



# Evaluation Report

## Research Experiences for Undergraduates and Veterinary Students

June 1-July 24, 2009

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## Executive Summary

### Brief Synopsis of Event

The NIMBioS *Research Experiences for Undergraduates* (REU) and *Research Experiences for Veterinary Students* (REV) programs took place simultaneously on the University of Tennessee, Knoxville (UT) campus June 1-July 24, 2009. During the programs, veterinary students and undergraduate students majoring in math, biology, and related fields lived on campus and worked in four-person research teams mentored by UT professors. The teams worked on state-of-the-art research projects at the interface of math and biology both in the lab and in the field. Participants learned how to write computer programs to model their research findings mathematically. Besides the research projects, program activities included lectures on modeling and background on the projects, lab tutorial work on Matlab and R, an ethics session, a career advice session, progress and finale presentations, a written report, and social activities. Participants were paid a stipend, and housing and travel allowances were provided. The program was designed to give participants the opportunity to actively participate in the various components of the scientific research process. Each project group had a math/computational mentor and a biology/vet mentor.

The REU/REV program comprised 16 participants who came from a diverse array of backgrounds, including agricultural sciences/natural resources, biological/biomedical sciences, engineering, veterinary medicine, and mathematics. A high school math teacher and biology teacher were also included in the 16. Four veterinary students and four undergraduate math majors took part in the REV program projects, while the remaining six undergraduates and two teachers participated in the REU program projects. Mentors in the program included UT professors Suzanne Lenhart (Mathematics), Steven Wise (Mathematics), Graham Hickling (Forestry, Wildlife, and Fisheries), Michael Gilchrist (Ecology and Evolutionary Biology), Agricola Odoi (Comparative Medicine—Veterinary College), and Kimberly Gwinn (Entomology and Plant Pathology) (See Appendix A).

### Evaluation Design

A pre/post evaluation design was used to measure changes in participant research skills and knowledge as a result of taking part in the program. Electronic surveys aligned to the following evaluation questions were designed by NIMBioS' Evaluation Coordinator with input from NIMBioS' Associate Director for Education, Outreach, and Diversity, and the Education and Outreach Coordinator.

1. Were participants satisfied with the program overall?
2. Did the research experience meet participant expectations?
3. Did the research experience impact participant plans to go to graduate school?
4. To what extent did participants increase their research skills during the program?
5. To what extent do participants feel they gained knowledge about the research process?

6. How satisfied were participants with their mentors?
7. How satisfied were participants with the accommodations offered by NIMBioS?
8. What changes do participants feel NIMBioS should make in the program for next year?

The final instruments were hosted online via the University of Tennessee's secure online survey host mrInterview. Links to the pre survey were emailed to the 16 REU/REV participants on May 27, 2009. Reminder emails were sent to non-responding participants on June 3, 2009. By June 5, 2009, 16 participants had given their feedback, for a response rate of 100%.

Links to the post survey were sent to the 16 REU/REV participants on July 24, 2009. Reminder emails were sent to non-responding participants on July 30 and August 10, 2009. By August 17, 2009, 16 participants had given their feedback, for a response rate of 100%.

## Highlights of Results

- Overall satisfaction with the program was high among participants, 100% of whom said they were “satisfied” or “very satisfied” with their experiences and would recommend the program to others.
- Fourteen of the sixteen participants said most or all of their expectations were met or exceeded during the program.
- The majority of participants (69%) thought the overall workload during the program was “just about right.”
- Overall, participants were highly satisfied with their mentors, indicating that they were very helpful and supportive during the research experience.
- Participants rated their mentors highly, with the average biology mentor rating at 4.8 and the average math mentor rating at 4.3 (on a scale of 1-5, with 5 being the most favorable).
- Most participants (88%) said they were satisfied with the computing resources offered during their research experiences, but many were dissatisfied with the mail service they received (50% "dissatisfied" or "very dissatisfied").
- Participants reported gains in several research-related skills, with an average rating of 3.4 for all skill levels on the pre survey and 3.9 on the post survey (on a scale of 1=extremely poor at the skill and 5 being excellent at the skill).
- Participants reported gains in knowledge regarding several research-related topics. Before the program, participants on average rated themselves 3.2 on a 5-point scale (1 = extremely poor understanding of the topic, 5 = excellent understanding). After participation, the average rating was 4.0.
- While most participants’ plans to go to graduate school remained unchanged as a result of participating in the program, one student said the experience encouraged him/her to attain a doctoral degree when he/she previously planned to attain only a bachelor’s degree.

## Conclusions and Recommendations

According to participant data, the REU/REV program was successful. Overall satisfaction with the program was high, with 100% of participants being “satisfied” or “very satisfied” with their experiences. All participants also indicated they would recommend the program to others. The majority of participants said the program met or exceeded their expectations, and that the workload was appropriate for the program. Participants were also highly satisfied with their mentors, indicating that they were skillful, helpful, and positively impacted the research experience overall.

Participants showed varying degrees of satisfaction with the accommodations offered during the program, with the majority being highly satisfied with computing resources and extracurricular activities, but less than satisfied with housing. Additionally, half of the participants who used the mail service were dissatisfied with it. Several participants suggested providing free transportation and meal plans for future participants as well.

Participants showed increased levels of confidence regarding how well they felt they could carry out several research-related skills. Analysis of pre and post responses showed that gains were reported in every skill on the survey, with an average rating for all skills at 3.4 on the pre survey and 3.9 on the post survey (on a scale of 1=extremely poor at the skill and 5 being excellent at the skill). Participants showed the greatest skill gains in integrating scientific theories with research, designing research plans, and using research literature.

Participants also showed increased levels of knowledge about the research process. Before the program, participants on average rated themselves 3.2 on a 5-point scale (1 = extremely poor understanding of the topic, 5 = excellent understanding). After participation, the average rating was 4.0. Participants showed the greatest gains in understanding the nature of interdisciplinary research collaborations and the demands of a research career.

Most participant plans to attain graduate degrees remained unchanged as a result of the program (15 planned on graduate school both before and after the program). However, one participant, who before the program had no plans to go to graduate school, said he/she now plans to earn a doctorate degree.

Based on analysis of participant response data, the recommendations are as follows:

- Because 31% of participants considered their workload too much or too little, consider defining participant workloads more clearly with program mentors before the next program, and ensure that these workload expectations are clear to participants before the program.
- Overall mentor satisfaction suggests retaining mentors from the current program for future implementations, however, consider emphasizing both overall program and research team goals with all mentors before the start of the program to avoid any confusion after the program begins.
- Some of the dissatisfaction with accommodations offered to participants appeared to stem from misunderstandings about what would and would not be offered. Consider creating a small

guidebook or handout for participants outlining what accommodations will and will not be provided by NIMBioS during the program. Consider including information about public transportation and campus eateries, as well as workload expectations.

