GOHREP and PLESI: guides to navigate through your research projects

Students can struggle to articulate the goals and rationale behind their research projects and navigate through the day to day challenges of laboratory research. GOHREP and PLESI can be helpful guides.

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I spent the last weekend in Southern Tunisia, an area of such peculiar beauty that you feel like you landed on another planet. No wonder the region inspired George Lucas to think up Anakin and Luke Skywalker's home planet of Tatooine, named after the Berber village of Tataouine and its spectacular surroundings. If you ever go for a walk in that desert, you will soon realize how easy it would be to get lost in the empty landscape given the absence of landmarks. Scientific research is not different. You need guides and beacons to articulate research projects and planify your daily research activities.

Planet Tatooine (aka Southern Tunisian desert)

This post describes GOHREP and PLESI, two guides we have developed in my lab over the years to help organize our projects, improve communication and perform research to the highest standards.

GOHREP: how to plan and manage a research project

GOHREP serves as a framework to develop a research project. We often use it as a verb too. If someone has an idea, then they're told to GO-HREP it! I expect every lab meeting presentation to start with a GOHREP slide (sadly, it doesn't happen as frequently as I would hope 😞). And it does wonders when introducing projects in seminars and other presentations, as well as guide writing abstracts and research reports. GOHREP is also useful when developing a fellowship or grant proposal to help conceptualize the project in some detail.

So, what is GOHREP? It stands for GOal, Hypothesis, Rationale, Experimental Plan.

GOal—here you write your main objective; what do you want to achieve in the project; achieving this goal is what defines the success of the project. After all, how would you ever reach your goals if you never write them down in the first place. Here, you can be somewhat general but not too vague.

Hypothesis—a hypothesis is a statement of a fact, an educated guess; it is central to scientific thinking so make sure you are familiar with the concept and read about it. The hypothesis needs to be specific, it is typically more specific than the overall goal.

Rationale—this is your logic for coming up with the hypothesis. The hypothesis rarely comes out of thin air but is the product of some background information or finding you have. Here, you describe the finding or observation that led you to make the educated guess of the hypothesis. Typically, the rationale is based on preliminary data.

Experimental plan—This is your to do list for the lab. Here, you write the approach and which specific experiments you will you undertake to challenge the hypothesis with the ultimate goal of achieving your objective. Please, note that a typical approach in science is to design experiments that aim at falsifying your hypothesis. You'll be on the right track as long as your hypothesis stands these repeated experimental challenges; otherwise, no worries mate, you simply need to get back to the drawing board and come up with a new hypothesis.

BBQ—the Big Biological Question

In addition to GOHREP, but only after you have defined the points above, you can list a series of **specific questions that you want to address**. This can be helpful as you develop the experimental plan but it doesn't replace the GOHREP framework. Far too often, students would present a question and nothing else. Your audience needs more. They want to know for example what your hypothesis is, why you came up with the question (the rationale) etc. That's why GOHREP is so critical. It doesn't just help you frame your project, but also communicate the key pieces of information that your audience requires to understand the project and how it fits within the scientific enterprise.

Another approach that can complement writing your Goal, is to write a ***BBQ—a Big Biological Question***. I often ask the question to my fellow scientists, what is your BBQ? You can't do research without a BBQ! If you're presenting your work to a broad audience, the BBQ is a must. This can also be very useful in talks, reports and research proposals. Yet, here again, I prefer to start with the minutiae of GOHREP and then frame a BBQ that matches my favorite projects. Science is the art of soluble, said the wonderful Peter Medawar. Some BBQs are important and fascinating, but current methods and experimental systems may not be ripe to address them. Leave such questions to others. Listen to Peter's wise advice.

You cannot do reserach without a BBQ. Image source from here.

