Encouraging Excellence and Building Community in the Undergraduate Research Lab

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Initial Mindset of Many Students

- Participation in research is an excellent résumé builder
- As long as you fulfill the minimum amount of time required in the lab, you are entitled to an "A" – research is too "subjective" to be evaluated in any other way
- It doesn't really matter if your experiments work as long as you appear to be trying

Central Questions

- What are the attributes of “excellence” in undergraduate research?
- How can you motivate undergraduate students to pursue excellence?
- How can you help students achieve excellence?
- How can you build meaningful relationships and a sense of community along the way?

Attributes of “excellence” in undergraduate research

- Good understanding, clarity, and design
  - Good understanding of relevant scientific literature
  - Clearly defined research question
  - One or more testable hypotheses
  - Well-designed experiments that address research question and hypotheses

Attributes of “excellence” in undergraduate research

- Careful, thorough, honest and accurate
  - Careful execution of experiments and collection of data
  - Thorough, honest and accurate documentation of all procedures and research results
  - Thorough, honest and accurate analysis of all research results and conclusions

Attributes of “excellence” in undergraduate research

- Displays perseverance and commitment
  - Repeats experiments until they work!
  - Repeats experiments until they yield reproducible results
  - Revises hypotheses and redesigns experiments as necessary
  - Arrives at clear conclusions that address the original research question and hypotheses

Attributes of “excellence” in undergraduate research

- Collegial and an effective communicator
  - Respectful and considerate of other lab members
  - Helps keep lab clean and orderly
  - Assists others when needed
  - Actively participates in group discussions
  - Effectively communicates research findings to lab group, campus and/or the larger scientific community

Motivating students to pursue excellence in research

1) Way to worship and serve our Creator and Lord

"To know the mighty works of God; to comprehend His wisdom and majesty and power; to appreciate, in degree, the wonderful working of His Laws, surely all this must be a pleasing and acceptable mode of worship to the Most High, to whom ignorance cannot be more grateful than knowledge."

-- Copernicus

Quoted by F. S. Collins, *The Language of God: A Scientist Presents Evidence for Belief,* (New York: Free Press, 2006).

Motivating students to pursue excellence in research

– We are called to search for truth and to "renew" our minds

"Therefore I urge you, brethren, by the mercies of God, to present your bodies a living and holy sacrifice, acceptable to God, which is your spiritual service of worship. And do not be conformed to this world, but be transformed by the renewing of your mind, so that you may prove what the will of God is, that which is good and acceptable and perfect."

-- Rom. 12:1-2 (NASB)

Other key verses: *Rom. 8:29; Phil. 3:20-21; 2 Cor. 3:18*
1 Peter 1:13-16; Eph. 4:17-23; 2 Cor. 10:3-5

Motivating students to pursue excellence in research

- We are called to work hard and be diligent in our pursuit of truth

  "Whatever you do, do your work heartily, as for the Lord rather than for men, knowing that from the Lord you will receive the reward of the inheritance. It is the Lord Christ whom you serve."

  -- Col. 3:23-24 (NASB)

  "Be diligent to present yourself approved to God as a workman who does not need to be ashamed, accurately handling the word of truth."

  -- 2 Tim. 2:15 (NASB)

- Prayer of dedication at beginning of semester

Motivating students to pursue excellence in research

2) Way we can serve humankind

- Simply “marking time” in the lab is not enough – we must be good stewards of our time and resources
- Getting interpretable results is essential to increase knowledge and understanding
- Need to be working on original research questions that have relevance to *real world problems* that have not already been “solved”
- Students may need help understanding potential practical applications

Motivating students to pursue excellence in research

3) Can be personally rewarding

- Intellectual stimulation and increased understanding
- Improvement in critical thinking, problem solving, oral and written communication, manual dexterity, use of equipment, etc.
- Acquisition of skills for further education and getting jobs
- Achievement of excellence can lead to favorable grades and letters of evaluation
- Possible financial assistance

Motivating students to pursue excellence in research

– Opportunity to find future mate?!

Bruno and Stephanie

Helping students achieve excellence in research

1) Set realistic goals and expectations – clearly communicate these to students at beginning of semester
   - Ideally involve students in this process!
   - Never expect students to do something you can't do yourself!
   - Students will not be as fast or as skillful as you are
   - Allow time for troubleshooting experiments
   - Recognize constraints of student schedules, course loads, involvement in extracurriculars, etc.

