



## 6. Leadership and Management in the Lab

### LEADERSHIP ON THE MOUNTAIN: Lessons for the Lab

by Kathy Barker

*“Challenge is the core and mainspring of all human activity. If there’s an ocean, we cross it; if there’s a disease, we cure it; if there’s a wrong, we right it; if there’s a record, we break it; and, finally, if there’s a mountain, we climb it.”*

—Climbing historian James Ramsey Ullman

Scientists are coming to terms with the fact that running a lab really is running a business. Yet, in looking for inspiration, most scientists find management and business leadership books— with their bottom line of sell, sell, sell—less than palatable. Scientific research is a product, but for most of us it isn’t all about the money. It’s about the science and the challenge. When it comes to management and leadership tomes, we want to read about leadership moti-

vated by needs other than getting rich and pleasing stockholders.

Look to the mountains! Or, more practically, look to the large genre of mountain-climbing books for inspiration on leadership and for guidance on how to build and motivate a team.

Decisions in the lab do not have a simple endpoint like getting to the summit, nor do laboratory errors have immediate life-or-death consequences. Usually. But the concentrated stories of conflict and triumph, cause and effect found in mountaineering books—these stories measured over weeks and months instead of years, as they might be in the laboratory—make for accessible, easily transferable lessons.

### **Choosing and Cultivating Your Team**

Leaders on the mountains and in the lab often feel, at first, similarly unequipped for the job. One chooses to become a principal investigator (PI) or an expedition head because of technical skills, but success depends on emotional resilience and communication skills. Mountains are not climbed alone, and research is not done in a vacuum; if the expedition leader or PI doesn't know how to choose and get the most out of team members, a project has little chance of success.

*“Most of all, our expedition needed a leader, someone with a strong personality who could gather the right people around him and fuse them into a close-knit unit that could work smoothly under the most miserable circumstances.”*

—Art Davidson, *Minus 148°: First Winter Ascent of Mt. McKinley*, p. 21

As in a lab, on a mountain bad people are worse than no people, and the leader needs to be careful to choose personnel well and to intervene if members of the group are having problems working together. Convinced that one of the reasons for the failure of the 1975 expedition to summit K2 had been the relative inexperience of most of the team members, leaders of the 1978 expedition decided that they would choose only highly motivated climbers with experience over 20,000 feet (6,100 meters). Choosing team members with compatible personalities was not a major consideration, and several team members known to be contentious were included.

Although the 1978 expedition would get four members to the summit of K2, the rancor within the group is what many remember and what is the subject of great discussions in *A Life on the Edge* and *Addicted to Danger*. There were storms and issues with the route, but problems among the climbers created an atmosphere that poisoned everyone.

*“Constantly frustrated by the weather, people’s nerves were fraying. Despite my attempts to run a democratic operation that gave everyone an even chance, different levels of skills and motivation were sorting us into two groups. Mediating between the two was difficult, not to mention thankless.”*

—Jim Whittaker, *A Life on the Edge: Memoirs of Everest and Beyond*, p. 192



Getting the first Americans on Everest in 1963 via the South Col route would be dangerous and exciting enough and would justify to the world the three years' worth of fund-raising and organizing. But some team members wanted to swap a "safe" South Col ascent for the additional twist and danger of the West Ridge.

One member of the climb thought that the presence of prima donnas, who believed that the climb would be easy, contributed to the unease. Some members objected to the presence of women, and some objected to favoritism in the choice of a summit team. Several team members would not compromise personal ambition in the slightest, making it impossible to forge a smoothly functioning team.

Jim Whittaker, the leader of the 1978 expedition, suggests that conflict is inevitable when diverse, highly motivated people undertake dangerous adventures. Conflict is probably inevitable when very different and highly motivated people do anything. On mountain or in lab, conflict is inevitable, but the leader must intervene to prevent that conflict from simmering or erupting into full-scale rebellion. Deal with every issue as soon as possible; problems won't go away by themselves.