The strategic rationale

A few years ago, Erin Zess, at the time a PhD student in The Sainsbury Laboratory, came up with a clever variation to GOHREP, by splitting the Rationale into a scientific and a strategic rationale. That was very a thoughtful tweak by Erin. Indeed, the rationale is often not just scientific, based on preliminary data or empirical observations, but it can include non-scientific arguments. Strategic rationale can be the availability of equipment, funding, bioresources, and so on that make it timely to undertake the project in question. It can even be the opportunity to fill an empty niche within the research field. Even a particular technical skill that the scientist has mastered can be part of the rationale for doing a project.

Another way to approach the strategic rationale is to build on top of earlier discoveries. Think of yourself as Cristopher Columbus landing in the Americas. Now that you discovered something new and exciting, you have a strategic advantage to make the most out of it. This is your opportunity to build on the new knowledge you have generated, make new predictions and be a trailblazer. It would have been silly if Columbus after finding America would have said, wonderful but I'm looking for a new route to India so dudes I'm out of here. In fact, the Dutch explorer Dirk Hartog did just that when he landed on the Western Coast of Australia. He examined the coast, found nothing of interest to him, sealed a historical plate on a rock and sailed on to Batavia (present day Jakarta). Have you ever heard of Dirk Hartog? Probably not.

(Incidentally, a brief note for the Gotcha! gang. I'm more than aware of the bloody history associated with European exploration and colonisation. The above metaphor isn't meant to glorify Columbus and company, but it does vividly illustrate my point.)

GOHREPping is thinking

You heard the saying "writing is thinking." That's another reason for GOHREPping your ideas. Ideas are cheap and can sometimes come by the dozens. Scientists who are highly creative and continuously produce new project ideas are critical for the scientific enterprise. But, most ideas will not pan out and many are simply not worth pursuing. By writing down your GOHREPs, you will have a working document to think more deeply about the potential project and share it with your colleagues for their feedback. Many GOHREPs will just not get pursued, and rightly so. Thus use GOHREP as a filtering mechanism to prioritize projects and decide which ones are worth pursuing.

PLESI: the four independent steps of experimental research

Where GOHREP is about the big picture and framing a research project, PLESI is for managing the day to day work. By now, you have settled on a GOHREP and are moving to the experimental phase of the project. That's when following PLESI comes in handy.

PLESI stands for PLanning, Execution, Scoring, Interpretation.

PLanning—this is where you sit down at your desk and precisely map out the details of the experiment you are planning. This step is so important and often neglected in the modern age of lab rats rushing to the bench to generate as much data as possible. The pipet then think plague of modern day molecular biology research. Planning can certainly save you a lot of time and grief if you make the effort to read on the experiments you are planning, discuss with others about the robustness of the methods and make sure your controls are covered. This is also where a solid GOHREP with help guide you in deciding which experiment should be prioritized and would best challenge your hypotehsis.

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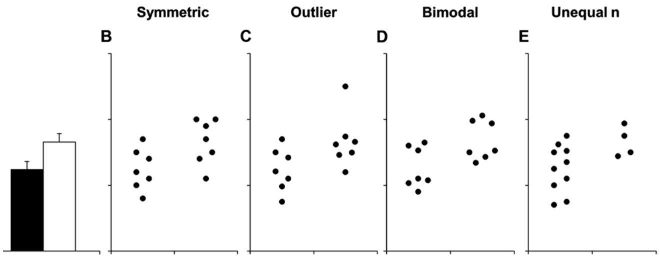
ıld her PIESI (Planning-Execution-Scoring-
ːerpretation) of @KamounLab hopefully she will learn
sooner than her dad!

PLESI: useful for all ages.

Execution—this is the part where you roll up your sleeves (or better put on your lab coat) and display your technical or programming skills. Experimental science requires skills, so you need to learn the methods and perform them precisely and efficiently. Many of the wet lab methods I learned as a student became obsolete just a few years later or are now offered as commercial services (Sanger sequencing anyone?). Still, laboratory skills are a huge part of the lore in biological research, and some computational skills are absolutely essential for modern day biologists.