Helping students achieve excellence in research

- Help student break up each project into smaller achievable goals that have well-defined “next actions”
- Useful tools for communicating goals and expectations:
  - individualized learning contracts
  - syllabus for research
  - rubric for evaluating research (1st semester, 2nd semester)

Overall Grade: _____ Semester: _____ Student: _____

Biological Research: *Grading Rubric (first sem. research student, 3 cr.)*

Evaluation Criteria *(weight given)*	**Unacceptable** *(< 55%)*	**Poor** *(55-65%)*	**Satisfactory** *(66-77%)*	**Good** *(78-89%)*	**Excellent** *(90-100%)*
Lab Notebook *(20%)* Neatness, organization; completeness and accuracy in documenting: lab times worked, procedures, data, observations and conclusions; up to date	_____	_____	_____	_____	_____
Amount of Lab Work Accomplished (for 3 credits) *(20%)* Successfully completed experiments and acquisition of useful data; prepping reagents, etc. for future experiments	_____	_____	_____	_____	_____
Efficient Use of "Waiting" Times in the Lab *(10%)* Reading research-related scientific lit., updating lab notebook, prepping future steps in expt., helping others; cleaning lab benches and glassware	_____	_____	_____	_____	_____
Self-Confidence & Independence in the Lab *(10%)* Ability to carry out previously demonstrated procedures without further demonstrations or questions	_____	_____	_____	_____	_____
Skillfulness in the Lab *(10%)* Ability to use equipment correctly and to do laboratory procedures correctly to get high quality data	_____	_____	_____	_____	_____
Understanding of Project & Relevant Literature *(10%)* Correct understanding of research aims, relevant terms/concepts and theory behind experiments; ability to interpret data and evaluate conclusions of others	_____	_____	_____	_____	_____
Contribution to Poster Presentation for Conference *(10%)* Quality of work contributed to poster presentation; active participation in INBRE Undergrad. Research Conf.	_____	_____	_____	_____	_____
Oral Presentation in Lab Meeting *(10%)* Targeted to appropriate audience, effective discussion of required content (see email), understanding of published lit., originality, quality of presentation	_____	_____	_____	_____	_____

Overall Grade: _____ Semester: _____ Student: _____

Biological Research: *Grading Rubric (2nd sem. research student, 3 cr.)*

Evaluation Criteria *(weight given)*	Unacceptable *(< 55%)*	Poor *(55-65%)*	Satisfactory *(66-77%)*	Good *(78-89%)*	Excellent *(90-100%)*
Lab Notebook *(20%)* Neat, well-organized; always up to date; complete and accurate documentation of lab times worked, experimental procedures, data, observations, conclusions, unanswered questions, future plans, etc.	_____	_____	_____	_____	_____
Amount of Lab Work Accomplished (for 3 credits) *(40%)* Good progress made in fulfilling major objectives of project; successfully completed expts. and collected usable data; trouble-shot expts. as needed; used time wisely to prepare reagents and equipment for future expts.	_____	_____	_____	_____	_____
Self-Confidence & Independence in the Lab *(10%)* Able to carry out previously demonstrated procedures without further demonstrations or questions; knew where to find supplies and equipment	_____	_____	_____	_____	_____
Skillfulness & Cleanliness in the Lab *(10%)* Used lab equipment properly and executed lab procedures correctly to get high quality data; thoroughly cleaned up after self in the lab and assisted in keeping common areas clean	_____	_____	_____	_____	_____
Understanding of Project & Relevant Literature *(10%)* Correctly understood research aims, relevant terms/concepts and theories behind experiments; able to interpret data and evaluate conclusions of others; had solid grasp of Wight lab articles	_____	_____	_____	_____	_____
Participation in Lab Meetings *(10%)* Attended all lab meetings; was always prepared to discuss progress made on project; actively participated in group discussions	_____	_____	_____	_____	_____

