Secrets to Success in Graduate Research

Disclaimer: The suggestions and remarks in this presentation are based on personal research experience. Research practices and approaches vary. Exercise your own judgment regarding the suitability of the content.

– P. Kamat

Breakdown of Research Topics

RESEARCH problem can be tackled on various fronts. One can broadly classify a research activity into one of the following categories:

1. Material and chemical synthesis; hybrid assemblies; etc.

2. Properties of new materials/molecules

3. Reaction mechanisms and kinetics

4. Understanding or elucidating a specific phenomenon or process

5. Fabrication and evaluation of devices

6. Applications

Your research will focus on one or more of these topics.
Most current research efforts are interdisciplinary.

Welcome to the exciting world of graduate research

You've made your choice of advisor and research topic. Now what?

It's time to start your long, hard research activity in the laboratory.

1. Getting Started

- Identify a specific research topic of interest to you
- Conduct literature search
- Identify specific issues/problems that emerge from literature search
- Familiarize yourself with major developments in the area

Ask yourself a few questions:
What new finding will this research contribute?
Will this fit into my overall thesis/research program?
Why should anyone care about this piece of investigation?

Well searched background material is the basic foundation for future research.

2. Research Plan

- Construct a brief outline of your research problem and experimental approach
- Discuss the topic with your advisor and fellow scientists. Revise the work plan based on discussions and existing resources
- Break the project down into several sets of experiments

For example:

- Synthesis and characterization
- Absorption and emission characteristics
- Spectroscopy measurements
- Construction of device
- Evaluation of device with appropriate measurements
- Stability and comparison studies

3. Execution

- Start with simple experiments
- Brave yourself to do some quick tests to check the feasibility of approach (for example, Does my sample emit? What are the wavelengths to monitor? Can I cast a film? Does it generate photocurrent? Etc.)
- After these qualitative tests, carry out well planned experiments. Note all experimental conditions.
- Remember to carry out blank/control experiments
- Plot or tabulate the data
- Repeat each experiment several times before drawing a conclusion
- Discuss with your advisor/colleagues

TRUST BUT VERIFY EVERY INTERESTING OBSERVATION

4. Be Your Own Critic

Question yourself before and after each set of experiments – the W's.

Why I am doing this experiment?

What is the right approach to carry out this experiment?

Whether the experiment was conducted without any interruption or deviation from the set protocol? (Note all day-to-day variations)

What are the expected results? Do the results follow expected trend? If not, what are the possible reasons? Can I repeat the unusual phenomenon I just encountered?

Watch for unusual behavior or trends. (Note: Most of the great discoveries are accidental!)

What did I learn from this experiment? Can I draw any important conclusion?

BE CURIOUS – Do not hesitate to try out a new idea/approach that may or may not work!

5. Data Analysis

Just because you collected the data does not mean the task is over.

Plot the data –preferably do it on the same day or next morning.
Make sure that there are at least 5 data points to represent a trend.
Include error bars.

Many times the data are better presented in table form

Discuss the results with your advisor and plan the next experiment

Questions to ask:

- Is this the best way to present the data?
- How does this set of data compare to the previous data set?
- What else can I vary in this set to seek additional information?
- How do these data compare with blank or control experiment?

Put forth your best efforts – Always AIM HIGH

Good Research Habits

- Get to know the expectations of your advisor and the laboratory protocols - each group operates with different protocols.
- Set your work habits and work ethics. Be sure to put in **at least 8 research hours** per day.
- Maintain a clean lab bench. Wash glassware regularly. Store cleaned spectroscopic cells in a safe place. (*Any spectroscopic cells lying around will be confiscated! If you cannot take care of them, you do not deserve them*.)
- Record all experimental details directly in your laboratory notebook. Attach printed results.
- Meet with your advisor **at least once a week**. Periodically analyze the overall progress. (Remember, the squeaky wheel gets the oil!)
- Scan through the table of contents of major journals daily. Read one research paper per day. Discuss with your advisor at least one interesting paper during the weekly discussions and suggest new ideas.

Additional Tips

- BE SELFISH. You are working for your degree program.
- Set a weekly goal and evaluate the progress routinely.
- Minimize the time on Internet for nonscientific browsing. Just because you are sitting at your desk does not mean that your day was productive.
- HAVE FUN, BUT REMEMBER TO PUT IN MINIMUM OF **EIGHT PRODUCTIVE HOURS I**N THE LAB DURING WEEKDAYS.
- IT IS YOUR PhD. IF YOU DO NOT TAKE INTEREST OR PUT HARD WORK INTO IT, NOBODY ELSE WILL!!
- The time required to complete the Ph. D. degree is inversely proportional to the time and effort you put in on a daily basis.

Note: You are a researcher and not a technician.

The role of your advisor is it guide you through your project and help you succeed in your thesis. Don't expect him/her to suggest to you experiments on a daily basis.

Get serious and take responsibility for your own project.

How to complete Your Ph. D. in less than 5 Years

- Complete all departmental requirements within two years
- By the end of summer of second year, you should be able to construct a broad outline of research that you would like to pursue
- The third year is the springboard to explore various facets of your project. You should have published at least one paper (with you as the first author).
- Schedule the candidacy exam with the graduate school
- Complete your planned experiments during the fourth year
- Publish 3-4 papers (with you as the first author) in high impact journals. Note: Each paper can serve as the basis for writing a chapter in your thesis.
- Discuss the plan for writing your thesis with your advisor. Plan to submit the thesis during the fifth year.

Make a worthwhile effort during your valuable career years.

Good Luck!