Scoring —this is where you just embrace your robotic self, put on your Mr. Roboto costume and score like a cold-blooded machine. Don't let emotions get in the way. Many scientists do experiments with the hope of finding something (say a cell death lesion in a leaf), yet they end up finding something else (a crinkled leaf). This is exactly what happened to my first PhD student Trudy Torto-Alalibo who performed our first expression screen of pathogen genes in plants. The hypothesis was that some of these would induce a local cell death response like the positive control we were using. Yet, Trudy found two genes that caused the leaves to crinkle instead of the death phenotype. When I first saw Trudy returning from the greenhouse after scoring her plants, she looked dejected. She said, it didn't work, none of them caused cell death. We went back to check the plants together and after I pointed out the two odd plants, she exclaimed "they are crinkled!" The lesson is don't just look quickly for what you're hoping for and move on. Carefully score your experiments and keep both eyes open for oddities and other cues. More often than not, they would lead to exciting new findings. Incidentally, we called Trudy's genes "Crinklers." And they turned out to cause cell death when we used more sensitive assays.



Test	p value			
st: Equal var.	0.035	0.050	0.026	0.063
st: Unequal var.	0.035	0.050	0.026	0.035
oxon	0.054	0.073	0.128	0.103

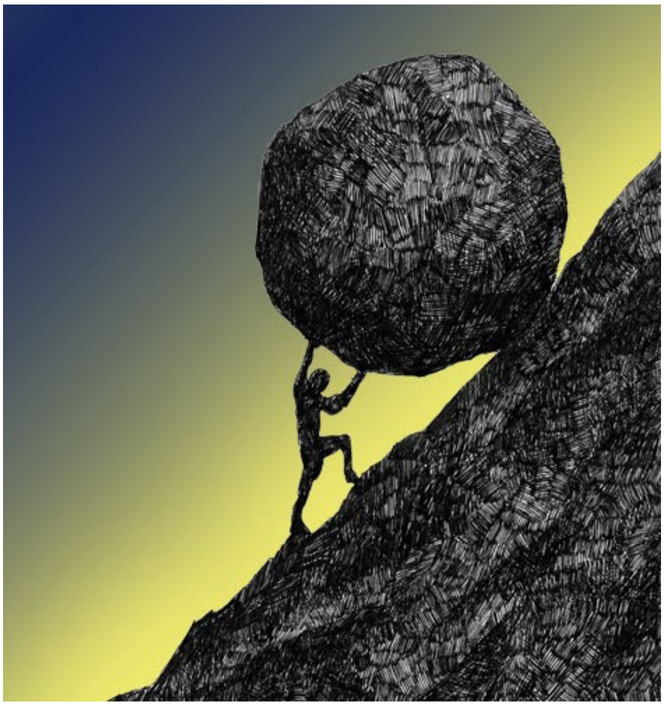
Beyond bar and line graphs.

Interpretation—This is the part where you analyze your data to draw conclusions. Here, you need to understand scale and significance, visualize your data using plots (learn R my friends), and have at least some basic knowledge of statistics. A clear plot is worth a thousands words. Learn that bar and line graph, such as old-style histograms, are now banned by progressive scientists and journals.

A key point about PLESI is that the four steps are ***equally important*** and ***fully independent***. In fact, the idea to PLESI came to me when a couple of students (who shall remain unnamed) where chatting about how they were scoring plant immunoassays while at the same time drawing conclusions and dreaming up the next experiments. Rigourous science doesn't work that way. They should be first scoring and recording the results as objectively as they can, then process their data, plot it in various ways and apply statistical analyses, and then—and only then—draw a conclusion and move to the next step.

PLESI and the never-ending cycle of experimental research

Another aspect of PLESI is that it's actually part of a recurring cycle—that never-ending cycle of experimental research. So think of it as a wheel, and when your experimental wheel is spinning smoothly, then the finding from your experiment calls for more planning and for a new PLESI cycle to kick in. Hopefully, it will not be as pointless as Albert Camus' and his absurdist depiction of Sisyphus pushing a rock to the top of a mountain only to let it roll down again. But, scientific research requires a tough skin and perseverance. That's precisely why you don't want to waste your time by rushing into the lab without a properly thought out plan.



