intensive post graduate laboratory training at the Cold Spring Harbor Neurobiology of Drosophila summer course

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Abstract

Intensive postgraduate courses provide an opportunity for junior and senior level scientists to learn concepts and techniques that will advance their training and research programs. It is commonly assumed that short intensive courses have positive impacts within fields of research; however, these assumptions are rarely tested. Here we describe the framework of a long running postgraduate summer course at Cold Spring Harbor and attempt to quantify the impact made over its history. For over three decades, the Drosophila Neurobiology: Genes, Circuits & Behavior Summer Course at Cold Spring Harbor Laboratories (CSHL) has provided participants with intense instruction on a wide variety of topics and techniques in integrative neuroscience using Drosophila as a model organism. Students are introduced to the latest approaches for studying nervous system development, activity and connectivity, as well as complex behaviors and disease models. Further, students learn a broad range of methods, including genetic manipulation of genes and neurons, phenotypic analysis, electrophysiology, anatomy, and behavior. The course includes an intensive hands-on laboratory component, a lecture component by instructors and visiting experts, and an evening seminar series where groundbreaking neuroscientists provide their perspectives on how Drosophila neuroscience research fits into the larger context of discovery in neuroscience. Student surveys indicate a high level of satisfaction including improved career outcomes and a direct impact on publications. Analysis of student success reveals that over 64% of participants obtain independent faculty positions, suggesting this course has a dramatic impact on trainee outcomes. Further, we describe on-going efforts to enhance diversity and encourage access to scientific research at undergraduate-focused institutions. Together, our findings suggest that laboratory-intensive postgraduate courses provide a highly effective mechanism for scientific training that has lasting positive impacts on trainees.
INTRODUCTION

Research on the fruit fly, has played an important role in uncovering principles of nervous system structure and function. Fundamental insights include the first molecular descriptions of nervous system differentiation reviewed in \(^1\), the identification and elucidation of axon guidance cues reviewed in \(^2\) the first cloning of ion channels reviewed in \(^3\) the first demonstration that SNARE proteins are required for chemical neurotransmission reviewed in \(^4\) and the identification of single genes that regulate complex behavior (reviewed in \(^5\)–\(^7\)). More recent advances are focused on neural circuit function and the neuronal basis for complex behavior reviewed in \(^8\) Drosophila often leads the way in the development of genetic technologies for identifying, manipulating and monitoring neural circuits \(^9\). Furthermore, complex behaviors, including learning, decision-making, feeding, circadian rhythms, arousal/sleep, aggression, courtship, and addiction, are now amenable to sophisticated experimental analysis. Increasingly, a full understanding of the connections between genes and proteins, neural circuits, and emergent behaviors is attainable \(^10\)–\(^14\). Importantly, conservation of both the genes that underlie circuit formation and function and the information-processing logic of neural circuits means that discoveries and technologies developed in Drosophila are often readily translated into insights into the mammalian nervous system \(^7\),\(^15\)–\(^17\).

Work in Drosophila has also made major contributions as a model organism in STEM education. For decades high school students and undergraduates have been taught principles of genetics through the use of Drosophila in classrooms. In recent years, Drosophila has also emerged as an extremely powerful model organism for teaching principles of integrative neuroscience. This emergence has been driven by several reasons: 1) Drosophila are inexpensive to rear and maintain, 2) their use does not require Institutional Animal Care and Use (IACUC) approval, 3) the research community is
committed to making genetic constructs freely available, 4) a rich array of tools are available for manipulating gene function as well as visualizing and manipulating the activity of neural circuits 5) electrophysiological and imaging preparations used in the research community can be exported to teaching laboratories at minimal cost, and 6) Drosophila show a rich repertoire of behaviors that can be easily measured with minimal equipment. All of these strengths combine to create an optimal platform for teaching trainees at all levels how to solve problems in neurosciences at the genetic, molecular, cellular, behavioral, and computational level simultaneously. These strengths also make Drosophila an ideal ‘animal ambassador’ for helping laypeople of all ages understand the value of basic research in invertebrate model organisms.

