



NSFREU Site on Neural Engineering: Aiming at High Research Standards (work in progress)

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NSF-REU Site on Neural Engineering: Aiming at Professional Research Standards

As described by the National Science Foundation (NSF), REU sites are summer programs that offer Research Experiences to Undergraduates with the goal of “engag[ing] a number of students in research.” In NSF-funded REU programs, about ten students from different parts in the country meet at the REU hosting institution and perform research and career-development activities for 10 weeks. The NSF-funded REU program at our Institute is the first one that focuses on Neural Engineering: a hot topic in research and also highly sought after by students. Neural engineering is a rapidly growing interdisciplinary research area that takes an engineering approach to analyze neurological function and to understand, repair, replace, or enhance the nervous system. The main goal of a neural engineer is to develop solutions to neurological and rehabilitative problems. The REU site in neural engineering (NEURON REU) at the New Jersey Institute of Technology (NJIT) is led by our biomedical engineering department in collaboration with the medical school. The two institutions collaborating for the NEURON REU are strategically located only 3 blocks apart from one another and they have a joint Ph.D. program, which attests to their long-time research collaboration.

Our REU program is organized in research teams consisting of 2-3 students each. Teams work on topics within the 4 main tracks of the very interdisciplinary field of neural engineering: *Materials for neural tissue engineering*; *Neurofunctional and neurobehavior analysis*; *Multicellular neural tissue engineering*; and *Neuromuscular control*.¹ In addition to introducing and encouraging students to pursue advanced degrees in the area of neural engineering, the REU site focuses on preparing students for productive careers in research—either in academia or industry—by means of (a) introducing students to the research process; (b) mentoring students to become independent, intellectual thinkers; and (c) teaching the art of technical communication. With their application form, students select two of the 4 tracks, which helps matching selected applicants with research projects in their favorite topics within neural engineering.

Each student research team has a research project and receives the support of one main faculty advisor, one graduate coach, and two or more supporting faculty advisors who work in a similar area of research as the main faculty advisor. The main faculty advisor defines the general hypothesis/ goal of the research project and hosts the student team in her/his laboratory. The graduate coach is a graduate student—an advanced master’s student or a PhD candidate—in the laboratory of the main faculty advisor. Graduate coaches introduce the student team to the basic use of instruments and tools in the lab as well as they serve as mentors for the student team helping them with everyday questions such as how to access the resources available in core facilities in campus or how to locate a substance in the chemical stockroom. Typically, graduate coaches do not contribute intellectually to the research project of the student team and do not typically become co-authors in publications stemming from the research carried out by the research teams. The supporting faculty advisors are faculty members who provide the student team with technical help or resources for their research project. Supporting faculty may be collaborators of the main faculty, may donate cells or animal models, provide access and training for the use of an instrument, or guidance in coding a script on specific software, for example. Supporting faculty also serve as pre-submission reviewers for the poster and abstract developed by the student research team.

	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
M	WELC	MMM	MMM*	MMM	MMM*	MMM	MMM*	MMM	MMM*	MMM
	WELC	R	R	R	R	R	R	R	R	R
T	O-S	R	R	R	R	R	R	R	R	R
	O-WS	R	R	R	R	R	R	R	R	R
W	R	R	R	R	R	R	R	R	R	R
	R	R	R	R	R	R	R	R	R	R
R	R	RMM	RMM	RMM	RMM	RMM	RMM	RMM	RMM	RMM
	R	R	R	R	R	R	R	R	R	R
F	WS	S	WS	S	V	WS	V	inPP	V	allIPP
	GW	GW	GW	GW	GW	GW	GW	GW	GW	allIPP

WELC: welcome activities; **O-S:** Orientation Seminar; **O-WS:** Orientation Workshop; **R:** Research; **MMM:** Monday Morning Meeting; **MMM*:** Monday Morning Meeting with all groups; **RMM:** Thursday Morning Meeting; **WS:** Workshop; **GW:** Group Work; **S:** Seminar; **V:** off-campus Visit; **inPP:** REU Poster Presentation; **allIPP:** NJIT-campus Poster Presentation. **W1 - W10:** weeks 1 through 10 of the REU summer program. **M, T, W, R, F:** Monday, Tuesday, Wednesday, Thursday, and Friday, respectively.

Figure 1: Summary of activities for each working day during the 10 weeks of the NEURON REU program at NJIT.