*"I wanted our group spirit to outweigh our individual-achievement ethic—a lot to ask. To get here had required extraordinary perseverance, even aggressiveness. Now that the final payoff was close, how could we be expected to let go of the very qualities that had got us here in the first place?"*

—Arlene Blum, *Annapurna: A Woman's Place*, p. 141

The way the leader handles those problems will depend on his or her style, and on the individual dynamic of the team. The 1978 American Women's Himalayan Expedition put the first Americans on Annapurna I at a time when few women were invited on climbing expeditions. Team leader and biochemist Arlene Blum considered personalities carefully when assembling the team, knowing that "finding climbers with the right mental and physical qualifications was extremely important.... For many climbers the initial glamour of expeditionary climbing soon fades, and the actual experience—altitude, grinding hard work, damp, cold, tedium, bureaucratic hassles, the possibility of illness or injury—can be wearisome, disappointing, even devastating.... The determination needed to keep melting snow for water and cooking can ultimately be more valuable than the skill needed to climb steep ice." (Blum, p. 14) An aside: There's another lab lesson here—hire for character, not just for technical expertise.

The women were determined to climb the mountain in a spirit of togetherness, and they considered *that* to be as much of a goal as reaching the summit of Annapurna. Indeed, they climbed with relatively little conflict, albeit with constant, even excessive discussion. This style of intensive introspection and interaction was particular to the dynamic of this group, but it was, apparently, effective. There are as many ways to be a leader and to be a team, their experience and the experiences of other expeditions prove, as there are people. Do what works for you.

## Choosing a Project: Risk Versus Surety

The American Mount Everest expedition of 1963 put four Americans on the summit of Everest via the already climbed South Col route, and two others via an unexplored route, the West Ridge. The expedition, led by organizer Norman Dyhrenfurth and climbing leader Willi Unsoeld, was one of the most stunning accomplishments in the history of climbing, not just for the meeting near the summit of two successful teams from opposite sides of the mountain, but for the teamwork that made the whole team much greater than the sum of the participants.

Setting the goals and choosing the right people to accomplish each part of the route was intrinsic to the teams' success. Getting the first Americans on Everest in 1963 via the South Col route would be dangerous and exciting enough and would justify to the world the three years' worth of fund-raising and organizing. But some team members wanted to swap a "safe" South Col ascent for the additional twist and danger of the West Ridge. A decision to put resources and people in the wrong place could risk the success of the entire expedition.

*"The question, as Dave put it one night, was, who would be willing to put his energy into the West Ridge, with failure as a not unlikely outcome, when reaching the summit by the South Col seemed so much more assured?"*

—Tom Hornbein, *Everest: The West Ridge*, p. 38

The route strategies evolved with time, as the dynamic and strengths of the team were unveiled through weeks of slowly moving up the mountain. Team leaders were aware of differences in personalities and skills—the climbers' ability to handle altitude, resilience in dealing with the cold and other hazards, motivation to climb in the face of almost certain frostbite and the possibility of death—and this knowledge helped sort the team into very compatible and successful subteams. Only when the capabilities of the team were known could the objective risks be assessed and route decisions be made.

Each scientist faces the question of the safe, fundable project versus the exciting foray into a new area. You, the leader, might be able to absorb the failure—but can your postdoc? There are no guarantees. The 1963 Everest expedition was successful, but a sudden storm, a recalcitrant team member, a bad choice of route ... any of these factors might have meant failure, or worse. You can stay on the predictable research path if you choose to, but even that might not work, especially if the field moves on without you, propelled along by someone else's successful gamble. Pls warn that it is unwise to put off trying something new too long. Constantly reassess your goals and capabilities, as well as your team's goals and capabilities, and know how much risk each person can bear.

## Independence Or Nurturing? Guide Or Climber? Colleague Or Acolyte?

Until a decade or so ago, the mountains 20,000 feet or higher were climbed by expeditions peopled with trained mountaineers who functioned as a team. As more and more routes up the difficult mountains have been established, amateur climbers have started looking for someone to guide



them up an established route—and proved to pay well for this expertise. Clients often outnumber real climbers, and this has a huge impact on the way teams are made and mountains are climbed.

