Making the Right Moves

A Practical Guide to Scientific Management for Postdocs and New Faculty

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Second Edition

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Chapter 7

PROJECT MANAGEMENT

To increase the output of your laboratory, you can either increase resources—by getting another grant and recruiting more people to work with you—or make better use of what you already have. One tool for achieving the latter is project management. Put simply, project management means allocating, using, and tracking resources to achieve a goal in a desired time frame. In a scientific setting, goals may include publishing a paper, obtaining a research grant, completing a set of experiments, or even achieving tenure. While keeping creativity intact, project management can help reduce wasted effort, track progress (or lack of it), and respond quickly to deviations from important aims. This chapter highlights some of the techniques of project management and how you can use them. The appendix at the end of the chapter shows a real-life example of project management applied to a project to determine the role of a gene in prostate cancer.

> *Project management helps you efficiently use your research funds, personnel, and time to publish research papers, obtain funding, and be promoted.*
>
> —Milton Datta, Emory University School of Medicine

WHAT IS PROJECT MANAGEMENT?

Project management is a series of flexible and iterative steps through which you identify where you want to go and a reasonable way to get there, with specifics of who will do what and when. The steps of project management are similar to the components of a grant proposal (see chapter 9, "Getting Funded"). With a grant proposal, the probability of success is proportional to the thought that has gone into each part of the proposal. The reviewers as well as the funding agency staff want to see that you have thought things through. The same process also applies to other aspects of running your laboratory and planning your career.

> *A detailed, well-designed project plan is one of the sharpest tools available for convincing a funder, such as NSF or NIH, to give you the resources you require.*
>
> —Stanley Portny, Stanley E. Portny and Associates

Deciding on a Project

You may have an endless number of ideas for projects, but your resources (e.g., research funds, number of students and postdocs, time, and so on) are limited. The first thing you will have to do is decide which projects to pursue within the limits of your resources and considering your laboratory's mission (see chapter 3, "Laboratory Leadership in Science").

For, example, you may want to obtain a second R01 grant because it will allow you to pursue another line of research and increase your chances of obtaining tenure. The grant deadline is in nine months. You should ask yourself the following:

◆   What experiments do I need to conduct to write a research paper and submit it for publication before the grant deadline?

◆   Do I have enough time to obtain the necessary data?

◆   Which students and postdocs could generate these data?

Once you have defined your overall objectives, how to get there, and from whom you need buy-in and participation, you can start the process of planning your project, working backwards from your stated objective:

My project is to get an R01 funded within one and a half years. I will need to

◆   *Obtain final data for the grant proposal (12 months)*

◆   *Submit the grant with preliminary data (9 months)*

◆   *Submit a paper for publication (6 months)*

◆   *Integrate data and start writing a manuscript (5 months)*

◆   *Complete the initial set of experiments (1 to 5 months)*

Project management consists of planning each part of your project using the tools outlined in the sections below. One of the most important benefits of project management is that it helps you accurately anticipate how much time a project will take and what resources you will need. Even if some back-of-the-envelope thinking convinces you that a project is worth pursuing and that you can generate an initial set of publishable results for your grant in five months, you will need to plan each

step more carefully to answer the following questions:

◆   How long will the project really take?

◆   Do we really have the people to do this?

◆   Do we really have the funds to do it?

◆   Can we get it done in time?

GETTING STARTED

The Statement of Work

The statement of work is a written document that clearly explains what the project is. It should include the following sections:

Purpose. This section should include

◆   *Background:* Why was the project initiated and by whom, what happens if it's not done, and what else relates to it?

◆   *Scope of work:* What will you do?—a brief statement describing the major work to be performed.

Question: Don't the strict definitions you impose when you set up a project management plan limit scientific creativity?

Answer: Not at all. All projects, including highly innovative ones, rely on defined resources. Regardless of the scientific goals of a project, project management helps you determine whether your ideas can be implemented with the resources at hand and how best to approach these ideas. If you realize ahead of time that you don't have the resources you need, you'll know you need to get them.

Question: Does project management discourage us from trying high-risk projects?

Answer: Scientists must work within the limits of their resources. This does not mean high-risk projects should not be done; it just means that one should know the risks involved before starting the project. Project management helps define what the risks will be; for example, you may use up your start-up funds before you get an NIH grant or you may produce one paper, rather than three, in one year. Once you know the risks involved, you can plan for them. Project management can also help you conserve some of your resources to use for high-risk projects. The more information you have at the outset of a project, the better you will be at allocating resources. The better you are at allocating resources for the work that has to get done (e.g., the experiments proposed in your funded grant), the more likely you will be able to save some funds for more speculative projects.