In order to implement the main objective of this and all REU Sites (i.e., preparing students for productive careers in research—for this site: research in neural engineering), each team in the REU is given an *independent* research project. We define independent research project as a project that is (i) related to the work in the lab of the team’s main faculty advisor but has (ii) goals and tasks that are clearly distinct from those carried out by the other students in the lab of the faculty advisor. By having the project related to the work of the faculty advisor, the students become part of the lab quickly and receive the technical support of their lab mates, which is very important during the first weeks of the REU, as students learn how to use the instruments and equipment in the host lab. By having a project that is different from the others in their main advisor lab, the student teams can organize their tasks independently (instead of following the lead of a graduate student) and own the research project (with its associated publications) completely. The NEURON REU projects are also chosen to be self-contained and finishable in 10 weeks. In other words, the goals of the REU projects must be achieved by the end of the 10 weeks of REU program instead of becoming just a part of a larger project in the lab of the main faculty advisor. Because the projects are self-contained, each REU team is expected to submit an abstract to a national conference relevant to the neural engineering field. The possibility of presenting their own work at a national conference motivates the REU students very much during their summer research. The conference chosen for the NEURON REU teams to submit their abstracts to is the Biomedical Engineering Society annual meeting, BMES, which has two deadlines for the submission of research abstracts: one in May for research carried out during the regular academic year, and another one at the end of July for undergraduate summer researchers who would miss the May deadline. Despite the different submission dates, both sets of undergraduate research abstracts go through a review process by the ‘technical program committee’² consisting of faculty members and researchers technically proficient in the field of biomedical engineering.

Publications (including conference abstracts) are the standardly accepted factor to assess the success of professional researchers. Because the main objective of REU sites is to prepare students for productive careers in research, the submission and acceptance of abstracts—written by the students about their own research—is of the utmost relevance in assessing the success of the NEURON REU program. In other words, the REU structure and formal assessment presented here consists of quantifying success through indicators of productivity similar to those of professional researchers. Additional, more traditional assessment tools, which are not within the scope of this paper, are also being used in the NEURON REU³.

Establishing the production of an abstract competitive at the national (undergraduate) level as the goal for the teams imposes two main requirements to the REU schedule: (1) as much time as possible must be devoted to research, and (2) progress in the lab must translate into public communications (slides and abstract) constantly, and for the whole length of the REU program. Typically, slides and abstracts are taken care of during the last days of a research program with a selection of the results obtained during the program. Our approach, however, focuses on establishing a clear research objective for each project and requires students (and advisors) to revisit such objective over and over again, in light of the accumulated and latest results. Our approach allows students to visualize the pieces they are missing in the puzzle of their research projects; for example, we do not want to realize that a control for one of our experiments is missing the day when the abstract is due. This approach applies to REU projects the arguments presented in the classic work “Whitesides’ group: writing a paper⁴.”

The weekly schedule of the NEURO REU (Figure 1) includes time for research in the lab (orange, **R**), workshops with the basics on oral and written research communication (pink, **WS**), visits to local industries (light blue, **V**), a mock poster presentation (brown, **inPP**), and a campus-wide poster presentation (brown, **allPP**). Note that the first two days of the program (green: **WELC, O-S, O-WS**) are dedicated to welcoming the students to campus, introducing them to the resources (gym, library, etc.) available for them, and getting their student identification cards and network usernames. Additionally, REU students have times scheduled for weekly meetings: one on Monday morning (**MMM**) to discuss the evolutions of the previous week—either with the whole REU community or with each team’s lab,—one in the middle of the week (**RMM**) to work on the research projects from the communication perspective—with the author and, if available, other faculty and graduate students,—and one at the end of the week—with the team members—to prepare the presentation for Monday. These pre-scheduled meetings are not supposed to substitute, but instead to add to the informal conversations during the week with lab mates, graduate coach, and faculty advisor(s).

Despite the regularity of the weekly schedule, the goals of the tasks for each week change as the research project progresses, as schematized in Figure 2. During the first week students are required to familiarize themselves with the project, via paper reading and conversations with their lab mates and faculty advisor, and present the project succinctly at the MMM of the second week. By the beginning of the third week, students are requested to provide a project timeline, with milestones and task distribution between team members. Oral presentations and abstracts make it possible to analyze the progress of the research project throughout the weeks and identify any modifications required in the project description and/or timeline—e.g., an unpredicted tool limitation or the damage to a piece of equipment—as well as needed