The main impact of this development has been on the new role of the team leader. On real expeditions teammates depend on each other, whereas on commercial expeditions, clients depend on the guides. This has led to a deep culture gap, with some guides being willing to nurture and pamper, and others expecting clients to be independent and responsible.

This uncertainty about responsibilities is highlighted in the series of books about the 10 May 1996 Mount Everest disaster, in which five people died alone in a sudden storm on the South Col route. Experienced mountaineer, journalist, and client Jon Krakauer (*Into Thin Air*), and professional climber and guide Anatoli Boukreev (*The Climb*) disagree on many details of that deadly day. But they agree that the multitude of people high on the mountain and dependent for survival not on themselves, but on a guide, was a recipe for disaster.

*“Neil said, ‘Anatoli, many of our members are at high altitude for the first time, and they don’t understand many of the simple things. They want us to hold their hands through everything.’ I replied simply, saying that was an absurd position. I repeated again my concerns that we had to encourage self-reliance.”*

—Boukreev, *The Climb: Tragic Ambitions on Everest*, p. 85

Unless a client is capable of troubleshooting at high altitude, or is one-on-one with a responsible guide, the person will always be especially vulnerable.

Another factor in the disastrous 10 May on Everest was that whatever the expectations were, they were not made clear. Many commercial expeditions have a defined turnaround time, a time where those who haven’t summited must turn around and head back down again, lest nightfall find exhausted members still on the mountain. The leaders of the 10 May commercial expeditions were vague and contradictory about a turnaround time, and many clients and guides were still struggling to reach the Everest summit late in the afternoon, even as clouds began to envelop the mountain.

Most PIs can recognize the difficulty of this decision: How much do you help lab members who are not as independent, or as gifted, as others? Do you carefully nurture each person to his or her own capacity? Do you write a paper for the student who can’t seem to get it done? Or do you refuse on the principle that since you are training potential PIs, you are doing no favors by expecting less than complete self-sufficiency?

Your choices will depend not only on your own personality, but on your situation: Your degree of mentorship may be different with a small lab than a big lab, or at a small college versus a terrifically competitive university. The key is to be clear about your

expectations, about your philosophies. This will help you choose a team, and it will help prospective team members choose a guide. As you go, your ideas can—and should—change. Just be sure to let everyone know when they do; don't make your team members guess about what is expected of them.

*"It is strange how when a dream is fulfilled there is little left but doubt."*  
—Tom Hornbein, *Everest: The West Ridge*, p. 183

Tenure may seem a high summit, but neither mountain peaks nor tenure assure fulfillment. Many scientists are disappointed that the milestones they reach for—tenure, or membership in the academy, or whatever—do not provide ultimate satisfaction. The last lesson from the mountains might be that it is the effort itself, not the achievement of the summit, that brings satisfaction. There is always another mountain to climb.

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## PROJECT MANAGEMENT FOR SCIENTISTS

by Stanley E. Portny and Jim Austin

All science involves some boring, routine labor—repetitive work in the laboratory, grant writing, keeping the books, and so on—but scientific research is fundamentally creative, and often unpredictable. As often as not, the course the research takes is unexpected. A principal investigator's (PI's) central challenge is to keep the lab afloat while stimulating and supporting the highest levels of creative insight and technical innovation. Few scientists are trained to do this; with most, it comes only from experience. Some never learn to manage their laboratories effectively, and this puts them at a considerable disadvantage compared to their colleagues.

Small research laboratories have their predictable aspects; indeed, they must be viable business entities to survive and thrive. This means assuring a sufficient flow of funds to attract and keep top-notch staff, as well as to obtain and maintain the required facilities and equipment. Furthermore, like shareholders of a corporation, the stakeholders in a laboratory—funding organizations, host institutions, taxpayers, and so on—demand a demonstration of the value they get for the money they spend. This is especially important for the PI when the time comes to seek a grant renewal—or tenure.