# REU/REV Evaluation Report

## Background

### Introduction

The NIMBioS *Research Experiences for Undergraduates* (REU) and *Research Experiences for Veterinary Students* (REV) programs took place simultaneously on the University of Tennessee, Knoxville (UT) campus June 1-July 24, 2009. During the programs, veterinary students and undergraduate students majoring in math, biology, and related fields lived on campus and worked in four-person research teams mentored by UT professors. The teams worked on state-of-the-art research projects at the interface of math and biology both in the lab and in the field. Participants also learned how to write computer programs to model their research findings mathematically. Besides the research projects, program activities included lectures on modeling and background on the projects, lab tutorial work on Matlab and R, an ethics session, a career advice session, progress and finale presentations, a written report, and social activities. Participants were paid a stipend, and housing and travel allowances were provided. The program was designed to give participants the opportunity to actively participate in the various components of the scientific research process. Each project group had a math/computational mentor and a biology/vet mentor.

The REU/REV program comprised 16 participants, including undergraduates, veterinary students, and two high school teachers. Veterinary students took part in the REV program projects, along with four undergraduate math majors. The other six undergraduates and two teachers participated in the REU program projects. Mentors in the program included UT professors Suzanne Lenhart (Mathematics), Steven Wise (Mathematics), Graham Hickling (Forestry, Wildlife, and Fisheries), Michael Gilchrist (Ecology and Evolutionary Biology), Agricola Odoi (Comparative Medicine—Veterinary College), and Kimberly Gwinn (Entomology and Plant Pathology) (See Appendix A).

### Project Backgrounds

Participants were selected to work on one of four research projects. Descriptions of the projects have been provided by program mentors:

#### *Modeling predictors of geographic distribution of campylobacter infections in East Tennessee* (Odoi/Lenhart)

Campylobacteriosis is a zoonotic disease caused by gram-negative bacteria, *Campylobacter*, which is the most common bacterial cause of diarrhea in the United States. Incidence of the disease varies widely depending on geographical location. It is thought that the incidence of campylobacteriosis is higher in East Tennessee than the rest of the state and the nation. Therefore, this project investigated the spatial patterns of campylobacter infections at various spatial scales in East Tennessee and model predictors of identified spatial patterns. Participants gained an understanding of the biology/epidemiology of the disease and were exposed to a number of spatial analytical techniques useful in investigating spatial disease patterns and in spatial modeling. The findings of the project will be useful in guiding disease control strategies.



#### *Plant Bioactive Natural Products (Gwinn/Wise)*

Research in the laboratory of Kimberly Gwinn focuses on the use of plant bioactive natural products as replacements for synthetic pesticides. The NIMBioS project examined time and growth phase effects on the production of monoterpenes in the genus *Monarda*. *Monarda didyma*, common bee balm, produces many monoterpenes. The NIMBioS project will provide information for that will assist in maximizing the potential of this environmentally responsible technology. The project focused on modeling in two biosynthetic pathways but also included experimentation for natural product isolation and analysis.

#### *Codon Usage Bias (Gilchrist/Wise)*

Codon usage bias (CUB) is the preferential usage of particular synonymous codons when encoding a given amino acid. The evolution of CUB is of great interest because it allows biologists to think about adaptation at a molecular level. The Gilchrist lab is focused on understanding how costly translational errors affect CUB through the use of biologically motivated mathematical models, computer simulation, and sequence analysis. The NIMBioS summer REU project focused on the relationship between adaptation in CUB of a gene and the structure of the protein it encodes.

#### *Spatial control of Ehrlichiosis, a Tick-borne Disease (Hickling/Lenhardt)*

*Amblyomma americanum*, the Lone Star tick, is the predominant tick species throughout the southeast United States. Its importance has grown over the past few decades as its importance in disease transmission was recognized and as ehrlichiosis cases have risen. The key to Lone Star tick control begins with an understanding of its complex three-host life cycle and continues long term with successful management of the tick on its primary host, the white-tailed deer. Here we formulate a discrete temporal model of the tick life cycle in order to investigate the optimal spatial arrangement of 4-poster feeders within the Fairfield Glade retirement community. Our model includes the distinct life stages of this tick population and the spatial features of this community. Data collected by J. Harmon (unpubl.) are used to estimate some of the parameters while others are based on previous lone star tick modeling work by Haile and Mount (1987). We formulate an economic criterion to evaluate various feeder placement scenarios that allow recommendations to be made to Fairfield Glade for 4-poster feeder arrangements that minimize both cost and ehrlichia cases and that tend toward future projects in optimization of this system.

#### **Participant Demographics**

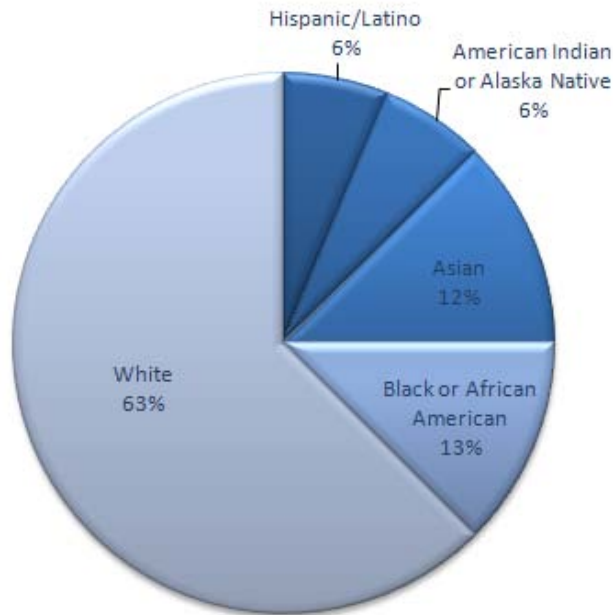
Program participants, who were either undergraduate students (63%) veterinary students (25%) or high school teachers (12%), came from 12 institutions in eight states. Nine participants said they heard about the program through faculty/staff at their university, while two received an email from their college notifying them about the opportunity. Others heard about the program through friends or coworkers. Primary fields of study for the 16 participants included agricultural sciences/natural resources, biological/biomedical sciences, engineering, health sciences, and mathematics (Table 1).