Helping students achieve excellence in research

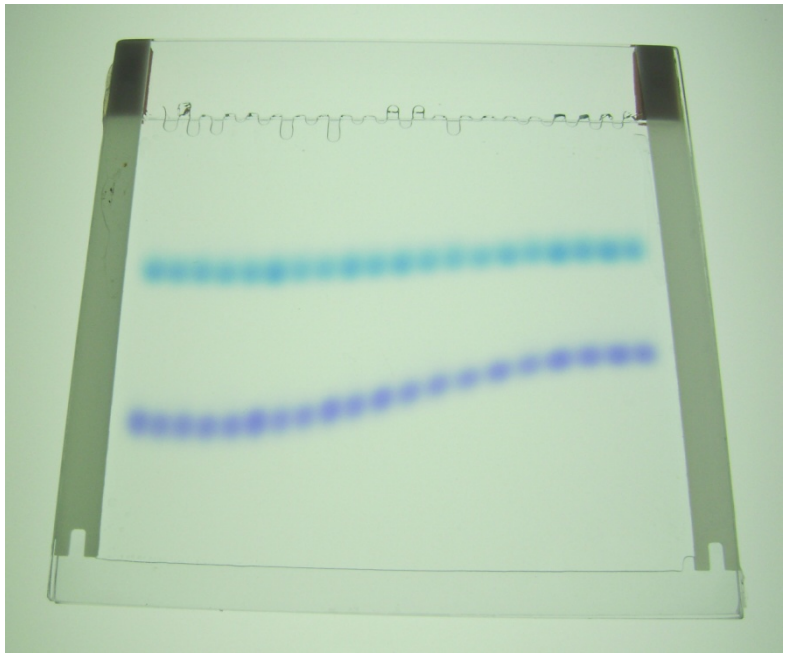
2) Provide frequent and constructive feedback

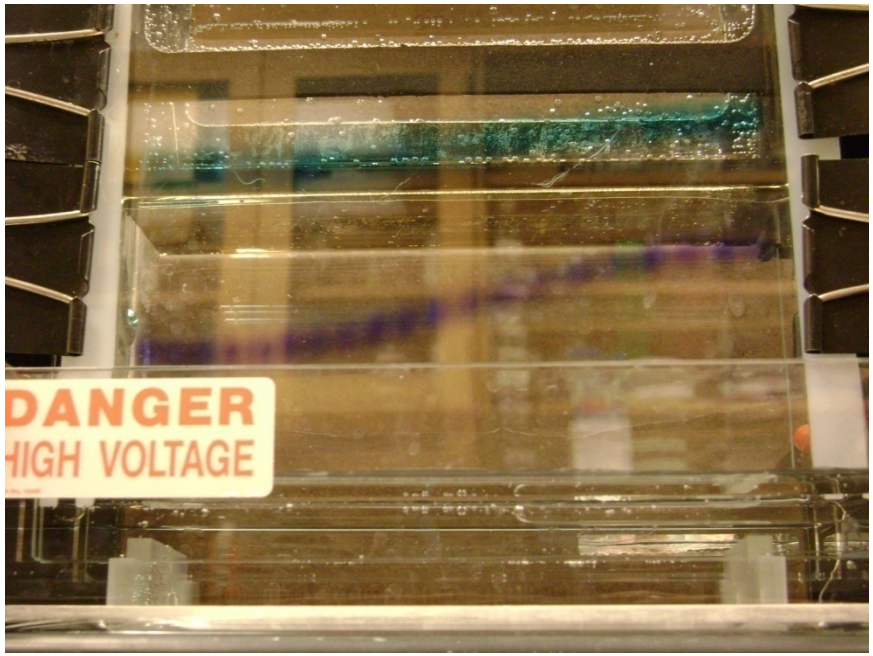
- In lab notebook, individual meetings in office or lab, emails, rubrics, etc.
- Be as specific as possible!
- Choose your words carefully to avoid misunderstandings
- Avoid comparisons with other students
- Never speak negatively to students about other students

