Wyoming INBRE Undergraduate Research Onboarding and Learning Expectations (2026–2027)

Introduction

The Wyoming INBRE welcomes you to the world of scientific research! Regardless of what your career goals may be or where your exposure to research may ultimately lead you, we hope that you'll find this experience to be interesting, enjoyable, and rewarding. Much of our daily life is built upon the concepts, technologies, and everyday products of research and innovation. We hope that acquiring new knowledge and learning some of the key principles that underlie the scientific process will be useful to you for understanding the world, making informed decisions, and perhaps influencing where you decide to focus your life's work.

We begin this document with some context about why you might want to pursue undergraduate research and how to go about doing that. We then jump into some of the challenges of doing scientific research and key concepts that you'll want to learn along the way. This is not meant to be a worksheet or an instruction manual that hands you all the answers. It's more of a guide that you can revisit over time as you develop as a researcher. Ideally, you'll discuss these concepts and questions with your mentors and fellow researchers.

Throughout this text, look for resource symbols superscript ([R1], [R2], etc.,) indicating web-based information (listed at the end) that is directly relevant to that section.

Why should I pursue an undergraduate research experience? [R1]

- To learn more about areas that interest me and discover new fields of research I had not considered
- To interact with faculty, graduate students, postdocs, scientists, peers, and outside professionals
- To learn to use instruments, libraries, databases, and software
- To apply course learning to authentic, hands-on, scientific investigation
- To engage in creativity through project design, problem-solving, presenting, and writing
- To feel pride in completing projects, presenting research data, and co-authoring publications
- To gain inspiration and confidence to continue in the research process, such as by pursuing graduate studies or working in a research-related field
- To gain practical experience with the scientific method
- To learn how to ask and answer scientific questions

Finding Research Opportunities [R1]

- Look for opportunities for fellowships, internships, scholarships, or research credit
- Find an advisor by:
  - Talking with a current instructor during student hours

- Talking to peers who are in research groups/teams
- Getting introductions from advisors to research-active faculty
- Searching faculty websites and published papers
- Emailing faculty directly
- Asking about the possibility to volunteer in a lab

Once you are invited into a research experience, whether it's a paid or volunteer position, a lab rotation, or for research credit [R2]

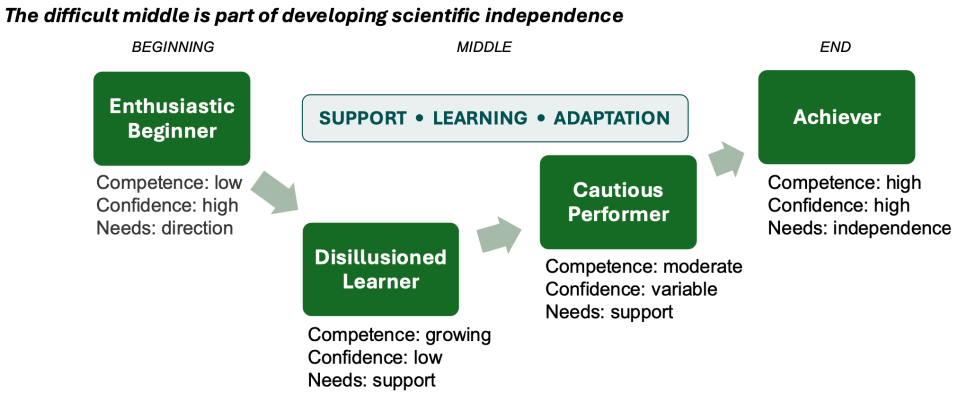
- Spend time reading key papers and background materials
- Be curious and ask questions
- Show you are present and interested during lab meetings
- Be professional by responding to emails, showing up on time, and communicating clearly if any issues come up
- Be a good lab citizen. Research is a team effort, and your lab mates may come from very different backgrounds and have points of view that differ from your own. Treat everyone with respect, do your share of group tasks, and give credit generously.

Setting Early Expectations [R1,R2]

Now that you are on the path to becoming an undergraduate researcher, let's cover one of the most basic truths of scientific research: Learning to do science is challenging for everyone! Whether this is your first experience working in an academic research lab or even your fifth, know that at times the amount of information coming at you may feel overwhelming. This is a normal reaction, and there are several good reasons why everyone feels this way (see below). But first take a heartfelt note from Martin Schwartz who wrote the brilliant essay, "The importance of stupidity in scientific research" (linked below). He writes, *Science makes me feel stupid too. It's just that I've gotten used to it. So used to it, in fact, that I actively seek out new opportunities to feel stupid. I wouldn't know what to do without that feeling. I even think it's supposed to be this way* (Schwartz, M.A., 2008, Ref 1).