Table 1. Participant fields of study and areas of concentration

Field of Study	Concentration	# Participants
Agricultural Sciences/Natural Resources	Animal Science	1
Biological/Biomedical Sciences	Biometrics & Biostatistics	1
	Ecology	1
	Pharmacology, Human & Animal	1
	Biology/Biological Sciences, General	1
Engineering	Industrial & Manufacturing	1
Health Sciences	Veterinary Medicine	4
Mathematics	Applied Mathematics	3
	Computing Theory & Practice	1
	Math/Statistics, General	2

The twelve female and four males (one of whom self-identified as Hispanic/Latino) also came from a diverse array of racial backgrounds (Figure 1).

Figure 1. Racial composition of program participants (n =16)



## Evaluation Design

### Evaluation Questions

The evaluation of the program was both formative and summative in nature, in that the data collected from participants was intended to both gain feedback from participants about the quality of the current program and also to inform next year's program. A pre/post evaluation design was used to measure self-reported changes in participant skills and knowledge as a result of taking part in the program.

The evaluation framework was guided by Kirkpatrick's Four Levels of Evaluation model for training and learning programs (Kirkpatrick, 1994<sup>1</sup>). The evaluation questions were developed according to level one of the model, participants' reactions, in order to gather information about how participants felt about the content and format of the program, as well as the accommodations provided by NIMBioS. Several questions constituted the foundation for the evaluation:

1. Were participants satisfied with the program overall?
2. Did the research experience meet participant expectations?
3. Did the research experience impact participant plans to go to graduate school?
4. To what extent did participants increase their research skills during the program?
5. To what extent do participants feel they gained knowledge about the research process?
6. How satisfied were participants with their mentors?
7. How satisfied were participants with the accommodations offered by NIMBioS?
8. What changes do participants feel NIMBioS should make in the program for next year?

### Evaluation Procedures

Electronic surveys aligned to the evaluation questions were designed by NIMBioS' Evaluation Coordinator with input from NIMBioS' Associate Director for Education, Outreach, and Diversity, and the Education and Outreach Coordinator. The final instruments were hosted online via the University of Tennessee's secure online survey host mrInterview.

Links to the pre survey were emailed to the 16 REU/REV participants on May 27, 2009. Reminder emails were sent to non-responding participants on June 3, 2009. By June 5, 2009, 16 participants had given their feedback, for a response rate of 100%.

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### Data Analysis

Data from the electronic surveys included both forced-response and supply-item questions. All data were downloaded from the online survey host into the statistical software package SPSS for analysis.

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<sup>1</sup> From Kirkpatrick, D.L. (1994). *Evaluating Training programs: The Four Levels*. San Francisco, CA: Berrett-Koehler.

Quantitative data were analyzed using SPSS, while qualitative data were analyzed in SPSS Text Analysis for Surveys. Qualitative responses were categorized by question and analyzed for trends.

## Findings

### Participant Satisfaction

#### *Overall Satisfaction*

Overall satisfaction with the program was high among participants, 100% of whom said they were “satisfied” or “very satisfied” with their experiences and would recommend the program to others:

*“It was a wonderful program and I appreciate every moment. I will brag about my experience and spread the word of NIMBioS to everyone!”* (REV participant)

*“...I liked how our mentor was very involved with our project. He spent a lot of time helping us figure things out, yet still giving us the independence to do things on our own. I feel like I learned a lot of new things this summer, in terms of how scientific research works, new analysis skills, and how to work together in a group. It was a very rewarding experience.”* (REU participant)

*“Having never participated in research, I thought this program gave me great insight on how research impacts real world issues. It also gives me something to use when trying to explain how math is used.”* (REU participant)

Before beginning the REU/REV program, participants were asked what they hoped to gain through participation. Almost half (44%) of the participants said they would like to gain understanding of how research is conducted:

*“I hope to gain a better understanding of scientific research including: developing my scientific reasoning skills, my laboratory techniques, and my troubleshooting skills.”*

*“I hope to gain better skill/comfort with research presentations and receive great knowledge in my research group through working in a group.”*

Another large percentage of the participants (44%) also said hoped to learn more about using mathematics in research:

*“I hope to gain real world experience in the field of mathematics, and hopefully gain an idea of what graduate school would be like if I were to attend graduate school.”*

*“A better understanding of how math is used in applications and how research is conducted.”*

*“I hope to gain real world experience in the field of mathematics, and hopefully gain an idea of what graduate school would be like if I were to attend graduate school.”*

Fourteen of the sixteen participants said most or all of their expectations were met or exceeded during the program. One participant who said only “some” of his/her expectations were met indicated that

he/she felt the workload was too much. While the majority of participants (69%) thought the overall workload during the program was “just about right,” others gave a range of responses (Table 2).

Table 2. Participant perceptions of overall workload during the program

How did you feel about your workload overall?	Frequency
Way too little	1
Too little	2
Just about right	11
Too much	2

The participant who felt his/her workload was "way too little" had this to say about the experience:

*"I feel that my group could have completed a lot more if we had been pushed more by our mentors."*

### **Satisfaction with Mentors**

Each participant had two mentors during the program: one specializing in biological science and one specializing in mathematics. Overall, participants were highly satisfied with their mentors, indicating that they were very helpful and supportive during the research experience. Some participant comments:

*"I learned a lot from Dr. Gilchrist and Dr. Wise. Dr. Gilchrist especially emphasized that his goal was to make sure that we learned something this summer, and came out appreciating science, which I thought was especially important for our group, since we came from such a diverse background of skills. ...he spent a lot of time helping us through this project, while still giving us the independence to try things on our own. He also tried to make sure all of us had something to do, so not a few people were left with the main burden of work. We all learned a lot about coding, since 3 out of 4 of us had no computer programming experience. He did have expectations of us, which I think helped solidify our group, because we knew what we wanted to accomplish. Overall, I had a great time working with him and the other group members on this project."*

*"I really appreciate their support."*

*"I thought very highly of both of my mentors, and they were both talented instructors as well."*

One participant, however, felt that the program mentors as a whole were not always moving in the same direction:

*"Only thought was that mentors had differing views of the goals of NIMBioS....varied not only between mentors but from group to group too."*

Another participant said while he/she liked working with both mentors, he/she did not like working with them together:

*"I really enjoyed working with both mentors but did not enjoy watching them attempt to work together. Both professors are incredibly intelligent and experienced in their research field but seemed to have difficulty, especially for the first month, in combining their expertise. Group meetings often consisted of them attempting to talk over each other until {one} finally backed down and waited. I am very pleased with the final results of our project but was honestly surprised by the level of professionalism and maturity demonstrated at times."*

Participants were asked to rate their biology and math mentors separately on several desirable characteristics. Overall, participants rated their mentors highly, with the average biology mentor rating at 4.8 and the average math mentor rating at 4.3 (on a scale of 1-5, with 5 being the most favorable). Participants rated several characteristics very highly for biology mentors, including mentor interest in enhancing participants' research experiences, offering constructive ideas for improvement, and positively impacting the research experience of participants (average rating 4.9 for each) (Table 3).