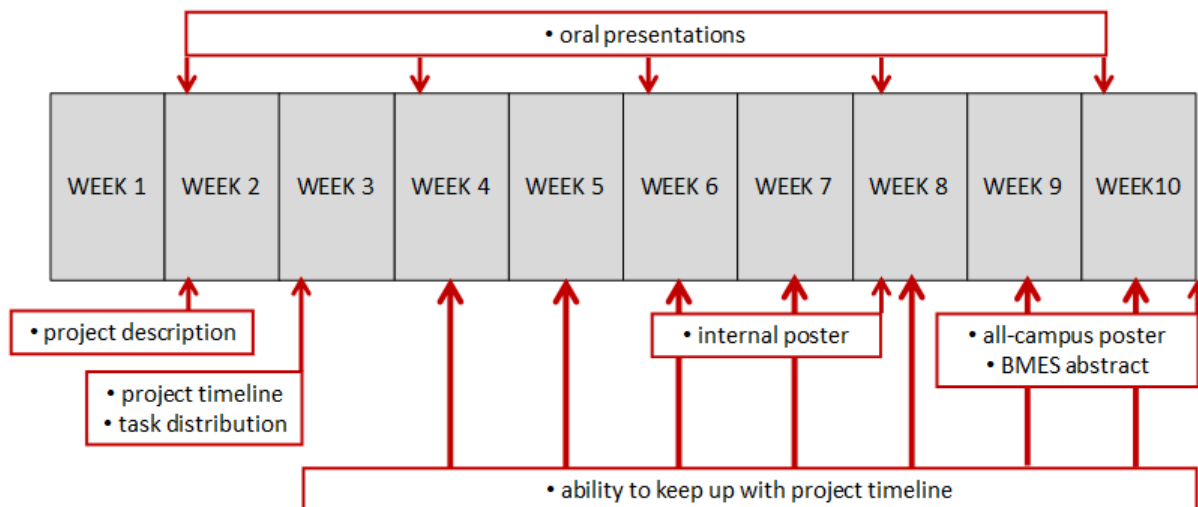


Figure 2: Sequence of partial and final goals along the 10-week NEURON REU program at NJIT.

administrative actions—e.g., reporting an invention disclosure or requiring an Institutional Review Board (IRB) approval. During the last three weeks, a mock poster presentation is scheduled before the real one with the rest of the undergraduate summer researchers in campus.

As an additional tool for coordinating the research tasks in the NEURON REU, we use a web-based, freely available educational tool—namely, a *wiki*—as a collaborative, interactive, remotely accessible electronic lab notebook (ELN). Wikipedia (probably the most widely known wiki) defines the term *wiki* “as a website whose users can add, modify, or delete its content [using] a web browser” by means that do not require any previous knowledge of webpage programming⁵. Wikis have been used previously for educational purposes, for the exchange of information between K-16 educators, and for communication between the members of research labs in higher education settings. In the search for web-based tools that would support access to an electronic lab notebook, we sought to accomplish the following goals for our NEURON REU: interactivity (to provide student-to-student and student-to-faculty interactions), real-time connectivity (to enable the synchronization of tasks between different members of one team and among teams), ease (to empower all users to benefit from the tool regardless of their web coding skills), and privacy (to avoid undesired disclosure of intellectual property). Additionally, we looked for a tool that could be easily adopted by others—for example in other summer programs. For all these reasons, we chose to set our wiki on wikispaces.com⁶, which provides free use of their wiki-hosting service for educators in K-16 through higher education institutions.

As illustrated by Figure 3, the NEURON REU wiki is organized into as many projects (see label ‘Projects’ in the middle box to left of the screen) as student teams in the program. Each project consists of an independent set of pages and files (see label ‘Pages and Files’ in the middle box) that each team populate according to their research results. All projects can be seen by all teams but each team can edit only their own wiki. In the lower box to the left of the screen, links to the ‘REU Google Calendar,’ ‘REU Resources,’ and ‘REU Social Space’ pages feature access to the Google calendar shared by everyone in the REU, to general use resources such as templates and REU logos for the posters, and to photos and details of social activities of the REU participants.