- Individual scientific fields typically accumulate a staggering amount of information over their long histories. Absorbing even a fraction of that knowledge—just the parts that pertain directly to your project—will take considerable time and effort. At times, this can feel like drinking from a firehose. It's also a great opportunity to learn and grow. Try to find a learning pace and style that is comfortable for you.
- Scientific lingo can be difficult to penetrate. Like all technical fields, science has lots of acronyms and other shorthand terms. These can be quite useful once you know the lingo but are an impediment to those who are new to the discipline. The only solution is to gradually become familiar with the relevant terms and concepts. When you hear something you don't understand, ask for clarification or make a note and look it up later.

- More generally, scientific research will almost certainly feel quite different than any work experience you've previously had. Good science requires an unusually high level of precision, attention to detail, and sustained focus. These are skills in themselves; they can be improved upon over time and applied to many other work environments. At the same time, despite all our best intentions, *failure is a common everyday part of doing science!* It's just something you have to get used to and is not a sign that you don't belong. An experiment that doesn't work out the way you'd hoped often teaches you something and sometimes an unexpected result opens a question that is more interesting than the one you started with.
- Related to the above points, there is a strong culture built around the premise that getting the science right requires deep and rigorous thinking, careful planning, ongoing self-reflection, and honest but direct input from other scientists. Learning how to receive critical input, as well as providing it to others in a constructive way, is an essential skill and underscores the point that science is a community effort. It's what allows science to be continuously advancing, self-correcting, and to stand the test of time. One example of this is the long-standing scientific *peer review* process where most publications and grants are critically assessed by experts in the field to determine if the studies pass muster. On a more general daily level, learning what your communication style is and that of others will allow you to have more transparent conversations and have a greater awareness of how to give and receive feedback.
- It's totally normal to go through highs and lows during your research career. You will progress from an enthusiastic beginner—when the expectations that you and others place on you are relatively low—to a more seasoned researcher, who might stumble as your confidence drops, even as your competence is increasing. Building resilience in scientific training, which is similar to the resilience you need for life in general, helps to get all of us through this process. Just know that the path toward becoming an independent scientific researcher is rarely, if ever, a straight one. Expect to have setbacks and know that how you respond to those setbacks is often what will dictate your ultimate success in the lab (also see Refs 2, 3).



This model, originally developed for workplace leadership, has since been adapted for many fields. Applied to research training, it starts with an honest look at where you are in learning a given skill or task, so that you and your mentor can match the right mix of guidance and support as you build confidence and resilience and move toward independence. Figure adapted from Blanchard et al., 1985, Ref.

Key Scientific Concepts You'll Want to Learn [R2]

Generally speaking, the goal of most scientists is to (i) ask good questions, (ii) come up with appropriate experiments to address those questions, (iii) generate quality data through successful experiments, and (iv) ultimately make sound conclusions based on what the data tell you. Needless to say, all of that's easier said than done! Even accomplished scientists with many years of experience run up against unexpected complications, confusing findings, and plenty of flat out failures. Don't worry about that now! Your goal as a student entering into research is to *learn the process by which good science is carried out*, regardless of whether your individual experiments work or give you the results you were expecting or hoping for.

Below we provide a list of foundational concepts and standard scientific practices—phrased in the form of questions—that you'll want to become comfortable with. In fact, you'll want these topics in the front of your mind while you're planning, carrying out, and interpreting your data. But know that for some of these questions, there may not always be a clear-cut or simple answer. If you want to learn more now, as a starting point, you can check out the sites we've highlighted below[2]. You could also use AI to explore some of these concepts on your own *but see our section at the end about using AI*. Finally, be sure to discuss these subjects with your research mentors along with lab mates, all of whom can be a great source of information and insights.

1. Controls

- What are experimental controls and why are they critical for interpreting data?
- What is the difference between positive and negative controls?
- Are controls always necessary or even possible?
- What does the term "historical control" refer to and what are the associated caveats?
- What are the important controls for your experiments?

2. Repetition and sufficient sample numbers

- Why does science typically require so much repetition?
- How does one determine how many samples or repetitions will be needed for a study?
- What is the difference between a technical and a biological replicate?
- How many samples and repetitions will be needed for your experiments?
- What are the differences between rigor, reproducibility, and accuracy?