Table 3. Average participant rating of biology mentors on a scale of 1-5 (1=Strongly disagree, 5 = Strongly agree), by research group

My biology mentor:	Average Rating for Biology Mentor				Average
	Gilchrist/ Wise	Gwinn/ Wise	Hickling/ Lenhart	Odoi/ Lenhart	
Was accessible	5.0	4.8	4.5	4.8	4.8
Was interested in enhancing my research experience	5.0	4.8	4.8	5.0	4.9
Communicated on an appropriate level	4.8	5.0	4.3	5.0	4.8
Encouraged independence	4.8	5.0	4.5	5.0	4.8
Offered constructive ideas for improvement	4.8	5.0	4.8	5.0	4.9
Was organized	4.5	4.8	4.5	4.8	4.6
Had the necessary skills to mentor	4.8	5.0	4.8	5.0	4.9
Positively impacted my research experience	4.8	5.0	4.8	5.0	4.9
<i>Average</i>	4.8	4.9	4.6	4.9	4.8

The highest rated characteristic for math mentors was accessibility (average rating 4.6), followed by interest in enhancing the research experience, encouraging independence, and being organized (average rating of 4.4 for each) (Table 4).

Table 4. Average participant rating of math mentors on a scale of 1-5 (1=Strongly disagree, 5 = Strongly agree), by research group

My math mentor:	Average Rating for Math Mentor				Average
	Gilchrist/ Wise	Gwinn/ Wise	Hickling/ Lenhart	Odoi/ Lenhart	
Was accessible	4.3	4.8	4.8	4.5	4.6
Was interested in enhancing my research experience	4.5	4.5	4.3	4.3	4.4
Communicated on an appropriate level	4.8	4.8	3.5	3.5	4.1
Encouraged independence	4.5	5.0	4.0	4.3	4.4
Offered constructive ideas for improvement	4.5	5.0	4.0	3.3	4.2
Was organized	4.5	5.0	4.0	4.0	4.4
Had the necessary skills to mentor	4.3	5.0	4.0	4.0	4.3
Positively impacted my research experience	4.3	4.5	3.8	3.8	4.1
<i>Average</i>	<i>4.4</i>	<i>4.8</i>	<i>4.0</i>	<i>3.9</i>	<i>4.3</i>

### Satisfaction with Accommodations

NIMBioS arranged housing for 14 of the participants, the majority of whom (64%) reported feeling "neutral" about the residential accommodations. Some of the discontent with housing appeared to stem from the addition of a non-NIMBioS participant being added as a roommate at the last minute:

*"... I loved living with the other two vet students in the REV program but was disappointed when we received a fourth, non-NIMBioS roommate without any warning. I would recommend keeping the apartments to three or fewer people in the future. Those spaces are quite tight for four, especially when everyone does not get along."*

*"The housing situation was fine except that we had a 4th roommate show up at 1:30 am in the middle of the week when we were not aware we were getting anyone else moved in. Not only was this extremely inconsiderate but she was not in our program and we lived completely different lifestyles. It made the living experience rough when it would have otherwise worked out wonderfully."*

Most participants (88%) said they were satisfied with the computing resources offered during their research experiences, but many were dissatisfied with the mail service they received (50% "dissatisfied" or "very dissatisfied"). Participant comments indicated an issue existed with mail being returned to senders:

*"... the UT mail system was extremely slow and confusing. Packages with the correct zip code were returned to the sender while others with the wrong zip code were received. The Andy Holt employees were not only not helpful in clarifying this matter, but downright rude and impatient that we even asked about mail issues".*

*"Please contact USPS regarding Andy Holt apartment address issue, if it will be the accommodation for NIMBioS next year."*

The majority of participants (66%) were satisfied with the extracurricular activities offered during the research experience (Table 5). Participants who felt “neutral” or “dissatisfied” with the activities offered no insight as to how they would improve activities for future programs.

Table 5. Participant levels of satisfaction with program accommodations

<b>Please indicate your level of satisfaction with the following accommodations:</b>	<i>n</i>	Very satisfied	Satisfied	Neutral	Dissatisfied	Very dissatisfied
Computing resources	16	44%	44%	13%	0%	0%
Housing	14	7%	29%	64%	0%	0%
Mail service	16	7%	14%	29%	14%	36%
Extracurricular activities	15	33%	33%	27%	7%	0%

Participant suggestions regarding accommodations for future programs included providing free transportation around town, a meal plan, and kitchen supplies:

*"For future REU's \*Transportation like a shuttle service for students without cars; The buses (not including KAT and the Trolley) were not free (many universities have free transportation on city bus lines). \*Meal plan \*Matlab Tutorial"*

## Program Impact

### Participant Skills

Participants were asked several questions before and after participating in the program to gauge how well they felt they could carry out several research-related skills. Analysis of pre and post responses showed that gains were reported in every skill on the survey, with an average rating for all skills at 3.4 on the pre survey and 3.9 on the post survey (on a scale of 1=extremely poor at doing the skill and 5=excellent at doing the skill). Participants showed the greatest skill gains in integrating scientific theories with research, designing research plans, and using research literature. Other skills enhanced by participation in the program included working collaboratively with other researchers, using mathematical tools or models to describe a biological scenario, and orally presenting research results (Table 6). One participant felt the constructive criticism offered during the mid-program presentations was a very useful for improving his/her presentation skills:

*"After the mid-program presentations, I enjoyed the constructive criticisms of our presentations from the advisors and directors. I felt like it helped make the presenters better for future oral presentations. After the final presentations, I feel like there were not many criticisms, only questions. I say use them in order to better help us to prepare for the future."*



Table 6. Average participant pre- and post-program self ratings of research skills on a scale of 1-5 (1=Extremely poor, 5 = Excellent)

How would you rate your ability regarding the following research skills?	Pre Survey	Post Survey
Integrating scientific theories with research	3.0	3.8
Designing a research plan	2.9	3.6
Using research literature	3.3	4.0
Working collaboratively with other researchers	3.8	4.4
Using mathematical tools or models to describe a biological scenario	3.0	3.6
Orally presenting results	3.5	4.1
Writing about results	3.4	3.7
Analyzing data	3.8	4.1
Interpreting results	3.8	4.1
<i>Average</i>	<i>3.4</i>	<i>3.9</i>

### *Participant Knowledge*

In addition to enhancing their research skills, participants also reported gains in knowledge about the research process. Participants were asked to rate their levels of knowledge about several research-related topics both before and after participating in the program. Before the program, participants on average rated themselves 3.2 on a 5-point scale (1 = extremely poor understanding of the topic, 5 = excellent understanding). After participation, the average rating was 4.0. Participants showed the greatest gains in understanding the nature of interdisciplinary research collaborations and the demands of a research career (Table 7).