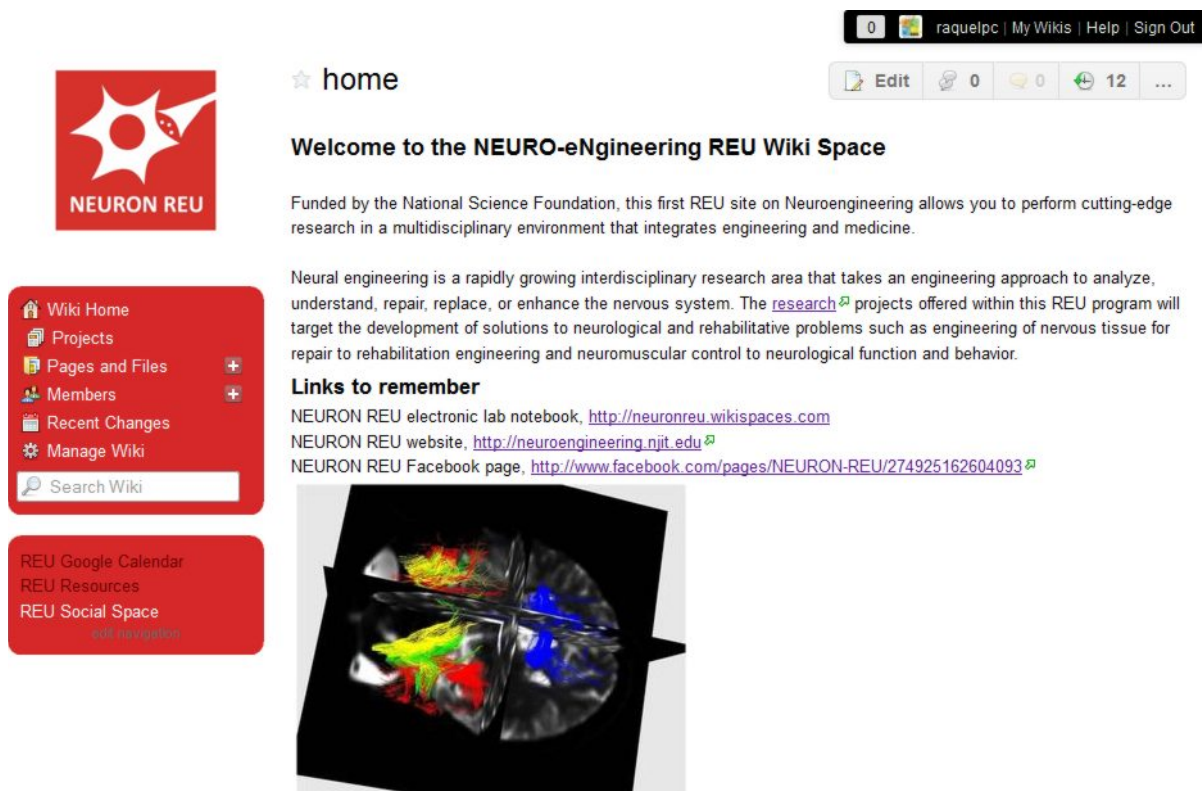


Figure 3: Main page of the Wiki used as the electronic, online lab notebook of the student teams in the NEURON REU.

All teams start with a fairly basic wiki structure that includes the following sections: Home, Calendar, Lab Notebook, Resources, and Team. The page ‘Home’ describes briefly the research project and lists the links to other sections of the project. The ‘Calendar’ page hosts a Google Calendar for the student team with meetings, core facility use appointments, etc. The ‘Lab Notebook’ is day-by-day recapitulation of the experiments and results performed and collected by the team each day. ‘Resources’ typically collects code scripts or software downloads that are needed by the student team in their research activities. Finally, the page ‘Team’ lists the names and emails of all the main members of the team: students, graduate coach, and faculty advisors. Additional to these basic sections, each student team is invited to create as many others as they see fit to their research needs. As an example, Figure 4 displays the main page of the wiki created by the students in the 2013 NEURO-BIOMATERIALS team. It is noteworthy that this team decided to create two additional sections for collecting their weekly ‘Presentations’ and their final ‘Presentation, Abstract, and Poster.’

The *wiki-ELN* concept provides a number of benefits to the REU participants—both students and faculty members—as it allows to (i) synchronize different activities carried out simultaneously by different members of a team at different locations/labs using, for example, a smart phone, (ii) document the research progress continuously—which emphasizes the importance of reporting the research process continuously, not only when some experiment “works”—and (iii) receive and answer comments from peers, which develops student awareness of the relevance of peer review in scientific research.



☆ home

NEURO-BIOMATERIALS TEAM homepage.

Project Description:

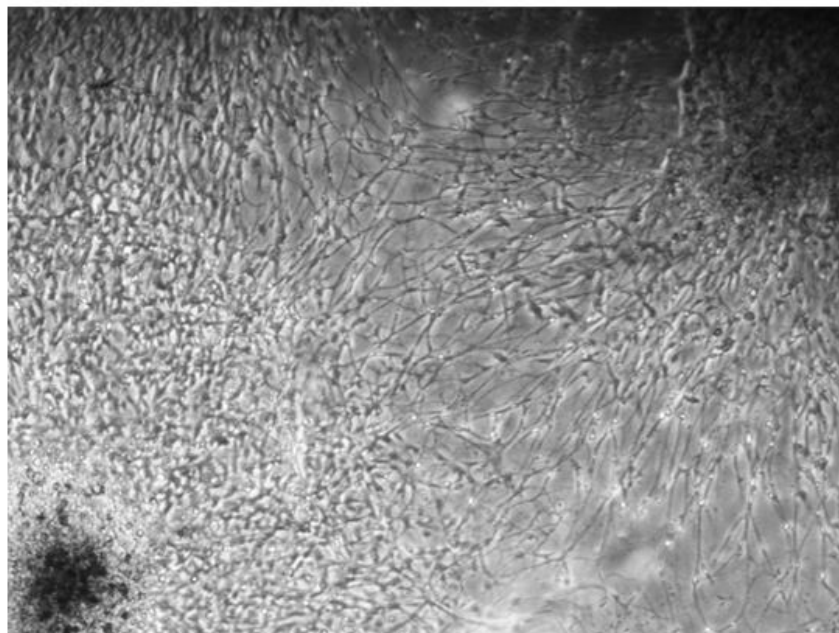
Implementation of wet spinning process to create collagen scaffolds