3. Statistics and quantification

- What is the purpose of statistics in science? Are statistics always necessary?
- How will one know which statistical tests will be appropriate to perform?
- What is a P-value? Why is it considered important? What does "P-hacking" refer to?
- Is it possible for a result to be statistically significant but scientifically unimportant?
- What is meant by subjective or pseudo-quantification of data?
- What statistical tests do you plan to use and why?

4. Elimination of bias

- What does bias mean in the context of science? Can it ever be fully eliminated?
- What are some standard practices used to eliminate bias?

- Might your studies be subject to bias and how will you deal with that?

5. Complementary approaches

- What is meant by complementary approaches? Are they always needed?
- How are complementary approaches used to strengthen conclusions?
- How is this topic related to the ancient "Blind Men and the Elephant" parable?
- Will your experiments include complementary approaches? Why or why not?

6. Record keeping

- What is the purpose of record keeping in science?
- Do your notes have to be clear just to you or also to anyone who reads them later?
- What types of records will you be keeping and where will you store them?
- What are the mandated rules regarding record keeping if your work is federally funded?

7. Communication and exchange of information and resources

- How do scientists share their findings with each other?
- What is the idea behind peer review? How does it work? Is it essential?
- What reagents or information are a scientist obligated to share with other scientists?
- What is the purpose of scientific collaborations? Are there any risks involved?
- How should scientists share their findings with the public?

8. Some general types of scientific approaches

- What are the differences between hypothesis- and needs-driven scientific studies?
- Will your studies be one, the other, or both?
- What is the difference between incremental and transformative science?
- Is there a correlation between the level of risk and the potential of the reward?
- How much control do you have over the types of studies you may be doing?

9. Key attributes of successful scientists

- Can you come up with an extended list of what you think are important traits?
- How do you weight their relative importance, such as essential versus useful?
- Here are a few to start you out: curiosity, drive, observational skills, subject knowledge…

10. The importance of trust

- Why is trustworthiness the most important of all scientific traits?
- What happens when a scientist betrays that trust?
- What should you do if you think that someone is betraying that trust?
- How does science correct its own mistakes?

11. Funding and stewardship (Bonus questions)

- Who pays for scientific research and how do scientists compete for that funding?
- What is the Wyoming INBRE, who funds it, and why does it exist?
- How does a grant determine what a lab can and cannot do?
- What does it mean to be a responsible steward of grant funds, including reagents, equipment, and your own paid time?
- Why must you acknowledge your funding sources on posters, talks, and publications?

Key Elements of an Effective Undergraduate Research Experience [R2]

Now that we have given you some of the questions related to scientific research, we'd like to take a step back and examine what makes a good undergraduate research experience. As a student, you might use these elements to think about your current undergraduate research experience or to consider what your future research experiences might look like. And if you're a research mentor, consider using the following as a checklist as you develop research experiences in your lab or classroom (also see Refs 4, 5).

Mentorship

- Includes close guidance from a faculty mentor, graduate student, postdoc, or more senior undergraduates
- Regular feedback and increasing independence over time
- Mentoring that covers both research skills *and* professional development
- Learning and applying mentorship skills to others as you become more knowledgeable

A Clearly Defined Research Question or Problem

- A focused, meaningful question or hypothesis
- Connection to a broader field or a real-world issue at the community or broader level
- Appropriate scope for an undergraduate timeline

Training in Research Methods

- Undergoing appropriate and ongoing lab safety training
- Learning discipline-specific techniques and tools
- Instruction in experimental design, data collection, and analysis
- Emphasis on rigor, reproducibility, and accuracy

Active Student Ownership

- Students contribute intellectually, not just technically
- Opportunities to make decisions and troubleshoot
- Gradual shift from guided tasks to independent work

Engagement in the Full Research Process

- Literature review including reading primary papers
- Data collection or creative inquiry
- Analysis and interpretation of data
- Drawing conclusions and identifying next steps

Ethical and Responsible Conduct

- Training in research ethics (institutional review board, animal care, data integrity, authorship)
- Understanding responsible conduct of research
- Awareness of societal impacts of research

Communication

- Writing research papers, research abstracts, reports, or theses
- Giving clear and substantive progress updates at lab meetings

- Presenting posters or talks at conferences or symposia
- Learning to explain research to both expert and non-expert audiences

Documentation

- Recording and preserving data including pertinent observations
- Keeping notes from discussions and relevant seminars
- Ensuring access to data and notes for future members of the lab