Table 7. Average participant pre- and post-program self ratings of research-related knowledge on a scale of 1-5 (1=Extremely poor, 5 = Excellent)

How would you rate your level of understanding in the following areas?	Pre survey	Post survey
The nature of interdisciplinary research collaborations	2.9	4.1
The demands of a research career in your discipline	3.1	4.0
The nature of the research process	3.3	4.1
How current research ideas build upon previous studies	3.3	4.1
How scientists work on real problems	3.3	4.0
Possible career paths in your discipline	3.1	3.8
Ethical issues in research	3.2	3.9
<i>Average</i>	<i>3.2</i>	<i>4.0</i>

### ***Graduate School Plans***

Participants were asked the highest level of education they planned to complete both before and after participating in the program, and if participation in the program impacted their plans to attain graduate degrees. Results showed that 15 of the participants planned on attaining graduate degrees both before and after participating in the program, and that the degrees they planned to attain did not change (4 master's and 11 doctoral degrees planned). One participant, who before the program had no plans to go to graduate school, said he/she now planned to earn a doctorate degree.

### **Conclusions and Recommendations**

According to participant data, the REU/REV program was successful. Overall satisfaction with the program was high, with 100% of participants being “satisfied” or “very satisfied” with their experiences. All participants also indicated they would recommend the program to others. The majority of participants said the program met or exceeded their expectations, and that the workload was appropriate for the program. Participants were also highly satisfied with their mentors, indicating that they were skillful, helpful, and positively impacted the research experience overall.

Participants showed varying degrees of satisfaction with the accommodations offered during the program, with the majority being highly satisfied with computing resources and extracurricular activities, but less than satisfied with housing. Additionally, half of the participants who used the mail service were dissatisfied with it. Several participants suggested providing free transportation and meal plans for future participants as well.

Participants showed increased levels of confidence regarding how well they felt they could carry out several research-related skills. Analysis of pre and post responses showed that gains were reported in every skill on the survey, with an average rating for all skills at 3.4 on the pre survey and 3.9 on the post survey (on a scale of 1=extremely poor at the skill and 5 being excellent at the skill). Participants showed the greatest skill gains in integrating scientific theories with research, designing research plans, and using research literature.

Participants also showed increased levels of knowledge about the research process. Before the program, participants on average rated themselves 3.2 on a 5-point scale (1 = extremely poor understanding of the topic, 5 = excellent understanding). After participation, the average rating was 4.0. Participants showed the greatest gains in understanding the nature of interdisciplinary research collaborations and the demands of a research career.

Most participant plans to attain graduate degrees remained unchanged as a result of the program (15 planned on graduate school both before and after the program). However, one participant, who before the program had no plans to go to graduate school, said he/she now plans to earn a doctorate degree.

Based on analysis of participant response data, the recommendations are as follows:

- Because 31% of participants considered their workload too much or too little, consider defining participant workloads more clearly with program mentors before the next program, and ensure that these workload expectations are clear to participants before the program.

- Overall mentor satisfaction suggests retaining mentors from the current program for future implementations, however, consider emphasizing both overall program and research team goals with all mentors before the start of the program to avoid any confusion after the program begins.
- Some of the dissatisfaction with accommodations offered to participants appeared to stem from misunderstandings about what would and would not be offered. Consider creating a small guidebook or handout for participants outlining what accommodations will and will not be provided by NIMBioS during the program. Consider including information about public transportation and campus eateries, as well as workload expectations.

## **Appendix A**

### ***List of Participants***

## Participants

Last name	First name	Status	Institution
Atchley	Taylor	Undergraduate student	University of Tennessee Knoxville
Auker	Cameron	Undergraduate student	Hampden-Sidney College
Bahorich	Laura	Veterinary student	University of Pennsylvania
Benally	Twyla	Veterinary student	Washington State University
Bennett	Crystal	Undergraduate student	North Carolina A&T State University
Briggs-Dunn	Kimberly	High school teacher	Clinton High School
Brown	Julie Paige	Veterinary student	University of Tennessee Knoxville
Coon	Kerri	Undergraduate student	University of Virginia
DeGroot	Crystal	Veterinary student	Michigan State University
Fassino	Steven	Undergraduate student	University of Tennessee Knoxville
Ferguson	Revorn	Undergraduate student	North Carolina A&T State University
Huang	Wen	Undergraduate student	Queens College CUNY
Khatri	Vishnupriya	Undergraduate student	Duke University
Nance	James	Undergraduate student	Emory University
Schiermeyer	Katherine	Undergraduate student	East Tennessee State University
Sills	Ginger	High school teacher	Clinton High School

### REU/REV Mentors

\*Suzanne Lenhart, Director, *Mathematics Department and NIMBioS Associate Director for Education, Outreach, and Diversity*

Graham Hickling, *Director of the Center for Wildlife Health and NIMBioS Associate Director for Partner Relations*

Mike Gilchrist, *Ecology and Evolutionary Biology Department*

Kim Gwinn, *Entomology and Plant Pathology Department*

Agricola Odoi, *Dept. of Comparative Medicine, College of Veterinary Medicine*

Steve Wise, *Mathematics Department*

\* Program organizer

## **Appendix B**

### ***REU/REV Pre and Post Surveys***

## Research Experiences for Undergraduates/Veterinary Students

### Pre Survey

Thank you for taking a moment to fill out this survey. Your results will be used to enhance your experience at the University of Tennessee this summer, to improve the REU/REV programs for future cohorts, and to track your progress during the program. Congratulations on your acceptance into the program. We hope you have an interesting and exciting experience.

Please enter your first and last name. Your name will only be used to match your pre and post survey responses. You will not be personally identified in any way during the reporting of survey results.