- Wiki Home
- Projects +
- ** NEURO-BIOMATERIALS Team
- Recent Changes
- Pages and Files +
- Members
- Search Project

All Pages

- home
- Biomaterials Calendar
- Biomaterials LabBook
- Biomaterials Presentations
- Biomaterials Resources
- Biomaterials Team
- Neuro-Biomaterials Final Presentation, Abstract, and Poster

[with navigation](#)



Dorsal root ganglia (DRG) cells plated on collagen coating during Week 3, magnification 4X, pH.L filter.

Navigation:

- [Neuro-Biomaterials Team](#)
- [Neuro-Biomaterials Calendar](#)
- [Neuro-Biomaterials Lab Notebook](#)
- [Neuro-Biomaterials Resources](#)
- [Neuro-Biomaterials Presentations](#)
- [Neuro-Biomaterials Final Presentation, Abstract, and Poster](#)

Figure 4: Main page of the Wiki by the 2013 NEURO-BIOMATERIALS team.

All participants of the REU (students and faculty members) have welcomed the use of the wiki-based electronic lab notebook (wiki-ELN). Overall, the major users of the wiki-ELN are those interacting with research results on a daily basis: that is, undergraduate students and graduate coaches. According to answers to free-response questions collected with a last-day survey, for these REU participants the wiki-ELN was key in (i) keeping all members of the team up to date about results and progress achieved by each member of the team—especially when they were not together in one location—and in (ii) recording and retaining easy access to research data. For the research advisors and the leadership of the NEURON REU program, the wiki-ELN ensures long-term retention of all data associated with the program, avoiding deletion of data by mistake by automatically keeping a copy of any file before modifying or deleting it.

We believe that our effort to focus the attention of the students and faculty members onto producing nationally competitive abstracts reporting on own research yields higher standards for the way research is performed. The expectations are obviously different when the results are to be presented in campus compared to results that need to compete with peers (summer undergraduate researchers) for a spot on a national conference. Such expectations generate friendly competition between student teams and even between faculty advisors, who realize the outcomes of the summer research projects will become public and if successful, they will also become part of their research curriculum vitae.

The structure of the NEURON REU site, emphasizing data recording with a wiki-ELN and featuring times throughout the 10 weeks of the program for training the students in the art of technical public communication, has been proven successful by the same indicator used to quantify productivity of professional researchers—that is, publications and among those, abstracts published in the proceedings of competitive, relevant, national conferences such as BMES. Records show that after two years of running the REU on neural engineering, each and all of the student teams (eight) have been able to submit an abstract to the BMES conference, with seven of the teams having their abstract accepted after review by professionals in the field. Of those accepted abstracts, six were chosen for poster presentation whereas one was selected for one of the very competitive sessions of oral presentations—in this case, only 1 out of 10 accepted abstracts were selected for oral presentation instead of poster presentation. We believe that other REU sites may find it useful to emphasize abstract submission and public presentation at technically reviewed, competitive conferences, which increases the engagement of all the REU participants involved, from the undergraduate students to the faculty advisors.

References:

- [1] REU site on Neural Engineering: <http://neuroengineering.njit.edu>
- [2] BMES Abstract Submission: <http://bmes.org/abstract>.
- [3] J. D. Carpinelli, L. S. Hirsh, H. Kimmel, A. J. Perna, and R. Rockland, “A survey to measure undergraduate engineering students' attitudes toward graduate studies” 1st Int. Conf. Research in Engineering Education, 2007.
- [4] G. M. Whitesides, “Whitesides’ group: writing a paper” Adv. Mater. 16(15):1375-7, 2004.
- [5] Wiki, as defined on Wikipedia: <http://en.wikipedia.org/wiki/Wiki>
- [6] Wikispaces: <http://www.wikispaces.com>