ɜ myth of Sisyphus. Scientific research can be frustrating. Have a plan!

acindela eburneola — fast running tiger beetle from Western Australia.

A GOHREP and PLESI example for all ages

To illustrate the GOHREP and PLESI guides, here is an example suitable for students of all ages. I selected this particular example because it's simple and straightforward, and based on my experience works very well even for 10-year old school children.

Background—*Tiger beetles are known as the fastest-running insects, but they become blind at high running speeds as Ed Yong wrote in National Geographic. It was unclear how they cope with their environment given their "blindness." Empirical observations through video footage of the running beetles showed that they can avoid obstacles. How do they manage? The experiment described below was conducted by Daniel Zurek and Cole Gilbert in their paper on how how beetles use their antennae to sense obstacles at high speed.*

GOHREP

GOal—Understand how tiger beetles avoid obstacles even though they become blind when they run fast.

Hypothesis—The beetles use their antennae to detect obstacles and avoid them.

Rationale—Video footage of running beetles shows that antennae are the first point of contact between the beetle and the obstacle.

Experimental plan –

1. Ablate the antennae of some beetles;

2. Test whether or not the beetles still manage to avoid obstacles;

BBQ—Big Biological Question—How do fast-moving insects cope with becoming blind at high-speed?

PLESI

PLanning—First find out the best conditions to maintain beetles in a terrarium; figure out the best obstacle height that they can avoid; set up running trials; test and optimize video equipemnt. Then design the experiment with 5 beetles with ablated antennae (antennectomized) and five without ablation but manipulated in the same way as the ablated beetles.

Execution—Set up and film running trials of the 10 beetles. Ideally, three running trials per beetle. Capture, label all curate the video footage.

Scoring—Process the video footage (ideally 30 clips). Measure the time lag (in milli-seconds) that the beetles take to overcome the obstacles. Based on your empirical observations of the footage, consider other type of measurements to capture anything that might reveal unexpected features. Carefully curate and label your datasets using appropriate data analysis software. Do not draw any interpretations at this stage.

Interpretation—Plot the data in graphs. Look for biases in the way the data points are distributed. Try multiple ways of plotting your data. It is a must these days to use scatterplots rather than histograms (see FIgure above). Perform statistical analyses on your data to challenge the hypothesis and determine the degree of significance between the treatments. Write down the *findings* of your experiment, for example this could be: "ablation of the antennae delays the capacity of the beetles to overcome obstacles." Next, consider the *implications* of this finding: "beetles use their antennae to detect obstacles and overcome their blindness." Ponder what these implications mean for the next phase of research. Discuss with your finding and implications with colleagues to brainstorm about the next phase.

Planning redux—Given the success of the experiment (see the video below), you can now think up the next hypothesis and the experiments that would further challenge the work. Ideally, you would want to challenge your finding using an independent experimental approach. You may also explore further this finding, for example by varying the size and color of the obstacle, determining the relationship between running speed and the use of antennae to detect obstacles, the influence of the length and angle of the antennae, doing the experiment with other beetle species, studying this phenomenon in the field etc.

It's back to the drawing board. You may even need a new GOHREP. And congratulations, this is scientific progress, you have entered a new round in the never-ending experimental cycle. Just like Sisyphus, you have pushed your rock to the top of the mountain only to see it roll down all the way to the bottom, forcing you to think of new objectives and hypotheses. But unlike Sisyphus, you're actually wiser and more knowledgeable than the previous time.

Daniel Zurek's experiment with antennectomized tiger beetles. See Zurek and Gilbert (2014) for more information.

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I am grateful to AmirAli Toghani, Bob Kuhn and many others colleagues past and present for triggering and inspiring this post.