How did you learn about this program?

What do you hope to gain through participation in this program?

Please select response that best describes your general field of study:

*Agricultural Sciences/Natural Resources*  
*Astronomy/Atmospheric Sciences/Meteorology*  
*Biological/Biomedical Sciences*  
*Chemistry*  
*Computer & Information Sciences*  
*Education*  
*Engineering*  
*Geological & Earth Sciences*  
*Health Sciences*  
*Humanities*  
*Mathematics*  
*Ocean/Marine Sciences*  
*Physics*  
*Social Sciences*  
*Other Professional Field*

Agricultural Sciences/Natural Resources: Please select the response that best describes your area of concentration:

*Agricultural Economics*  
*Agricultural Animal Breeding*  
*Agricultural Science, other*  
*Agriculture, General*  
*Agronomy & Crop Science*  
*Animal Nutrition*

*Animal Science, Other*  
*Environmental Science*  
*Fishing and Fisheries Sciences/Management*  
*Food Science*  
*Food Science and Technology, Other*  
*Forest Sciences and Biology*  
*Forest/Resources Management*  
*Forestry & Related Science, Other*  
*Horticulture Science*  
*Natural Resources/Conservation*  
*Plant Breeding*  
*Plant Pathology/Phytopathology*  
*Plant Sciences, Other*  
*Poultry Science*  
*Soil Chemistry/Microbiology*  
*Soil Sciences, Other*  
*Wildlife/Range management*  
*Wood Science & Pulp/Paper Tech.*

Biological/Biomedical Sciences: Please select the response that best describes your area of concentration:

*Anatomy*  
*Bacteriology*  
*Biochemistry*  
*Biomedical Sciences*  
*Biometrics & Biostatistics*  
*Biophysics*  
*Biotechnology*  
*Botany/Plant Biology*  
*Cell/Cellular Biology and History*  
*Developmental Biology/Embryology*  
*Ecology*  
*Endocrinology*  
*Entomology*  
*Genetics, Human & Animal*  
*Immunology*  
*Microbiology*  
*Molecular Biology*  
*Neuroscience*  
*Nutrition Sciences*  
*Parasitology*



*Pathology, Human & Animal*  
*Pharmacology, Human & Animal*  
*Physiology, Human & Animal*  
*Plant Genetics*  
*Plant Pathology/Phytopathology*  
*Plant Physiology*  
*Toxicology*  
*Biology/Biological Sciences, General*  
*Biology/Biomedical Sciences, Other*  
*Zoology, Other*

Health Sciences: Please select the response that best describes your area of concentration:

*Environmental Health*  
*Environmental Toxicology*  
*Epidemiology*  
*Health Systems/Service Administration*  
*Kinesiology/Exercise Science*  
*Nursing Science*  
*Pharmacy*  
*Public Health*  
*Rehabilitation/Therapeutic Services*  
*Speech-Language Pathology & Audiology*  
*Veterinary Medicine*  
*Health Sciences, General*  
*Health Science, Other*

Engineering: Please select the response that best describes your area of concentration:

*Aerospace, Aeronautical & Astronautical*  
*Agricultural*  
*Bioengineering & Biomedical*  
*Ceramic Sciences*  
*Chemical*  
*Civil*  
*Communications*  
*Computer*  
*Electrical, Electronics and Communications*  
*Engineering*  
*Engineering*  
*Engineering Physics*  
*Engineering Science*  
*Environmental Health*  
*Industrial & Manufacturing*

*Materials Science*  
*Mechanical*  
*Mechanics*  
*Metallurgical*  
*Mining & Mineral*  
*Nuclear*  
*Ocean*  
*Operations Research*  
*Petroleum*  
*Polymer & Plastics*  
*Systems*  
*Engineering, General*  
*Engineering, Other*

Computer & Information Sciences: Please select the response that best describes your area of concentration:

*Computer Science*  
*Information Science & Systems*  
*Computer & Information Science, Other*

Mathematics: Please select the response that best describes your area of concentration:

*Algebra*  
*Analysis & Functional Analysis*  
*Applied Mathematics*  
*Computing Theory & Practice*  
*Geometry/Geometry Analysis*  
*Logic*  
*Number Theory*  
*Operations Research*  
*Statistics*  
*Topology/Found.*  
*Math/Statistics, General*  
*Math/Statistics, Other*

Astronomy/Atmospheric Science/Meteorology: Please select the response that best describes your area of concentration:

*Astronomy*  
*Astrophysics*  
*Atmospheric Chemistry and Climatology*  
*Atmospheric Physics and Dynamics*  
*Meteorology*  
*Atmospheric Science/Meteorology, General*

*Atmospheric Science/Meteorology, Other*

Chemistry: Please select the response that best describes your area of concentration:

*Analytical*

*Inorganic*

*Medicinal/Pharmaceutical*

*Organic*

*Physical*

*Polymer*

*Theoretical*

*Chemistry, General*

*Chemistry, Other*

Geological & Earth Sciences: Please select the response that best describes your area of concentration:

*Geochemistry*

*Geology*

*Geomorphology & Glacial Geology*

*Geophysics & Seismology*

*Mineralogy & Petrology*

*Paleontology*

*Stratigraphy & Sedimentation*

*Geological and Earth Sciences, General*

*Geological and Earth Sciences, Other*

Physics: Please select the response that best describes your area of concentration:

*Acoustics*

*Atomic/Molec/Chem*

*Biophysics*

*Condensed*

*Matter/Low Temp*

*Nuclear Physics*

*Optics/Phototonics*

*Particle (Elem)*

*Plasma/Fusion*

*Polymer*

*Applied Physics*

*Physics, General*

*Physics, Other*

Ocean/Marine Sciences: Please select the response that best describes your area of concentration:

*Hydrology & Water Resources*

*Marine Sciences*

*Oceanography, Chemical and Physical*

*Ocean/Marine, Other*

Social Sciences: Please select the response that best describes your area of concentration:

*Anthropology*

*Area Studies*

*Criminology*

*Demography/Population Studies*

*Econometrics*

*Economics*

*Geography*

*International Relations/Affairs*

*Political Science & Government*

*Public Policy Analysis*

*Sociology*

*Statistics*

*Urban Affairs/Studies*

*Social Sciences, General*

*Social Sciences, Other*

Humanities: Please select the response that best describes your area of concentration:

*History*

*Letters*

*Foreign Languages & Literature*

*Other Humanities*

Education: Please select the response that best describes your area of concentration:

*Adult & Continuing Education*

*Counseling & Guidance*

*Curriculum & Instruction*

*Educational Administration & Supervision*

*Educational Assessment/Testing/Measurement*

*Educational Leadership*

*Educational Psychology*

*Educational Statistics/Research Methods*

*Educational/Instructional Media Design*

*Elementary Education*

*Higher Education/Evaluation & Research*

*Pre-elementary/Early Childhood Education*

*School Psychology*

*Secondary Education*

*Social/Philosophical Foundations of Educational*

*Special Education*

*Education, General*

*Education, Other*

Other Professional Fields: Please select the response that best describes your area of concentration:

*Business Management/Administrative*

*Communications*

*Family/Consumer/Human Science, General*

*Law*

*Library Science*

*Parks/Sports/Rec./Leisure/Fitness*

*Public Administration*

*Social Work*

Other field, please specify:

What is the highest level of education you have completed to date?