The growing diversity of genetic approaches and specialization of individual laboratories presents an impediment to scientific training. Creative and novel approaches to science require a familiarity with cutting-edge genetic technology and approaches in model organisms, yet this type of specialized coursework is not provided in most laboratories or training programs. Laboratory-intensive courses provide trainees with intensive research experience including exposure to research areas and techniques that may not be available at their host institution. The Drosophila Neurobiology Course has been held annually since 1983 and is an example of a short course that has made a sustained impact within a field. Each year, 12 trainees are selected through a competitive admission process to participate in the three-week course. Here, we describe current recruitment efforts, structure, and methodology. Further, we provide a systematic analysis of student satisfaction and long-term career success of participants. Our analysis reveals remarkable sustained achievement and highlights the potential of similar courses to promote catalyze scientific impact and promote diversity within the scientific community.

METHODS
Course Structure

This laboratory and lecture course is intended for researchers at all levels who want to use *Drosophila* as an experimental system for studying the nervous system. It is a modern, state-of-the-art laboratory course designed to introduce students to various preparations for studying *Drosophila* neurobiology. Students of the course learn how to examine the larval and adult *Drosophila* nervous systems in order to study development, neurophysiology, neuroanatomy, and behavior. Students learn a range of methods and techniques including genetic, electrophysiological, imaging and behavioral techniques. This balance allows us to maintain the in-depth nature of the course while expanding the breadth of topics covered. Daily seminars introduce the history behind special topics while providing updated the current knowledge by including recent contributions to the literature and interactive discussions about outstanding questions. Student discussion is actively encouraged and major emphasis is placed on experimental methodology. Guest lecturers provide original preparations for demonstration, experimentation and discussion, and direct laboratory exercises and experiments in their areas of special interest and expertise. Each lecturer provides a supplementary reading list and several background papers or reviews that students are encouraged to read before each lecture. Students are also provided with detailed protocols for all laboratory experiments to facilitate the transfer of their experiences in the course to their home labs, and if requested can also take with them cutting edge optogenetic, thermogenetic and genome editing tools that are rapidly advancing this field.

The material provided by instructors, both in lectures and in many laboratory exercises, is supplemented by evening seminars that provide specific information on the current status of research in the invited speakers’ area of expertise. The invited speakers are strongly encouraged to devote more than a day to visiting the Laboratory, during which they spend
many hours informally discussing the participants’ experiments in relation to their current research interests. Daily formal and informal discussions between students, faculty and invited speakers on the finer points of the techniques and concepts being taught in each course is a valuable source of intellectual stimulation. These discussions also allow the instructors and lecturers to provide insight and advice on how to address the specific problems being encountered by students in their own research. These facets of the program all contribute to the total immersion of the participants in the subject. Topics are covered to a depth that is not possible in other courses and workshops, and because of the unique atmosphere and tradition of Cold Spring Harbor, there is a very strong interaction between the instructors and participants. Participants are able to focus their attention on the scope of the course, without the distraction of other responsibilities, and are essentially forced to immerse themselves in the relevant methodologies and concepts. Living, eating and spending informal hours with the established investigators, the permanent staff and the frequent casual visiting scientists to Cold Spring Harbor allows the participants to absorb much understanding and enthusiasm both inside and outside the lab and lecture hall.

The Drosophila Neurobiology Course is designed such that students spend most of their time performing hands-on laboratory activities to consolidate information they learned during seminars about cutting-edge research and lectures of basic neurobiological, genetic, developmental, molecular and behavioral concepts. The syllabus is formulated so that students first learn the basic neurodevelopmental and genetic concepts prior to learning physiology, sensory systems, simple behavior, and then finally complex behavior. Typically, students receive two lectures in the morning: one on basic concepts, then one on cutting edge research techniques, then are in the lab all afternoon and into the evening. Approximately half of the evenings of the course have additional lectures designed to
expose students to exciting contemporary research in *Drosophila* neurobiology and give perspective on how this works complements work in other model organisms. The twelve students accepted to the course are encouraged to think independently and use cooperative learning to maximize their own and one another’s learning.

