The Researcher’s Handbook

Instructors: Alexandra Schnoes, PhD (lead), Thi Nguyen, PhD, Elie Maksoud, PhD, Shannon Behrman, PhD

Course Description:
The Researcher’s Handbook is a 9-day course designed to guide you through the process of doing experimental biology research. Scientists with a variety of expertise and diverse backgrounds give concrete steps and advice on these topics: frameworks for asking scientific questions, building a research plan, designing experiments, considering bias in research, and engaging with a research mentor. We will discuss foundational papers as case studies to make the abstract more tangible. In science, there is often no simple or right answer. However, you can develop a general approach to doing research. By the end of this course, you will gain a comprehensive understanding of how to approach your research questions strategically, design and plan a research project that complements your clinical expertise, and engage a research community to execute the project effectively.

Course Participants:
This course was designed for 1st-yr fellows participating in the CZ Biohub Physician Scientist Fellowship Program, but it can be adapted for 1st-yr graduate students, among other scientists-in-training.

Course Objectives:
By the end of this course, fellows will be able to:
- Draw on clinical expertise to frame research questions with relevance to human biology
  - Define their research vision
  - Describe how their research will fill a gap in the field
- Develop skills in research design and experimental methods
  - Learn broadly about models systems used to test research questions
  - Acquire and adopt new tools for inquiry that are guided by the scientific questions
  - Develop critical thinking in research design and problem-solving experimental methods
  - Hone skills of nimbleness in adopting new skills, and scientific resilience
  - Identify experimental bias in research
  - Discuss inclusion and racial bias in research
- Set strategic goals for career progress
  - Identify mentors in their research community and network
  - Apply strategic planning tools to manage their research and their time
  - Develop career goals for their time as research fellows

Course Evaluation:
Fellows are requested to participate in pre-course and post-course evaluations. These surveys help the instructors improve the course and make adjustments to better serve the fellows during the year.

Course Format:
Two-hour sessions will be held via Zoom. Fellows will receive instruction to complete pre-session work. Completing the work before the session will greatly enhance the group discussions, and typically the preparation may take 2-4 hrs/session. Fellows will complete work via Google Docs kept on a shared Google Drive. During the virtual meetings, fellows are encouraged to participate in discussions.

Acknowledgement: The original Researcher’s Handbook syllabus and lesson plans were developed and implemented with input from Bill Burkholder, PhD (CZ Biohub), Ethan Weiss, MD (UCSF), David Cornfield, MD (Stanford), and Arun Padmanabhan, MD PhD (UCSF).

For more information, please contact Dr. Alexandra Schnoes at alexandra@scicommlab.org. Please do not share without permission.
Lesson Plan Overview

Videos and articles for this course are curated from the iBiology online courses: Planning Your Scientific Journey (PYSJ), Let's Experiment (LE), and Business Concepts for Life Scientists (BCLS).

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<th>Day 1</th>
<th>Session Summary</th>
<th>Session Goals</th>
<th>Skills</th>
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| Introduction to Research: Vision, Impact, & Skills | Fellows will orient themselves around the WHAT and the WHY of research. By discussing research from notable physician scientists, the fellows will begin to define their research vision, how they aim to impact the field, and connecting clinical work with research. | GOALS for DAY 1  
- Get to know our community and describe the principles by which we will interact with each other  
- Draw on clinical expertise to frame research questions with relevance to human biology  
- Apply the skill of mind-mapping to understand research papers | Research strategy  
- Research strategy  
- Reading academic papers | - Complete pre-course survey  
- Watch iBio videos from PYSJ: Introduction (3min) and What Motivates You (9min)  
- Read 2 papers with clinical research relevance  
- Read about mind mapping/concept mapping |

Note: Guest speaker

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| Research Questions, Part I: Beginning the Investigation | Fellows will begin to learn HOW research is conducted, broadly. Building on conversation on vision and using foundational research papers, the fellows will begin identifying basic models for research, types of experiments, and explaining hypotheses. Fellows will consider their own research vision. | GOALS for Day 2  
- Develop skills in research design and experimental methods  
- Learn broadly about models systems to test research questions  
- Intro to scientific inquiry process  
- Define your research vision  
- Describe how your research will fill a gap in the field  
- Identify how your research connects with your clinical work | Forming hypotheses  
- Research strategy | - Watch iBio video from PYSJ: What’s a Hypothesis, Anyway?  
- Watch iBio video from LE: Choosing a Model System  
- Read foundational papers for experimental details.  
- Read an article about building a research vision |