Question: Given the uncertainties in science, is project management feasible?

Answer: Project management isn't meant to be rigid or blindly restrictive. Indeed, by reexamining goals and circumstances in a systemized way, project management encourages you to reconsider which path is best many times during the course of a given project.

◆   *Strategy:* How will you perform the work, who will do it, and what funds are available for the work?

Objectives. Objectives are the end results achieved by the project. Each objective should include

◆   *Statement:* A description of the desired outcome when the project is completed.

◆   *Measures:* Indicators to assess how well you have achieved the desired outcome.

◆   *Specifications:* Target values of the measures that define successful results.

Constraints. These are the restrictions on the project, which fall into two categories:

◆   *Limitations:* Constraints set by others (such as limited start-up funds for your laboratory, or teaching responsibilities that will limit your research time).

◆   *Needs:* Constraints set by the project team (such as wanting to complete a project three weeks early because one of the key people will be leaving the lab).

Assumptions. These are the unknowns you posit in developing the plan—statements about uncertain information you will take as fact as you conceive, plan, and perform the project (e.g., you may assume that your clinical or teaching loads will not increase in the next year or that no one will leave the project before a certain milestone is reached).

Be aware that as your project progresses, your goals may change. Build in periodic reviews of results against objectives and revise the objectives if necessary. No matter how much you've invested in a project, it's never too late to redirect or stop work altogether if you discover, for example, that another route is more promising than the main avenue of research, or a key premise was off base, or that someone publishes the work before you do.

The appendix at the end of this chapter shows a real-life example of a statement of work.

Defining the Audience

Any of your audiences—the people and groups that have an interest in your project, are affected by it, or are needed to support it—can sink the entire enterprise if their needs are not considered. Early on, you should make a list of the project's audiences, both within your institution and outside it. Although you can do this in your head, a written list serves as a reminder throughout the project to touch base with these stakeholders as you proceed. A project can succeed only if everyone involved does his or her part.

Divide your audience list into three categories:

◆ *Drivers:* People who tell you what to do, defining to some degree what your project will produce and what constitutes success. As a principle investigator, you are the main driver for your research. Additional drivers might include competitors and collaborators in your field, the editors of scientific journals (if they are advising you on what experiments should be done in order to get a manuscript published), and the study section reviewers of the research grants (if their feedback is shaping the course of your research project). If possible, keep these people abreast of how the project is going or consult with them before changing direction or branching out in a different area. For example, if an editor at *Nature* has requested specific experiments in a revised manuscript but you decide to do different ones that you think are more appropriate or easier to do given the expertise in your lab, you can contact the editor to make sure that the proposed experiments will satisfy his or her requirements.

◆ *Supporters:* People who will perform the work or make the work possible (e.g., the students and postdocs in your lab as well as the program director for the organization that is funding the project). Make sure that these people are motivated to do the work and understand how what they are doing relates to achieving the overall scientific goal. (See chapter 3, "Laboratory Leadership in Science.")

◆ *Observers:* People who have an interest in your project but are neither drivers nor supporters. They are interested in what you're doing, but they're not telling you what to do or how to do it (e.g., other scientists working in your field, mentors, and potential supporters). It can be helpful to your career to let as many scientists as possible know what you have accomplished. This can be done by giving presentations at meetings and conferences, by asking colleagues to review a manuscript that you are preparing to submit for publication, or by sending scientists in your field copies of a paper you have published. Keep in mind that people who are familiar with your work, but who are not direct collaborators, will have to submit letters for your tenure. These people might also invite you to give talks or suggest that you participate in study sections or become part of a meeting planning team.

As you work on the project, revise the list as necessary. Categorizing audiences is less difficult than it may look, and you don't have to start from scratch for every activity. Many of the same people are likely to be on your audience list over time for different activities.

Defining Who Does What and When

The work breakdown structure (WBS) is an outline of all the work that will have to be performed for your project. To develop a WBS, start with broad work assignments, break them down into activities, and divide these into discrete steps (see the appendix for a real-life example). In the jargon of the project management field, an

activity is a task that must be performed for your project and an event is a milestone marking the completion of one or more activities. You will want to list on your timeline resources and the people that will carry out the activities, so that you can successfully complete some milestone event—for example, getting a paper accepted, a grant funded, or a difficult technique reduced to practice.