A central goal of the course is to expose students to techniques that can be readily implemented at their home institution. The course covers a broad range of standardized techniques, such as Ca$^{2+}$ imaging, neuromuscular junction electrophysiology, and behavioral analysis using cutting-edge genetic tools. In addition, we focus on Do-it-yourself (DIY) systems for behavioral analysis, including use of 3D printing to construct behavioral systems. The potential for students to establish similar DIY systems at their home institutions is emphasized, thereby increasing the impact of these techniques.

**The CSHL environment**

CSHL provides an optimal setting for summer courses. Faculty and students stay together on campus throughout the course, within walking distance from the teaching labs, seminar rooms, cafeterias, libraries and recreational facilities. This represents a significant investment in terms of resources and support and ensures that faculty members can focus completely on teaching. CSHL is a secluded, self-sustaining scientific environment; this helps students drown out distractions and fully immerse themselves in the course material. Importantly, there are multiple courses that run simultaneously, providing rich interactions with trainees with backgrounds in related research.

**Admissions and recruitment**

Applications are open to candidates at any stage in their postgraduate career from academia and industry within the United States and from overseas. Applicants are
required to supply a curriculum vitae, letters of recommendation, a statement of research interests and specific reasons for wanting to take the course, as well as request for scholarship aid. Requests for financial aid have no bearing on whether applicants are accepted. Participants are selected by the course instructors on the basis of several criteria including quality of proposed research, demonstrated need for training in specific research area, Institutional/community impact of training, national versus international reach, US underrepresented minority (URM) status, breadth of representation of scientific approaches and gender balance. Course faculty make efforts to select multiple stages of trainees, ranging from graduate students to senior investigators. This distribution offers several distinct advantages: students and fellows often benefit from working closely in an informal setting with more mature advanced scientists, particularly in terms of learning approaches and priorities. Conversely, more established scientists respond favorably to the high degree of enthusiasm and "willingness to try anything" attitude often ventured by early career researchers. These interactions have consistently generated a dynamic and stimulating environment that facilitates maximal exchange of ideas and philosophies within the course.

Admissions and recruitment of underrepresented minorities

CSHL-wide diversity recruitment retention schemes are augmented by efforts specific to the Drosophila Neurobiology Course. These including working with industry, non-profits, and universities to encourage applications from diverse backgrounds. The course leverages these connections to recruit the best URM researchers in the field. Additionally, the course recruits undergraduate educators to attend the course who can then incorporate cutting-edge Drosophila neuroscience into course curricula at URM serving institutions. This 'teach the teacher' strategy ensures that the course content propagates to the largest possible number of URM undergraduates.
Service evaluation

The academic administration of the teaching program at CSHL is the responsibility of the course instructors. The course curriculum is determined by the course instructors, and progress is monitored by the senior administrative staff by discussion and evaluation during and after each course with faculty, students, and guest lecturers (including former instructors). The students complete anonymous course evaluation forms at the end of the course with the primary aim of improving the quality of the course. In addition, feedback is solicited from the wider community during biennial CSHL research conferences on *Drosophila* neurobiology. The close contact between the CSHL Summer Program leadership, course faculty, and research conference organizers also provides many opportunities for informal course evaluation. All data collection, analysis and presentation was performed in accordance with Cold Spring Harbor Laboratories IRB Protocol 17-019.

RESULTS AND DISCUSSION

Course Participants

Admission to the course is competitive, with an average acceptance rate of approximately 30% over the last nine years. From 2008-2016, the course typically had 12 students from diverse career stages (Table 1). The majority of students (63%) were doctoral trainees, with an additional 27% postdoctoral trainees and 9.4% senior scientists. The course has also maintained gender and geographic diversity, with a nearly 1:1 male-female ratio, and 32% of students coming from outside of the United States.

Instructors and Lectures

The course faculty is formed by researchers who are active in complementary research of fly genetics, neurodevelopment, physiology and behavior. The course is led by three to four instructors (organizers), who collaboratively design the course syllabus, plan the
course schedule, and invite suitable lecturers, based on the current *Drosophila* neurobiology research and student feedback. From 2008-2011, each year, approximately sixteen lecturers gave both seminars and laboratory sessions, whereas an additional ~eight lecturers gave evening seminars on cutting edge research in their laboratories. Lecturers formed a cross section of the *Drosophila* community, coming from the United States (83.6%) and outside the US (16.4%). They represent primarily research universities (61.2%) and research institutes (37.7%), but also government (0.9%) teaching colleges (0.9%). A range of career stages are represented from full professors (12.93%), and tenure track faculty (58.7%) to postdoctoral fellows graduate students and technicians (33.6%). Gender balance was actively encouraged in recruitment of course lecturers, instructors and TAs, with an overall 60.3%/39.7% male female/ratio across 8 years.