*High school diploma*

*Associate's degree*

*Bachelor's degree*

*Master's degree*

*Doctoral degree*

Other degree, specify:

Are you currently enrolled in a degree-granting program?

*Yes*

*No*

What type of degree are you currently pursuing?

*Associate's degree*

*Bachelor's degree*

*Master's degree*

*Doctoral degree*

Other degree, specify:

What is the highest level of education you hope to complete?

*High school diploma*

*Associate's degree*

*Bachelor's degree*

*Master's degree*

*Doctoral degree*

Other degree planned, specify:

**The questions on this page will be used to track your progress as a researcher during the program. It's okay if you don't feel as though you have strong skills in all areas.**

How would you rate your ability regarding the following research skills?

*{Extremely poor, Below average, Average, Above average, Excellent }*

Using research literature (e.g. journal articles, books, publications)

Integrating scientific theories with research

Designing a research plan

Using mathematical tools or models to describe a biological scenario

Working collaboratively with other researchers

Analyzing data

Interpreting results

Writing about results

Orally presenting results

**The questions on this page will be used to track your progress as a researcher during the program. It's okay if you don't feel as though you have a good understanding of all the subjects listed.**

How would you rate your level of understanding in the following areas?

*{Extremely poor, Below average, Average, Above average, Excellent }*

How scientists work on real problems

The nature of the research process

The nature of interdisciplinary research collaborations

Ethical issues in research

How current research ideas build upon previous studies

The demands of a research career in your discipline

Possible career paths in your discipline

Please give any suggestions for activities you would like for us to do as a group (social and/or research related):

Please use this space for any additional comments:

## Research Experiences for Undergraduates/Veterinary Students

### Post Survey

Thank you for taking a moment to fill out this survey. Your results will be used to improve the REU/REV programs for future cohorts, and to track your progress during the program. We hope you had an interesting and exciting experience!

Please enter your first and last name. Your name will only be used to match your pre and post survey responses. You will not be personally identified in any way during the reporting of survey results.

Overall Evaluation Overall, how satisfied were you with your research experience?

*Very satisfied*

*Satisfied*

*Neutral*

*Dissatisfied*

*Very dissatisfied*

To what extent did this research experience meet your expectations?

*No expectations met*

*Some expectations met*

*Don't know*

*Most expectations met*

*All expectations met or exceeded*

How did you feel about your workload overall?

*Way too little*

*Too little*

*Just about right*

*Too much*

*Way too much*

Did this research experience impact your plans to go to graduate school?

Yes → Please explain how the research experience impacted your plans for graduate school:

No

What is the highest level of education you hope to complete?

*High school diploma*

*Associate's degree*

*Bachelor's degree*

*Master's degree*

*Doctoral degree*

*Other degree planned, specify:*

**The questions on this page will be compared with your pre survey answers to track your progress as a researcher during the program.**

How would you rate your ability regarding the following research skills?

*{ Extremely poor, Below average, Average, Above average, Excellent }*

Using research literature (e.g. journal articles, books, publications)

Integrating scientific theories with research

Designing a research plan

Using mathematical tools or models to describe a biological scenario

Working collaboratively with other researchers

Analyzing data

Interpreting results

Writing about results

Orally presenting results

**The questions on this page will be compared to your pre survey answers to track your progress as a researcher during the program.**

How would you rate your level of understanding in the following areas?

*{Extremely poor, Below average, Average, Above average, Excellent}*

How scientists work on real problems

The nature of the research process

The nature of interdisciplinary research collaborations

Ethical issues in research

How current research ideas build upon previous studies

The demands of a research career in your discipline

Possible career paths in your discipline

Would you recommend the NIMBioS REU/REV program to others?

*Yes*

*No* → Please explain why you would not recommend the NIMBioS REU/REV to others:



Please use this space for any additional comments about your research experience overall:

### **Accommodations Evaluation**

Please indicate your level of satisfaction with the following accommodations provided to you during your research experience:

*{ Very satisfied, Satisfied, Neutral, Dissatisfied, Very dissatisfied, Not applicable }*

Computing resources

Housing

Mail service (postal)

Extracurricular activities

Did you find the Wiggio was a useful means of communicating within the REU/REV group?

*Yes*

*No*

*I did not use the Wiggio*

*I did not know about the Wiggio*

How often did you use TRECS (the student recreational center)?

*Every day*

*Twice a week*

*Once a week*

*Twice a month*

*Once a month*

*Less than once a month*

*Never*

Please describe any accommodations/supports you needed that were not supplied (if any):

Mentor Evaluation Your responses to the following questions will be kept confidential. Your name will not be associated with any of your responses regarding your mentors during reporting. Who were your mentors? (check one)

*Odoi/Lenhart*

*Hickling/Lenhart*

*Gwinn/Wise*

*Gilchrist/Wise*

My biology mentor (Odoi, Hickling, Gwinn, or Gilchrist):  
{*Strongly agree, Agree, Neutral, Disagree, Strongly disagree*}

Was accessible  
Was interested in enhancing my research experience  
Communicated on an appropriate level  
Encouraged independence  
Offered constructive ideas for improvement  
Was organized  
Had the necessary skills to mentor  
Positively impacted my research experience

My math mentor (Lenhart or Wise):  
{ *Strongly agree, Agree, Neutral, Disagree, Strongly disagree*}

Was accessible  
Was interested in enhancing my research experience  
Communicated on an appropriate level  
Encouraged independence  
Offered constructive ideas for improvement  
Was organized  
Had the necessary skills to mentor  
Positively impacted my research experience

Please use this space for additional comments about your mentors:

## **Appendix C**

### ***Open-ended Survey Responses***

## Open-ended responses, by question and response category

### Pre Survey

#### How did you learn about this program? (n=15)

##### ***University faculty/staff (9)***

an email from Dr. Gary Smith, one of my vet school professors

Associate Professor Dr. Kimberly Gwinn, who I helped as an undergraduate research assistant.