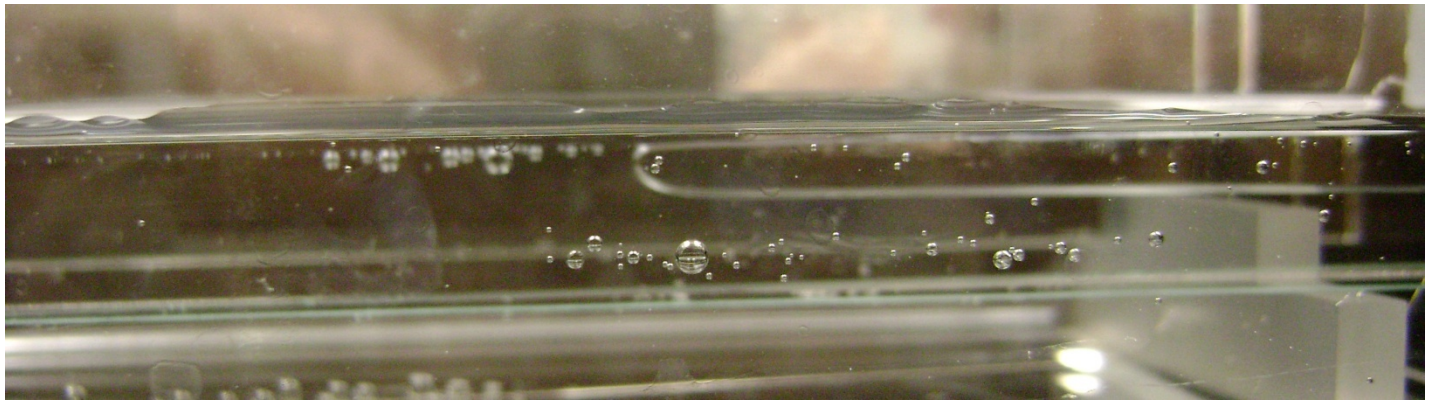
– Celebrate successful experiments: “Jubilation Moments”

Jubilation #1

– Try to turn “problem” experiments into positive learning experiences







Helping students achieve excellence in research

3) Model excellence yourself in your mentoring of students *(Phil. 4:8)*

- Be prepared for individual and group meetings
- Have good grasp of scientific literature and theory behind all experimental procedures
- Be able to personally demonstrate all experimental procedures that students do
- Show students characteristics of good lab technique and simple ways to minimize mistakes
- Do the experiments together the first few times; then progressively allow student independence

Helping students achieve excellence in research

- Early during training, analyze results of experiments together; allow greater independence with experience
- Encourage students to provide input into how to troubleshoot experiments and to participate in design of follow-up experiments

Helping students achieve excellence in research

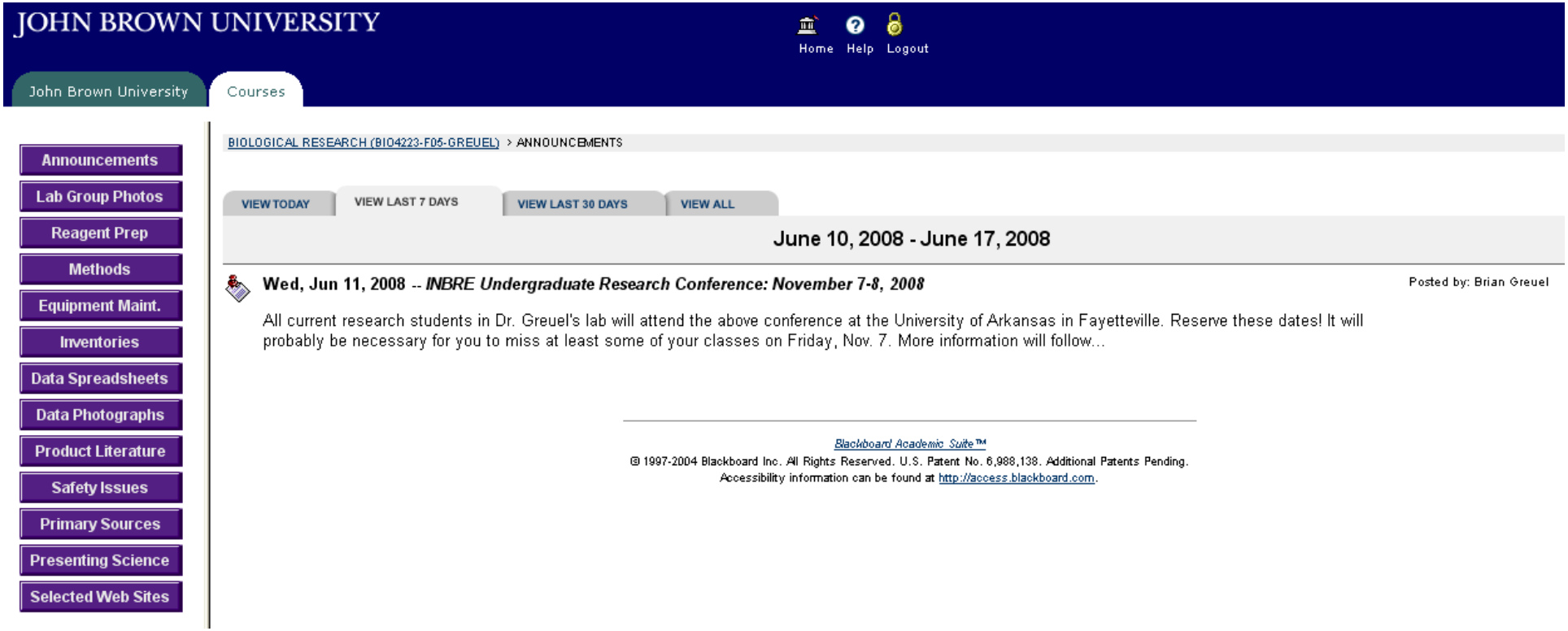
4) Develop systems of organization in the lab that foster student independence