The WBS is one of the most important elements of project management as it will help you schedule the project and its parts, estimate resources, assign tasks and responsibilities, and control the project. (For more information about developing this kind of outline, see *http://www.4pm.com/articles/work_breakdown_ structure.htm*).

When you develop a WBS, think in one- to two-week increments. You probably wouldn't want to include detailed plans for activities that take less time (e.g., experiments to be done each day). However, the level of detail you include in your WBS depends, in part, on who is doing the work. Most undergraduates will need more detail than an experienced postdoc or technician. It may be useful to teach your trainees to think in this time- and resource-aware way, perhaps by, early in their stay in your lab, having them write out detailed weekly plans or design flow charts for how they intend to work through a difficult technical issue at the bench.

To decide whether a particular part of the project is detailed enough, ask yourself these three questions. Based on the WBS can

◆　You determine a reasonable estimate of the resources (including people) required for this work?

◆　You determine a reasonable estimate of the time required to do this work?

◆　Anyone charged with one of these activities understand it well enough to do it to your satisfaction?

If the answer to any of these questions is "no," more detail is necessary.

In science, it's unlikely that you'll be able to make a detailed plan very far in advance. Much of the detailed planning will be done "on the fly" as the project proceeds. Try a rolling approach, in which you revise estimates in more detail as you progress through the project.

In addition to planning experiments, you can use the WBS to set up the lab and divide big tasks into smaller ones—for example, ordering equipment; hiring staff; and dealing with institutional review boards (IRBs), radiation safety, and other issues.

Question: Is project management a top-down or a mutual process?

Answer: It must be mutual. For the best possible outcome, you need both staff insights and "buy-in." Project management does not say, "Forget thinking and just do what I say." It's a process for identifying what to think about, not how to think about it.

Question: If I have experiments A, B, C, and D, is it reasonable to do detailed planning only for A first and deal with the others later?

Answer: That may be reasonable, but what if B isn't entirely dependent on A, and you could have done some work for B or any of the other experiments without waiting until A was done? Project management tools and software can help you see where timelines may overlap, so that you can use your time most productively.

TRACKING THE WORK AND THE RESOURCES

Complex projects require a series of activities, some of which will have to be performed in sequence and others in parallel. Project schedules outline the order in which activities are to be performed and estimates of how long each will take. In addition, for each step of the schedule, you will need to assign the necessary resources, including people, funds, equipment, supplies, facilities, and information. To schedule your activities and resources, you will need to follow these steps:

1. Identify activities and events (from the WBS).
2. Identify constraints (from the statement of work).
3. Determine the durations of different activities and, if more than one person will be involved, who will be doing them.
4. Decide on the order of performance.
5. Develop an initial schedule.
6. Revise your schedule as necessary.

Tools for Developing Schedules

You have probably seen some of the tools for developing schedules, timelines, flow charts, and so on, before. Here are some popular ones:

◆ *Key events schedule:* A table showing events and target dates for reaching them (remember that events are milestones signaling the completion of one or more activities).

◆ *Activities plan:* A table showing activities and their planned start and end dates (see appendix, page 141).

◆ *Gantt chart:* A graph consisting of horizontal bars that depict the start date and duration for each activity (see appendix, page 142).

◆ *PERT chart:* A diagram in which activities are represented by lines and events on the nodes (typically depicted as circles or bubbles).

The key events schedule and the activities plan display dates better; the Gantt and PERT charts give a better overview of how long activities take and where they coincide. Regardless of which format you use, take the time to develop a schedule you have a reasonable chance of meeting. Think realistically and estimate how long each step will take, how many uninterrupted hours you have available during the day, and how other demands on your time will affect what you or your lab can get done.

To determine how long a very complex process may take, think about similar things you've done before. Flip through your notebook or calendar and try to remember—how many hours did it really take you to write, edit, get feedback on, make figures for, revise, revise again, and submit that last paper or grant? Try to be conservative in your estimates. When it comes to planning benchwork, an accurate assessment of the skills, experience, and limitations of your staff will help

you match the right people to each task. Stretching is good, but failing because of overreaching is not. If your team lacks the expertise required for completing a specific goal you may need to find a suitable and willing collaborator. Collectively these scheduling tools will

◆ Provide ways of tracking the work.

◆ Identify the order of experiments, which will define how long it will take to get the job done.