**Student Satisfaction**

The perceived impact of the course on students was quantified through a standardized questionnaire solicited each year from 2012-2016. The survey was designed to measure both personal satisfaction and the perceived contribution of the course to the trainees’ career. Evaluation sheets were typically circulated on the last day of the course and students were encouraged (but not required) to complete and return the evaluations before they depart from CSHL. Importantly, evaluations are handwritten and completely anonymous, thereby encouraging students to be open and frank in their comments. Each evaluation includes a scoring system in response to questions about different aspects of the course: 1 (needs improvement) - 5 (exceptional). Each evaluation also asked specific questions requiring a written response. Evaluations were independently reviewed by course instructors and by Cold Spring Harbor program staff within four weeks of completion of the course to ensure significant criticisms may be addressed, as well as to incorporate suggestions and comments into the design of the course in the following
years. Table II includes a summary of average scores for the course since 2012. Evaluations have indicated a clear level of satisfaction amongst each student class upon completion of the course. While enthusiasm for the course and points of strength vary from year to year, students express strong overall enthusiasm for all aspects of the course, with all areas averaging a score of 4.1 (out of 5) or greater (Table 2). On average, the highest scores are obtained for helpfulness of instructors, receiving an average score of 4.88.

**Long-term Qualitative Impacts**

In all, more than 300 trainees have participated in the course over its 33 year history. We assessed longer term impacts by 1) soliciting feedback from alumni in previous years of the course and 2) tracking of careers of former students.

We solicited feedback from alumni from 1996 to 2015 and asked how the course contributed to the individual's intellectual development, technical expertise, and publications, as well as impact on the field as a whole. In all, 85 alumni responded in full to the survey. The results of this survey reveal that the majority of students found the course to be helpful for their career (87%; Table 3). In addition, the vast majority reported that the course helped initiate new research directions (78%; Table 3) and was a highlight of their scientific career (95%). The high satisfaction with the course is indicative of substantive and long-lasting positive impact on career development.

The success of the course can also be measured by assessing the career trajectories of alumni. An exhaustive internet search of publically available information was conducted to identify the current positions of course graduates from 1983-2016 (Fig 1). We were able to confirm the career status of 287 former students of the course. This revealed that
64% are currently in academic faculty positions with 55% of identified course alumni in tenure track positions. This number is remarkably high compared to recent estimates. In the United States, an estimated 65% of graduate students move on to post-docs, and only 10-13% secure faculty positions. In our course, a relatively small percentage of graduates (29 students, 9%) obtained industry research positions, likely indicative of the focus on basic science in Drosophila research and success in obtaining tenure track positions. Importantly, alumni also showed a diverse set of non-research careers; examples included scientific journal editors, teachers, and entrepreneurs. The long-term impact on student success is indicative of a high return on investment, both in terms of student time and scientific funding. Further, while difficult to quantify, it is likely that the course’s effectiveness extends beyond alumni as they were likely to share their training with those in their local scientific communities. The fact that a large number of respondents indicated that publications could be attributed to taking the course suggests that there was indeed transfer of knowledge to local communities and that that knowledge was effectively translated into research outputs. Indeed 90% of respondents confirmed that at least 2 publications could be attributed to taking the course (Table 4).

Beyond assisting the careers of individual students, the course is uniquely positioned to provide training opportunities to those with limited access to research resources. While many training opportunities, including National Institutes of Health NRSA fellowships, strongly consider training environment, this course focuses on providing access to students from diverse geographic and scientific backgrounds. The ability to recruit and train students from diverse backgrounds has the potential to extend neuroscience training to communities that are underrepresented in scientific funding. From 2008 until the present, our course steadily increased numbers of students from URM backgrounds (Table 1). The small class size inherently limits the number of URMs we can train.
address this problem, in recent years (2015-present), special efforts have been made to recruit students and lecturers who teach at URM serving institutions. This approach provides the course with a way to extend Drosophila neuroscience into underserved communities.