Note: Guest speaker

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| **Research Questions, Part II: Refining the Questions** | Fellows will answer the HOW for their own research vision. By conducting a lit search of papers targeting their research and characterizing those papers, they will begin to define their hypothesis and research objectives (FINER framework). We will also discuss research bias, and individuality/inclusion in research. Note: Guest speaker | GOALS for Day 3: 
- Develop critical thinking skills in research design 
- Explain different frameworks for framing hypotheses (apply the FINER framework) 
- Discuss inclusion and racial bias in research at individual and institutional levels | - Literature search 
- Scientific inquiry 
- Addressing bias in research 
- Diversity and Inclusion | - Read CME article about research questions and objectives from the perspective of clinical research scientist 
- Lit search; Find 4-6 papers for your research question. 
- Watch iBio video series: Importance of Improving Diversity and Inclusion in Science 
- Read SciAm article from PYSJ on how diversity matters: Point of View Affects How Science Is Done |

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| **Experimenting Part I: Design** | Fellows will define their experimental approaches. By dissecting foundational papers and literature for their projects, they will identify classes of experiments (type I/II/III), how researchers perturbed their systems, define models and predictions, measure experimental outcomes, and examine time scales. Fellows will also discuss resilience, research roadblocks, optimizing experiments, and addressing assumptions. Note: Guest speaker | GOALS for Day 4: 
- Develop skills in experimental design 
- Acquire knowledge of new tools for inquiry that are guided by the scientific questions 
- Hone skill of scientific resilience 
- Identifying experimental bias, attention to bias is necessary early and often in scientific research (build on yesterday, idea of being skeptical of your experiments) | - Experimental design 
- Failure in the scientific process | Draw out predictions and research models 
- Watch iBio video from PYSJ: When Thinking of Expts 
- Watch iBio videos from LE: Art and Practice of Experimental Design & Pilot Your Experiment 
- Watch iBio videos on research resilience from LE: Don’t Be Wed To Your Hypothesis 
- Read case study papers |

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| Experimenting Part II: Critical Thinking | Fellows will critique the experimental approaches they mapped. Building on explanations of how researchers perturbed their systems, defined models and predictions, and measured outcomes -- fellows will ask “How do we know it worked?” Discussion will include experimental problem solving (variables, controls, replicates, repeat experiments). | GOALS for Day 5  
- Develop critical thinking in experimental design  
- Dive deeper into critical experimental design skills of controls, replicates and repeat experiments  
- Practice problem-solving for experimental methods | Critical thinking  
- Troubleshooting | - Watch videos from LE:  
Getting an Experiment to Work, Controls, & Validate Your Results Thru Orthogonal Approaches  
- Watch videos from LE on rigor:  
Be Rigorous and Transparent, What is Variation?, & How to Think about Replication  
- Watch iBio case study videos on experimental design: Ana’s Case Study: Investigating Mechanisms of Breast Cancer  
- Review a paper as a case study in controls |
| Day 6 | Fellows will determine their communication style. Fellows will also dive deeper into resilience and motivation. Fellows will identify mentors in their research community. In discussion/wi | GOALS for Day 6  
- Hone skills of nimbleness in adopting new skills and scientific resilience; complements the idea of being critical and safeguarding against bias...it can be exhausting; how do you move forward and motivate yourself  
- Identify mentors in your research community  
- Explain how you will engage mentors and build relationships | Mentoring  
- Communication | - Watch videos from PYSJ to explore your science community:  
How Science Really Happens & Seek Advice Early and Often  
- Review Cartoon on Imposter Syndrome  
- Complete a Communication Styles self-assessment  
- Reflect and answer questions on your expectations as a mentee |

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| Day 7 | Experimenting Part III: Case Study Deep Dive | Fellows will learn about single cell RNA Sequencing and the computational processing thereof. Fellows will leave knowing how to learn more and what resources and tools are available to them for computational work with sequencing data. Note: guest speaker | GOALS for Day 7  
- Become excited about the possibilities of using computational tools in your research  
- Be more confident to employ computational tools in research  
- Be knowledgeable about next steps and resources for further computational training.  
- Be aware of computational resources/tools that enable you to process experimental data (Galaxy, UCSF’s Wynton/Stanford’s Sherlock, R/Python) | - Critical thinking  
- Computation techniques | - Watch videos from LE: Think About Your Data and How To Analyze It  
- Read paper on single cell RNA-sequencing  
- Watch iBio research talk video: Single Cell Sequencing |