   – Designated space for each student in the lab

   – Orderly arrangement of chemicals and supplies

   – Repository of information easily accessible to students (e.g. Blackboard site)

Front Page of Blackboard Site for Research in My Lab



Organization of Research Blackboard Site


Biological Research Course Map
Expand All
Collapse All
Refresh
Biological Research
Announcements
Lab Group Photos
INDIVIDUAL RESEARCH STUDENTS
"JUBILATION" MOMENTS
RESEARCH CONFERENCES
AR INBRE Research Conference -- Nov. 9-10, 2007
Experimental Biology (San Diego) -- Apr. 5-9, 2008
Reagent Prep
BUFFER SOLUTIONS
EMSA REAGENTS
GEL ELECTROPHORESIS REAGENTS
Agarose Gels
EMSA Gels
Polyacrylamide Gels (Native)
Polyacrylamide Gels (SDS-PAGE)
GENERAL LAB REAGENTS
PLASMID PREP REAGENTS
TISSUE CULTURE MEDIA & REAGENTS
Methods
GENERAL LAB SKILLS
Adjusting pH of Solutions
Preparing Solutions & Dilutions
Spectrophotometry
ASSAYS
DNA Concentration Measurements
Electrophoretic Mobility Shift Assays (EMSAs)
Protein Concentration Assays
Reporter Gene Assays
Transient Transfection Experiments
BACTERIOLOGICAL METHODS
GEL ELECTROPHORESIS
Horizontal Gel Electrophoresis
Vertical Gel Electrophoresis
PLASMID PREPS
Large-Scale Plasmid Preps
Plasmid Minipreps
Plasmid Prep Reagents
Plasmid Prep Characterization Template
RECOMBINANT DNA METHODS
TISSUE CULTURE METHODS
VIDEO DEMONSTRATIONS
VIDEO: Measuring a Solution's pH (length: 12:46)
VIDEO: Passaging Cells (length: 32:08)
Equipment Maint.
Inventories
Data Spreadsheets
ASE FUNCTIONAL ANALYSIS PROJECT
EMSA PROJECT
BCA Protein Assays
EMSA Binding Reactions
TM3 CELL PROJECT
Transfection Set-Ups
Processed Transfection Data
TRANSCRIPTION FACTOR MODIF. PROJECT
Data Photographs
ASE LS MUTANT PROJECT
DNA Concentration Estimations
Fragment Isolations
PCR Reactions
Restriction Digests
Large-Scale Plasmid Preps -- Confirmatory Digests
Plasmid Minipreps -- Confirmatory Digests
Preparation of Recombinant Plasmids
EMSA PROJECT
EMSA Blots
Fragment Isolations
PCR Reactions
TM3 CELL PROJECT
Large-Scale Plasmid Preps -- Confirmatory Digests
TRANSCRIPTION FACTOR MODIF. PROJECT
Product Literature
BACTERIAL STRAINS
DNA VECTORS (COMMERCIAL)
GEL ELECTROPHORESIS
GENE TRANSFER
MOLECULAR BIOLOGY KITS
SAFETY-RELATED
TISSUE CULTURE PRODUCTS
Safety Issues
CRYOGENIC MATERIALS
ELECTRICAL SHOCK HAZARDS
HAZARDOUS CHEMICALS -- HANDLING & DISPOSAL
RADIOISOTOPES
Primary Sources
NATURE & PRACTICE OF SCIENCE
TRANSCRIPTION FACTORS
WIGHT LAB ARTICLES
Presenting Science
LAB NOTEBOOKS
ORAL PRESENTATIONS
POSTER PRESENTATIONS
SCIENTIFIC WRITING
Selected Web Sites