◆ Show the relationship of experiments to each other (e.g., do they need to be done sequentially or can they be done in parallel?)

◆ Identify bottlenecks.

As the work progresses, make adjustments to your schedule or the resources needed. For example, the estimates of times can be replaced with actual times. In cases where there are delays in the schedule, additional resources may be needed to make up for time and the diagram may be modified to reflect the new situation.

Question: It sometimes takes longer than I think it will to complete new experiments. How do I plan accordingly?

Answer: The work breakdown structure will help you see where inherent difficulties in experiments or bottlenecks in the procedures are, and you can then add time and resources to address these. For example, you may pair an experienced postdoc with a new student who is responsible for a step in the protocol, or give a technician who has to establish a new technique in the lab time for several trials and revisions of the procedure.

Do I Have the Resources?

Once you have made an outline of the activities to do in a given timeframe and who will perform the work, you may want to more precisely determine how much of a given resource the project will use up—e.g., how many hours a postdoc will have to work each week to complete his or her activities (see appendix, page 142) or how much money will be spent. This will help you identify potential bottlenecks—even the best postdoc cannot work 37 hours a day!

PROJECT MANAGEMENT SOFTWARE

If you are keeping track of a simple project involving only one or two individuals, you can probably use a network diagram drawn on a board or in an electronic document. But as the number of projects and responsibilities you juggle grows, you may want to make use of one of the many software packages available. They can help you spot, for example, resource conflicts (such as one person assigned to three overlapping activities) and identify which activities can be delayed to accommodate that problem without jeopardizing the schedule. Good software helps you brainstorm the organization of activities on screen, create a WBS, link activities, develop a schedule, identify resources, maintain information on progress, and generate reports. When you make a change, the software reflects the impact of that change throughout the project.

Microsoft Project, a program that seamlessly integrates with Microsoft Office, is a popular choice. The software package lets you enter any number of tasks and schedule them. You can then view the data using multiple formats (e.g., Gantt charts or PERT diagrams). You can also enter cost for each resource and the software will automatically track the spending of the project. Other popular choices are the packages Act! (Symantec Corp.) and Now Up-to-Date (Qualcomm, Inc.). For information about others, see *http://www.project-management-software.org*. Like other software, project management programs come with bells and whistles you may never need or use. Remember that software is merely a tool to help you plan and organize your work. It should not become your work, bogging you down in complex manipulations or fancy graphs and charts that look impressive but don't improve on simpler presentations of the information.

After some short training on these software packages, it is straightforward to build new plans. Several fields, including construction and some areas of business management, make extensive use of this kind of software. You may be able to find undergraduates, especially in engineering or business schools, who would be eager to polish their skills (and get a line for their résumé) by doing the grunt work needed to move your established pencil-and-paper plans onto the computer.

Question: I've done some experiments so many times that I already know how long it will take and the resources I need. Should I add these experiments to my plan?

Answer: Not for your benefit, but you have to consider whether others need to know what you're doing—the sequence of steps as well as the materials and time required. If they do, a written work plan can also be a useful part of the record. Project management isn't just a planning tool, it's also a training and communication tool.

Question: Despite the best explanations, inexperienced students may focus only on their part of the work. Are there devices to help them get the big picture?

Answer: It's important that they do get the big picture, and project management may be part of the solution. Although it's true that project management encourages a focus on details, it also encourages you to consider the big picture. Think of a project's detailed plan as being like a metabolic map: If students can see how their work connects to a greater whole, they may be more motivated to think about their own small projects and to ask bigger questions about the lab's work and the broader field. Young students may be reluctant to admit what they don't know. By walking them through the field's complicated issues and ongoing controversies, you can convey to them that it's alright not to know and customary to ask others to explain things. Get them to talk about what they're doing, and paraphrase what they say, highlighting the places where their work intersects with other work in the lab, or ask them to write a statement of work for their part of the project, which requires knowing the background on the project as a whole.

CONTROLLING THE PROJECT

Effective project management demands that the components of a project be constantly monitored and revised with new information. The principle investigator typically plays this role in addition to the following tasks:

◆ Championing the project for the project audience (e.g., through seminars and informal updates to supporters).

◆ Clearing away obstacles for the project team (such as minimizing other responsibilities for the team members and providing a supportive and comfortable work environment).

◆ Providing resources, by way of funds, access to essential equipment, and technical skills.

◆ Communicating the project vision to keep the team motivated and focused.