Outlook for the future

The CSHL Drosophila Neurobiology course has demonstrated remarkable success over more than three decades. This likely reflects both a general effectiveness of the intensive short summer course format for postgraduate researchers and the specific approaches utilized by this course. In particular, the flexible curriculum, with rotating organizers, instructors, and laboratories, have maintained cutting-edge research and techniques over the duration of the course. Moving forward, we plan to continue this innovation by investing in growing areas of research. For example, future iterations of the course are likely to emphasize computational approaches to neuroscience, functional imaging and quantitative tracking and analysis of animal behavior. In addition, we will increase the emphasis on DIY approaches, such as use of 3D printing to construct laboratory apparatus. Finally, we hope to leverage the success of this course to extend beyond the reach of CSHL. For example, forming collaborations with faculty outside CSHL that extend course laboratory modules into undergraduate curriculums will significantly broaden the impact of the course. Indeed recent participants at the course have adapted CSHL modules for use in undergraduate education and these modules are now published and freely available. Finally, generation of publically accessible protocol videos will enhance the broader impact of this course. These points of emphasis, combined with incorporating rapidly improving genetic technology in the fly, will allow this course to remain current and innovative into the future.
Conclusions

*Drosophila* are uniquely suited to teach fundamental principles in neuroscience research. The amenability to laboratory manipulation and short generation time allow for implementation of cutting-edge genetic-technology to investigate development, physiology, and behavior in a short-course format. Our analysis reveals that the *Drosophila* Neurobiology Course has experienced remarkable success in terms of student satisfaction and career outcomes. The active emphasis on selecting students from diverse backgrounds promotes scientific access, gender equality, and success for underrepresented minorities.

Acknowledgments

We would like to thank the CSHL staff, and the students, lecturers and teaching assistants that participated in the *Drosophila* Neurobiology Course. We would also like to extend a special thank-you to past course instructors Kate O’Connor-Giles (University of Wisconsin-Madison), Adrian Rothenfluh (University of Utah) and Greg Macleod (Florida Atlantic University) for assistance with an early version of portions of this text. This work was funded by the National Science Foundation Division of Integrative Organismal Systems (NSF IOS 1523125) and National Institute for Drug Abuse (NIDA R13DA034437).

Works Cited

3. Frolov, R. V, Bagati, A., Casino, B. & Singh, S. Potassium channels in


Figure 1. Current professional status of course graduates.
In total, 55% of eligible course alumni received professor appointments, while 64% hold academic appointments (including non-professor appointments). 9% of alumni work in industry, 4% in outreach. Grey (23%) represents other professional positions.
## Table 1

<table>
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<td>3</td>
<td>3</td>
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<td>3</td>
<td>3</td>
<td>3</td>
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<td>3</td>
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<td>17</td>
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<td>18</td>
<td>19</td>
<td>22</td>
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<td>5</td>
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<td>7</td>
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<td>4</td>
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<td>3</td>
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<td><strong>Applicants</strong></td>
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<td>34</td>
<td>24</td>
<td>23</td>
<td>43</td>
<td>42</td>
<td>32</td>
<td>32</td>
<td>36</td>
<td>319</td>
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<td>12</td>
<td>12</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
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<td><strong>Grad Stud</strong></td>
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<td>6</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>10</td>
<td>9</td>
<td>6</td>
<td>6</td>
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<td>4</td>
<td>3</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>29</td>
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<td><strong>PI/Sen Sci</strong></td>
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<td>3</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>1</td>
<td>10</td>
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<tr>
<td><strong>Gender</strong></td>
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<td>5m/7f</td>
<td>6m/6f</td>
<td>5m/6f</td>
<td>6m/6f</td>
<td>5m/7f</td>
<td>7m/5f</td>
<td>6m/6f</td>
<td>5m/7f</td>
<td>51m/55f</td>
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<tr>
<td><strong>US (%)</strong></td>
<td>7(64%)</td>
<td>9(75%)</td>
<td>6(50%)</td>
<td>6(55%)</td>
<td>9(75%)</td>
<td>9(75%)</td>
<td>8(67%)</td>
<td>9(75%)</td>
<td>9(75%)</td>
<td>72(68%)</td>
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<tr>
<td><strong>URM</strong></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>na</td>
<td>2</td>
<td>3</td>
<td>12(17%)</td>
</tr>
</tbody>
</table>