Data Analysis

- Interpreting data and making clear figures and tables
- Applying appropriate statistical methods
- Linking findings to previous results from the lab or other research groups

Reflection and Metacognition

- Reflecting on what was learned and why it matters
- Connecting research experiences to coursework and career goals
- Recognizing and responding to challenges and failures with a growth mindset

Community Engagement and Service

- Inspiring others about STEM
- Sharing knowledge and communicating science topics to people of all ages
- Engaging in workshops, seminars and trainings outside of your discipline
- Mentoring or aiding other scientists including new lab members

Integration into a Scholarly Community

- Participation in lab meetings, seminars, or research groups
- Exposure to how knowledge is created in the discipline
- Willingness to collaborate and engage in transdisciplinary science/engineering
- Networking to make and retain professional connections
- Sense of belonging in an academic or professional community

Professional and Career Development [R3]

- Building skills like critical thinking, problem-solving, and teamwork (and see below)
- Clarifying interest in graduate school or other research-based careers
- Developing a professional identity as a researcher
- Writing and tailoring a resume/CV and personal statement; understanding email etiquette; delivering an elevator pitch; developing a LinkedIn profile; participating in mock interviews, networking opportunities, and career panels

Writing a Research Proposal

Effective writing and communication is one of the most important assets for scientists to develop and is critical for many other professions. Like learning to perform experiments, writing is a developed skill that requires practice, commitment, and feedback. Below is a very general guideline for developing a research proposal as an undergraduate.

- Find a topic that interests you or a mentor who works on a research question/field that is of interest to you
- Review background information to find the gaps in the current knowledge; often you will be aided by a mentor with more experience in the field
- Discuss one or more gaps and ways to address these with your mentor
- Understand why the work matters and where it could lead
- Design the aims, including the specific questions and experiments to address the knowledge gap.
- Consider potential outcomes along with your plans for analyzing data (e.g., statistics)
- Set a timeline and realistic expectations
- Write an Abstract or Project Summary (often last in the process)

A Word about Using AI

Yes, AI platforms can be extremely useful for getting information, for answering the questions above, suggesting avenues of research, or processing data. In fact, AI skills can already be considered an essential part of a complete tool kit in many scientific disciplines. Just be sure to validate the information you're given, whether by individuals in the lab or by AI, and be completely transparent about when you are using AI. In the end, when it comes to scientific research, it will be *your responsibility* to get the science right.

Resources and References

[R1] For general information about getting started in undergraduate research:
https://helpimascientist.com/2023/01/07/how-to-try-out-undergrad-research/
https://www.blakeporterneuro.com/science/navigating-academia-as-an-undergraduate/how-to-get-into-a-research-lab-as-an-undergraduate/
https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/bes2.1745
https://journals.biologists.com/jcs/article-pdf/121/11/1771/1372198/1771.pdf

[R2] For information about standard academic lab policies and scientific culture:
https://helpimascientist.com/2022/11/20/katherine-rogers-lab-guidelines/
https://helpimascientist.com/wp-content/uploads/2023/02/Becky-Burdine-Lab-Goals-and-Policies_2023.pdf
https://helpimascientist.com/2023/02/22/keeping-a-lab-notebook/
https://helpimascientist.com/2022/11/20/stages-of-scientific-development/
https://helpimascientist.com/2022/11/20/how-hard-should-you-work/
https://helpimascientist.com/2022/11/20/what-is-the-purpose-of-group-meetings/

[R3] For information about going to graduate school:
https://helpimascientist.com/2022/12/24/should-you-go-to-graduate-school/
https://www.brains-explained.com/advice-for-applying-to-phd-programs/
https://gonzales.science/resource-blog/for-prospective-phd-students
https://helpimascientist.com/2023/01/07/choosing-rotations-and-a-dissertation-lab/

References and additional resources:

1) Schwartz, M.A. (2008). The importance of stupidity in scientific research. J. Cell Sci. 121: 1771.
2) Hersey, Paul, and Kenneth H. Blanchard. 1969. "Life Cycle Theory of Leadership." Training & Development Journal 23 (5): 26–34.
3) Blanchard, K., Zigarmi, P., & Zigarmi, D. (1985). Leadership and the One Minute Manager: Increasing Effectiveness Through Situational Leadership. New York: William Morrow.
4) https://www.cur.org/resources-publications/coeur-2-0/
5) https://irp.nih.gov/podcast/2022/12/dr-sharon-milgram-making-the-most-of-the-trainee-experience