◆ Communicating with the department chair, NIH, journal editors, and the external collaborators.

> *The greatest chances for success are achieved when project information is used to align, guide, and motivate team members, and when these team members, in turn, use this information to guide their work.*
>
> —Stanley Portny and Jim Austin, "Project Management for Scientists," ScienceCareers.org, 2002

Keeping Your Work on Track

It is hard to predict how the course of a project will run. Flexible planning is needed to help you deal with the unexpected and still keep your many projects moving. The following is a list to help you stay on track:

◆ As you would do in a good R01 or other grant application, consider different scenarios to identify what may not unfold as you anticipate, and identify the range of ramifications and how you would address them.

◆ Select aspects of your project that are most likely to slow things down (e.g., a graduate student who is not familiar with interpreting experimental results and thus may slow progress or a technician who does not aggressively follow up on orders from a slow vendor and thus may not receive needed reagents on time), and monitor them closely.

◆ Develop strategies to reduce the likelihood of deviations, as well as contingency plans for any that occur.

◆ Create indicators or defined results (such as a completed Western blot or a clearly interpretable experimental finding) that will help you evaluate the project against your stated objectives. The indicators should be clear and directly relate to your objectives. Poorly chosen indicators are worse than none at all and may cause you to abandon a project when in fact the objective may be sound.

◆ Monitor the project carefully and consistently to promptly identify detours from course.

◆ Implement contingency plans, and revise your master plan as necessary.

Question: How do I finish projects while allowing key people to leave when they're ready?

Answer: Project management can help you anticipate and plan for their departure. Identify who's most likely to leave and the places in the project where that's most likely to happen. When it does happen, stop and assess the impact on your project and determine steps you can take to minimize the effects.

As a scientist, you want your work to be worthwhile, even if it doesn't proceed the way you planned or produce the expected outcome. To get the most out of your investment of project resources, learn to work through the "what ifs" by positing multiple possible outcomes and timelines, and planning ways to deal with each one.

RESOURCES

Austin, Jim. "Management in the Lab." ScienceCareers.org (September 13, 2002), *http://sciencecareers.sciencemag.org/career_development/previous_issues/articles/1890__1/management_in_the_lab*.

Austin, Rob. "Project Management and Discovery." ScienceCareers.org (September 13, 2002), *http://sciencecareers.sciencemag.org/career_development/previous_issues/articles/1890__1/project_management_and_discovery*.

Barker, Kathy. *At The Helm: A Laboratory Navigator.* Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press, 2002.

Harmening, Denise M. *Laboratory Management: Principles and Processes.* Upper Saddle River, NJ: Prentice Hall, 2002.

Heldman, Kim. *Project Management JumpStart.* Alameda, CA: Sybex, 2003.

Henry, John B., ed. *Clinical Diagnosis and Management by Laboratory Methods.* Philadelphia, PA: W.B. Saunders, 2001.

Hudson, Jane, ed. *Principles of Clinical Laboratory Management: A Study Guide and Workbook.* Upper Saddle River, NJ: Prentice Hall, 2003.

Kemp, Sid. *Project Management Demystified.* New York, NY: McGraw-Hill, 2004.

Lewis, James P. *Fundamentals of Project Management: Developing Core Competencies to Help Outperform the Competition.* New York, NY: American Management Association, 2002.

Luecke, Richard. *Managing Projects Large and Small: The Fundamental Skills to Deliver on Cost and on Time.* Cambridge, MA: Harvard Business School Press, 2003.

Martin, Vivien. *Managing Projects in Health and Social Care.* London: Routledge, 2002.

Portny, Stanley E. *Project Management for Dummies.* Hoboken, NJ: Wiley Publishing, 2000.

Portny, Stanley E., and Jim Austin. "Project Management for Scientists." ScienceCareers.org (July 12, 2002), *http://sciencecareers.sciencemag.org/ career_development/previous_issues/articles/1750/ project_management_for_scientists*.

Portny, Stanley E. "Project Management in an Uncertain Environment." ScienceCareers.org (August 23, 2002), *http://sciencecareers.sciencemag.org/ career_development/previous_issues/articles/1820/ project_management_in_an_uncertain_environment*.

Project Management Institute. *Guide to the Project Management Body of Knowledge.* Newtown Square, PA: Project Management Institute, 2000.

Sindermann, Carl J. *Winning the Games Scientists Play.* Cambridge, MA: Perseus Book Group, 2001.