**Table 1: Makeup of course students, assistants and faculty from 2008-2016.** The number instructors (Course organizers), lecturers, teaching assistants, applications, and students for each year from 2008-2016. The breakdown of students (bold) between grad student, postdoc, and PI/senior scientist, as well as gender. The percentage of students from the US. URM denotes US underrepresented minority.
Table 2.

<table>
<thead>
<tr>
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<td>In general, did the course meet your needs /expectations?</td>
<td>4.5</td>
<td>4.6</td>
<td>4.1</td>
<td>4.8</td>
<td>4.9</td>
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<td>Were the lecture topics well chosen?</td>
<td>4.5</td>
<td>4.5</td>
<td>4.1</td>
<td>5.0</td>
<td>4.8</td>
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<td>Was the level of the lectures appropriate?</td>
<td>4.3</td>
<td>4.7</td>
<td>4.5</td>
<td>4.8</td>
<td>4.8</td>
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<td>Were the presentations clear?</td>
<td>4.2</td>
<td>4.5</td>
<td>4.1</td>
<td>4.5</td>
<td>4.6</td>
</tr>
<tr>
<td>Were the instructors helpful?</td>
<td>4.9</td>
<td>4.9</td>
<td>4.6</td>
<td>5.0</td>
<td>5.0</td>
</tr>
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<td>Was the selection of lab exercises appropriate?</td>
<td>4.1</td>
<td>4.5</td>
<td>3.6</td>
<td>4.7</td>
<td>4.8</td>
</tr>
<tr>
<td>Was there sufficient/too much supervision of the lab?</td>
<td>4.3</td>
<td>4.5</td>
<td>4.2</td>
<td>4.5</td>
<td>4.8</td>
</tr>
<tr>
<td>Were the labs well enough equipped?</td>
<td>3.9</td>
<td>4.4</td>
<td>4.2</td>
<td>4.3</td>
<td>4.8</td>
</tr>
<tr>
<td>What was the utility and quality of the written protocols?</td>
<td>3.8</td>
<td>4.4</td>
<td>3.4</td>
<td>4.3</td>
<td>4.5</td>
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<tr>
<td>How was the course work load?</td>
<td>4.5</td>
<td>4.3</td>
<td>4.4</td>
<td>4.4</td>
<td>4.8</td>
</tr>
</tbody>
</table>

Table 3: Student course evaluations from 2012-2016. Average scores from course evaluations over a five-year period. Scale: 1-Poor→5-Excellent.
Table 3. Long-term impact assessment of students from 1996-2015. Previous students were contacted and asked about the impact the course had on the career over the summer of 2016. The number of responses for the 85 recipients for each category are listed.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The course helped me achieve my next career transition.</td>
<td>41</td>
<td>31</td>
<td>11</td>
<td>0</td>
<td>1</td>
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<tr>
<td>The course had a positive impact on my scientific career as a whole.</td>
<td>71</td>
<td>13</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
<td>The course helped me initiate a new research direction.</td>
<td>39</td>
<td>29</td>
<td>15</td>
<td>1</td>
<td>1</td>
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<tr>
<td>The course taught me new techniques that were subsequently applicable to my research</td>
<td>56</td>
<td>24</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>The course was a highlight in my scientific career.</td>
<td>56</td>
<td>24</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>The course has a positive impact on the broader biological research community.</td>
<td>62</td>
<td>19</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Do you still work in this scientific area?</td>
<td>YES</td>
<td>NO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of research publications that could be attributed to taking this course?</td>
<td>70</td>
<td>12</td>
<td>~7</td>
<td>~4</td>
<td>~2</td>
</tr>
<tr>
<td>Number of patents that could be attributed to taking this course?</td>
<td>4</td>
<td>10</td>
<td>14</td>
<td>49</td>
<td>7</td>
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</tbody>
</table>

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