Email forward from Barb Robbins, Academic Coordinator, WSU CVM

I learned about this program from my school's (East Tennessee State University) Temp. Chair of the Math Department, Dr. Jeff Knisley.

I learned about this program through my math professor.

mentor at my university

Through a Professor at my institution.

Through an email the bio department sent to our school, and through my independent study mentor.

Through Dr. Gross at the University of Tennessee

##### ***Email from the college (2)***

An email sent through the College of Vet Med at MSU

an email sent to all University of TN veterinary students

##### ***Miscellaneous (4)***

Church member who works on faculty at UT.

Co Worker

From Steve Stratton, a math teacher at Clinton High School

I learned about this program through a presentation at a seminar

#### What do you hope to gain through participation in this program? (n=15)

##### ***Gain understanding of how research is conducted (7)***

A better appreciation and interest in research. I know the field of research for veterinarians is ever expanding but I

have yet to experience it.

To gain an understanding of the researches conduct and obtain new information related to biomathematics.

I hope to gain a better understanding of scientific research including: developing my scientific reasoning skills, my laboratory techniques, and my troubleshooting skills.

Research experience and what goes into a research project.

Research experience to create more realistic labs.

I hope to gain better skill/comfort with research presentations and receive great knowledge in my research group through working in a group.

A greater knowledge of how biological systems work while finding out what being a researcher is really about

### ***Learn more about mathematics in research (7)***

research and mathematical modeling experience

A better understanding of how math is used in applications and how research is conducted.

I hope to gain real world experience in the field of mathematics, and hopefully gain an idea of what graduate school would be like if I were to attend graduate school.

understand how to apply mathematical models to infectious disease research

A sense of what all I can do with an applied math major.

Additional mapping skills, predictive mapping skills

experience working with others; experience applying statistics to biology

### ***Miscellaneous (1)***

I hope to have a unique public health experience to gauge my interest in the field and gain a better appreciation of how veterinarians can be involved in this sector.

## Post Survey

### Please describe any accommodations/supports you needed that were not supplied (if any): (n=6)

#### ***Better mail service (2)***

Please contact USPS regarding Andy Holt apartment address issue, if it will be the accommodation for NIMBioS next year.

My only complaints do not involve NIMBioS itself. First, the UT mail system was extremely slow and confusing. Packages with the correct zip code were returned to the sender while others with the wrong zip code were received. The Andy Holt employees were not only not helpful in clarifying this matter, but downright rude and impatient that we even asked about mail issues.

#### ***Transportation issues (2)***

\*Transportation - The KAT buses going off campus were not free.

Food stipend Transportation to grocery store, etc. Kitchen supplies

#### ***Housing issues (2)***

Second, I loved living with the other two vet students in the REV program but was disappointed when we received a fourth, non-NIMBioS roommate without any warning. I would recommend keeping the apartments to three or fewer people in the future. Those spaces are quite tight for four, especially when everyone does not get along.

The housing situation was fine except that we had a 4th roommate show up at 1:30 am in the middle of the week when we were not aware we were getting anyone else moved in. Not only was this extremely inconsiderate but she was not in our program and we lived completely different lifestyles. It made the living experience rough when it would have otherwise worked out wonderfully.

#### ***Miscellaneous (1)***

Additional opportunity to increase mapping skills.

### Please explain how the research experience impacted your plans for graduate school: (n=2)

I plan to go to graduate school, and this REU has made rethink on when I plan to enter grad school.

My mentor of REU is a good guide, my teammates are smart and responsible, I realized with such people and in a campus like UTK with good resources, doing research is fun and rewarding.

**Please use this space for additional comments about your mentors: (n=5)**

***Positive (3)***

I learned a lot from Dr. Gilchrist and Dr. Wise. Dr. Gilchrist especially emphasized that his goal was to make sure that we learned something this summer, and came out appreciating science, which I thought was especially important for our group, since we came from such a diverse background of skills. As I said before, he spent a lot of time helping us through this project, while still giving us the independence to try things on our own. He also tried to make sure all of us had something to do, so not a few people were left with the main burden of work. We all learned a lot about coding, since 3 out of 4 of us had no computer programming experience. He did have expectations of us, which I think helped solidify our group, because we knew what we wanted to accomplish. Overall, I had a great time working with him and the other group members on this project.

I really appreciate their support.

I thought very highly of both of my mentors, and they were both talented instructors as well.

***Negative (2)***

I really enjoyed working with both mentors but did not enjoy watching them attempt to work together. Both professors are incredibly intelligent and experienced in their research field but seemed to have difficulty, especially for the first month, in combining their expertise. Group meetings often consisted of them attempting to talk over each other until Graham finally backed down and waited. I am very pleased with the final results of our project but was honestly surprised by the level of professionalism and maturity demonstrated at times.

Only thought was that mentors had differing views of the goals of NIMBioS....varied not only between mentors but from group to group too.

**Please use this space for any additional comments about your research experience overall: (n=10)**

***Great experience (7)***

Great experience and would definitely do the whole thing over again

I enjoyed working on a research project as a group, since I have never done this before to such an extent. I liked how our mentor was very involved with our project. He spent a lot of time helping us figure things out, yet still giving us the independence to do things on our own. I feel like I learned a lot of new things summer, in terms of how scientific research works, new analysis skills, and how to work together in a group. It was a very rewarding experience.

I had a great experience.

I thoroughly enjoyed learning to integrate math & biology.

I would do it again!

It was a wonderful program and I appreciate every moment. I will brag about my experience and spread the word of NIMBioS to everyone!

Having never participated in research, I thought this program gave me great insight on how research impacts real world issues. It also gives me something to use when trying to explain how math is used.

***Miscellaneous (3)***

After the mid-program presentations, I enjoyed the constructive criticisms of our presentations from the advisors and directors. I felt like it helped make the presenters better for future oral presentations. After the final presentations, I feel like there were not many criticisms, only questions. I say use them in order to better help us to prepare for the future

I feel that my group could have completed a lot more if we had been pushed more by our mentors.

For future REU's \*Transportation like a shuttle service for students without cars; The buses (not including KAT and the Trolley) were not free (many universities have free transportation on city bus lines). \*Meal plan \*Matlab Tutorial