Usherwood, Tim. *Introduction to Project Management in Health Research: A Guide for New Researchers.* Bristol, PA: Open University Press, 1996.

APPENDIX: PROJECT MANAGEMENT— A REAL-LIFE EXAMPLE

The Statement of Work

Section 1: Purpose

Background. Theresa, a postdoc in the laboratory, wants to examine the possible role for alterations in the gene *Sumacan* in prostate cancer. She noted that *Sumacan*, which encodes a growth factor receptor, maps to a genetic region involved in human prostate cancer. Current studies in the lab focus on the role of *Sumacan* in brain tumors. Bob, a postdoc, is screening drugs that block *Sumacan* function; Ming Li, a graduate student, is elucidating the functional pathways *Sumacan* is involved in; and Steve, a graduate student, is performing a mutational analysis of the *Sumacan* gene. These same studies can be applied to prostate cancer, thereby opening up potential avenues for funding through prostate cancer foundations.

Scope of work.

◆ Examine whether the functional pathway for *Sumacan* is present in human prostate cancer cells.

◆ Compare the expression of *Sumacan* in normal human prostate tissues and prostate cancers, and correlate expression levels with clinical outcome in prostate cancer.

◆ Identify mutations in *Sumacan* in patients with prostate cancer.

Strategy. Each person in the lab is already working on different aspects of *Sumacan* biology in brain tumors. In each case, the work will be applied to prostate cancer cell lines that we will obtain from Mike, a colleague in our department. We have identified two additional potential collaborators—Rajiv, a pathologist who studies human prostate tissues and cancers, and Kathy, a geneticist who studies human prostate cancer families. We will use funds from our current R01 grant to obtain preliminary findings. We plan to use these findings to obtain a second R01 grant to the laboratory.

Section 2: Objective

Statement. Investigate the possible role of *Sumacan* in prostate cancer.

Measure #1. Our experiments will provide preliminary evidence to either support or deny a role for *Sumacan* in prostate cancer.

Specification. The experiments we carry out will answer the following questions:

◆ Is *Sumacan* expressed in the prostate?

◆ Is *Sumacan* expressed in prostate cancer?

◆ Is there a difference between the expression of *Sumacan* in the prostate and in prostate cancer?

Measure #2. The results obtained by these experiments will generate publications and grants.

Specifications.

◆　At least two (one for each postdoc working on the project) research articles will be accepted for publication in a top-tier research journal in the field.

◆　A request to NIH for funds to continue the research begun receives a percentile score on first-round submission of at least 25 percent and subsequent funding on the resubmission.

Measure #3. People in the field are aware of our research.

Specifications.

◆　We will receive several requests for information about the research.

◆　We will publish at least two research articles in the scientific literature.

◆　We will present the research results at at least two conferences in one year.

Section 3: Constraints

Limitations.

◆　The NIH proposal is due June 1, 2007. This means that the first research manuscript must be submitted for publication by approximately January 1, 2007, and accepted by mid-April 2007.

◆　Our lab has limited funds to cover the generation of preliminary data, which means that productivity has to be reviewed monthly.

Needs.

◆　Our lab needs to be able to grow prostate cancer cells.

◆　Our lab needs to be able to handle human prostate cancer specimens.

Section 4: Assumptions

◆　The current research team will be willing and able to perform prostate cancer studies in addition to their brain tumor studies.

◆　The collaborators we have identified will be willing and able to work with our group or will provide the name of another person who wants to collaborate.

The Work Breakdown Structure

Activity 1: Determine whether *Sumacan* is expressed in the prostate.

1. Determine where to obtain human prostate cells.

2. Determine how to grow human prostate cells.

◆ The type of medium and serum they require

◆ The optimal conditions for growth

3. Determine whether we can isolate RNA and protein from human prostate cells.

◆ Try the same technique we use to isolate RNA from brain cells.

◆ Develop a different technique.

4. Determine whether we can perform quantitative RT-PCR for *Sumacan* expression.

◆ Primers and positive and negative controls

5. Determine whether we can perform a Western blot for *Sumacan* expression.

◆ Test whether the antibody we use in the brain works in the prostate and determine what size protein band(s) is identified.

◆ Identify positive or negative controls for protein quality and *Sumacan* identification.

Note: Steps 1 to 3 must be done sequentially, but once step 3 is completed, steps 4 and 5 can be done at the same time.