Building Relationships & Community in the Research Lab

1) Events at mentor's home

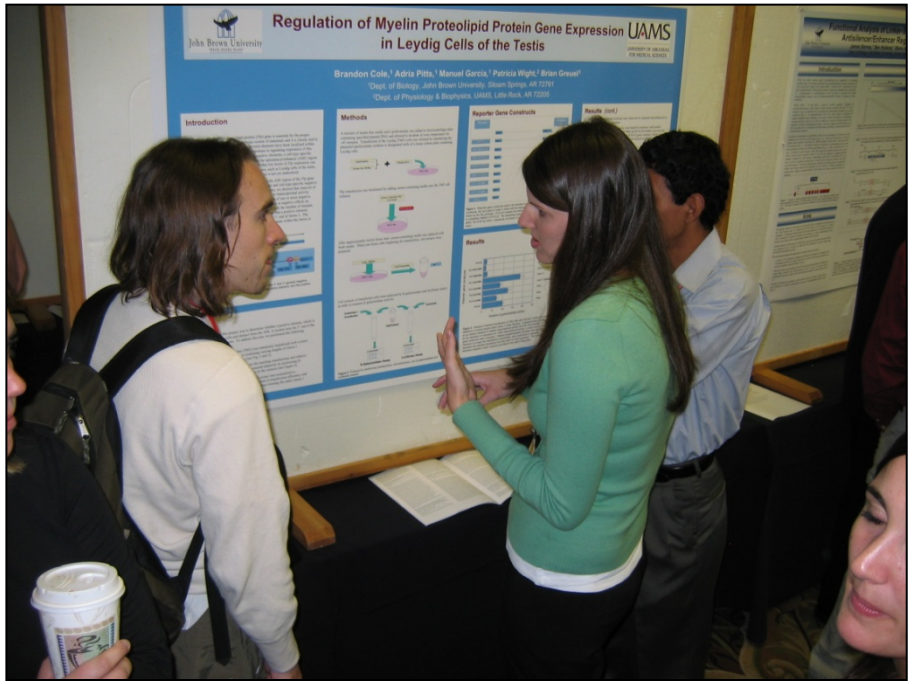
First annual reunion of past (and current) research & work-study students (Fall, 2007)

Building Relationships & Community in the Research Lab

2) Regular lab group meetings
   - Open and close in prayer
   - Short devotional by me (or a student)
   - Provide refreshments – students participate in this
   - Formal or informal presentations by students
   - Group discussion of what's working well and technical challenges to overcome

Building Relationships & Community in the Research Lab

3) Attend scientific conferences together



Arkansas IDeA Network of Biomedical Research Excellence (AR INBRE) conference
October, 2007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ls of the Testis
UAMS
Reporter Gene Constructs
Results
Functional Analysis of Linker-Scan Mutations Within Inverted Fragments of the Antisilencer/Enhancer Region of the Myelin Proteolipid Protein Gene
UAMS
Introduction
Methods
INBRE ARKANSAS


HEINZ
YELLOW
ORGANIC

Building Relationships & Community in the Research Lab

4) Individual or small group meetings

- Office, coffee shop, while working in the lab together
- Make good use of waiting periods (incubation times) during experiments

Conclusions

1) Mentoring undergraduate research students is among the most personally fulfilling aspects of my job
2) Students will strive for excellence in the research lab (just like any other class) if they have a clear idea of the goals and expectations
3) There are a variety of things you can do to promote the pursuit of excellence while also fostering teamwork and a sense of community

Acknowledgements

John Brown University

"HEAD, HEART, HAND"

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