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| Day 8 | Turning Plans into Action: Research Community Deep Dive | Fellows will learn about the extended academic research culture including the administrative tasks related to research. They will discuss the complex research ecosystem. Fellows will learn from near-peers guests on how to utilize strategy, vision, and brand to communicate about their research. Fellows will begin to build their own vision and brand. Note: guest speakers | GOALS for Day 8  
- Learn about the complex research ecosystem and related admin tasks  
- Being a colleague in the research lab; place and lack of hierarchy and teaching each other  
- Hear how others have tackled the issues you face in your current transition & career pathway  
- Identify your brand and deepen your research vision | - Mentoring  
- Branding your research | - Review panelists bios  
- Listen to Strategy4Scientists podcasts from iBio course BCLS: #7 Mark Ansel, UCSF  
#6 Bob Farese, HSPH, formerly Gladstone Institutes  
#12: Yaisa Andrews-Zwilling, Industry |

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| Day 9 Keep It Moving: Strategic Planning & Management | Fellows will discuss how to manage their research in the context of other responsibilities. Fellows will learn strategic planning tools, and discuss the economic principle of opportunity cost. Program directors (and guest speakers) will share their experiences in a Q&A. Note: Guest speaker | GOALS for Day 9  
- Set priorities and learn a framework for saying yes to your goals (and no to others)  
- Apply strategic planning tools to manage your research and time  
- Discuss the economic principle of opportunity cost as it relates to acquiring and adopting new tools for inquiry  
- Develop career goals for your time as a research fellow | - Strategic planning,  
- Saying no  
- Time management  
- Watch videos from PYSJ: The Importance of Planning  
- Watch iBio videos from BCLS: Environmental Assessment Tools: SWOT/PEST, Developing Strategy: Two Factor Matrix, & Finance in Academia  
- Listen to Strategy4Scientists podcasts from iBio course BCLS: #11 Aimee Kao, PI; Dr Kao is a mentor to a Biohub fellow (and the new MSTP director!)  
#10 Neal Alto, PI  
- Read “Applying Business Strategies to Establish Your Research Program” (Curr Protocols in Essential Lab Tech)  
- Read guest speaker bio |
# Sample Lesson Plan from Day 2

<table>
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<tr>
<th>ACTIVITY</th>
<th>INSTRUCTIONS</th>
<th>RESOURCES</th>
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<tbody>
<tr>
<td>For all participants and directors - Welcome and touch base</td>
<td>Facilitator-led. Discuss: How was your experience reading about experimental methods and model systems? What questions do you still have about the papers that you are hoping to get answered in today’s conversation?</td>
<td>PRE-WORK on model systems and hypotheses&lt;br&gt;- Watch video from PYSJ: <em>What’s a Hypothesis, Anyway?</em>&lt;br&gt;- Watch video from LE: <em>Choosing a Model System</em></td>
</tr>
<tr>
<td>For all participants and directors - Icebreaker</td>
<td>Facilitator-led</td>
<td>Share a bucket list item</td>
</tr>
<tr>
<td>Break out rooms - Read foundational papers more closely. Same papers as Day 1</td>
<td>Director-led in the break out rooms. Guided questions. Answer: HOW is the hypothesis framed? What questions are they answering? HOW did they approach the research? Which model systems are they using?</td>
<td>Use mind mapping to help make sense of the papers&lt;br&gt;Reference an example for paper mapping&lt;br&gt;Reference an example for paper mapping&lt;br&gt;Template: <a href="#">Paper mapping template</a></td>
</tr>
<tr>
<td>Stretch break</td>
<td></td>
<td></td>
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<tr>
<td>For all participants and directors - Q&amp;A with guest speaker</td>
<td>Facilitated Q&amp;A all together with fellows.</td>
<td>Guest speaker bio: <a href="#">Jay Horton, MD</a></td>
</tr>
<tr>
<td>Prep the next day</td>
<td>Facilitator-led. Go over the assignments. Answer questions.</td>
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