Activity 2: Determine whether *Sumacan* is expressed in prostate cancer cells.

1. Determine where to obtain human prostate cancer cells.

2. Determine how to grow human prostate cancer cells.

◆ Type of medium and serum they require

◆ Optimal conditions for growth

3. Determine whether we can isolate RNA and protein from human prostate cancer cells.

◆ Try the same technique we use to isolate RNA from brain cells.

◆ Develop a different technique.

4. Determine whether we can perform quantitative RT-PCR for *Sumacan* expression.

◆   Primers and positive and negative controls

5. Determine whether we can perform a Western blot for *Sumacan* expression.

◆   Test whether the antibody we use in the brain works in prostate cancer cells and determine what size protein band(s) is identified.

◆   Identify positive or negative controls for protein quality and *Sumacan* identification.

Note: Steps 1 to 3 must be done sequentially, but once step 3 is completed, steps 4 and 5 can be done at the same time. In addition, activities 1 and 2 can be done at the same time, although this may result in higher resource costs if both tasks fail.

Activity 3: Determine whether there is a difference in *Sumacan* expression between normal and cancer cells.

1. Determine the difference in RNA expression.

2. Determine the difference in protein expression.

3. Determine the relationship between RNA and protein expression.

Note: Activity 3 involves analysis of the data collected in activities 1 and 2 and thus cannot be performed until these two activities are completed.

An Activities Plan

Activity	Person Responsible	Start Date	End Date	Notes
Identify sources of prostate cells	Theresa	Aug. 1	Aug. 5	
Identify sources of prostate cancer cells	Bob	Aug. 1	Aug. 5	
Grow prostate cells	Theresa	Aug. 5	Aug. 26	
Grow prostate cancer cells	Bob	Aug. 5	Aug. 26	
Isolate RNA and protein from prostate cells	Theresa	Aug. 26	Sept. 26	
Isolate RNA and protein from prostate cancer cells	Bob	Aug. 26	Sept. 26	
Perform RT-PCR on prostate cells	Theresa	Sept. 26	Oct. 26	
Perform RT-PCR on prostate cancer cells	Theresa	Sept. 26	Oct. 26	
Perform Western blots on prostate cells	Bob	Sept. 26	Oct. 26	
Perform Western blots on prostate cancer cells	Bob	Sept. 26	Oct. 26	
Compare the levels of *Sumacan* RNA in the prostate and prostate cancer cells	Theresa and Bob	Oct. 26	Nov. 5	
Compare the levels of *Sumacan* protein in the prostate and prostate cancer cells	Theresa and Bob	Oct. 26	Nov. 5	
Compare the levels of *Sumacan* RNA and protein with each other	Theresa and Bob	Oct. 26	Nov. 5	

Note: Each of these activities can be broken down further if more detail is needed. For example, if the activities are being performed by a new graduate student, you may want to explain the different protocols to use to perform RT-PCR from prostate cancer cells and what controls should be used as well as alternative protocols to use in case the first ones do not work.

A Gantt Chart

Activity	August	September	October	November	Person responsible
SUMACAN EXPRESSION IN PROSTATE CELLS					
Find cells Grow cells	▓				Theresa Theresa
Isolate RNA and protein		▓			Theresa
RT-PCR and Western blots			▓		Theresa and Bob
SUMACAN EXPRESSION IN PROSTATE CANCER					
Find cells Grow cells	▓				Bob Bob
Isolate RNA and protein		▓			Bob
RT-PCR and Western blots			▓		Theresa and Bob
COMPARE RESULTS					
Data Analysis				▓	Theresa, Bob and PI

A Loading Chart

This chart displays Theresa's workload. She is responsible for the first three steps in determining *Sumacan* expression in prostate cells. Step 1 (looking for prostate cells) is done in week 1, step 2 (trying to grow the cells) in weeks 2 to 4, step 3 (isolating RNA and protein) in weeks 5 to 8, and step 4 (doing RT-PCR on normal and cancer cells) in weeks 9 to 13. In addition, during the time the project is being run, she will be teaching a microbiology lab course (5 hours/day with monthly exams).

Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13
Research Hours	7	10	10	10	8	8	8	10	25	25	25	25	25
Microbiology Lab Hours	25	25	25	35	25	25	25	35	25	25	25	35	25
Total Time	32	35	35	45	33	33	33	45	50	50	50	60	50

Source: The examples in this appendix were provided by Milton W. Datta, Emory University School of Medicine.