Herein lies the real challenge for the small laboratory manager: How can you create and maintain an environment that allows free and unbounded creative exploration, yet assures solvency and maintains accountability to those who have a stake in the lab's operation?

The answer is effective management. You need to manage your labo-



You need to manage your laboratory the same way you do your science: boldly but methodically, with the right balance of purposefulness and opportunism.

ratory the same way you do your science: boldly but methodically, with the right balance of purposefulness and opportunism. Project management provides the tools you need to systematize the management of your laboratory, to make sure the risks you take are calculated. Best of all, you're likely to find that taking a structured approach to managing the laboratory nurtures, rather than inhibits, creativity.

### **What Is Project Management?**

Project management was created more than 50 years ago to manage technical development and manufacturing projects of great complexity. In its early days it was a highly technical field known best, perhaps, for generating reams of paperwork. Even today, many people think of project management as a series of graphs, charts, and procedures, often implemented through a software package, designed to plan and guide to completion repetitive and highly predictable work ... or—worse—to fill the empty hours of soulless bureaucrats.

Project management has evolved over the years. Today's project management is less an arcane technical discipline than a set of principles intended to provide a structured approach to making the everyday decisions that keep a business running, even a small business. Or a laboratory.

Project management begins, as it should, by defining its subject: A project, according to project management theory, is an activity with three characteristics:

- » Specific outcomes or results
- » Definite start and end dates
- » Established resource budgets

Projects can be large or small, planned and tracked formally or informally, and defined by a legal contract or an informal agreement. They can involve activities that have been performed many times before or entirely new approaches and technologies.

### **Science Projects**

At first blush the above definition of projects may not seem a perfect fit for the work that goes on in a science lab. The outcomes of a research effort often lack a precise definition. While a project might have a definite start date, an end date is rarely specified. Even when the funding ends on a specific date, it's usually assumed that a renewal will be sought. Even budgets—which are, regrettably, fixed—often seem fluid.

So how can we bridge this gap between a project's technical definition and a PI's daily experience? First, by realizing that these difficulties are not limited to science. Indeed, some degree of ambiguity exists in every project. Yet, in science as in other kinds of projects, there is value in trying to eliminate as much ambiguity as possible.

Second—and this may be the most important point in relating

project management to science—the specified outcomes, end dates, and budgets are always provisional. Project management allows—indeed, insists—that the components of a project be constantly revised as new information arises. Defining, for example, the desired project outcome means deciding what you hope to accomplish *as of now*, with the understanding that those definitions will probably change with time.

### **The Key Components of Project Management**

Project management is simply guiding a project from inception to successful completion, making coordinated use of processes and systems to guide and encourage people to successfully perform a project's work.

The three key steps of project management are:

One: Planning—clarifying:

- » Desired project outcomes
- » Stakeholders: who will be affected by, are needed to support, or will be interested in the project outcome?
- » Activities that have to be performed to complete the project
- » Dates on which each project activity will start and end
- » Budgets for all required project resources (including, but not limited to, money)
- » Significant project risks and how they will be managed

Two: Organizing—specifying roles and responsibilities for project personnel

Three: Controlling the performance of project work—including:

- » Organizing, focusing, and continually motivating project personnel
- » Tracking and comparing project work and results against the plan
- » Considering and making changes to plans when tracking suggests a change is called for
- » Keeping everyone informed of project accomplishments, issues, and changes
- » Continuously tracking and dealing with evolving project risk

Organization information systems can be used to support project planning and control, including the maintenance of records of:

- » The dates on which activities are started and completed and milestones are reached
- » The amount of work effort expended by people on project activities
- » The funds expended on project activities

Put another way: Project management expands the concept of “budgeting” to cover not just monetary resources, but other



resources such as time and personnel.

Encouraging people to perform up to their maximum potential means:

- » Helping each person to appreciate:
  - The value to him or herself and to the organization of the project in general and of his or her assignment, in particular
  - The feasibility of successfully accomplishing the project objectives
- » Regularly providing project personnel information about how their actual performance and accomplishments compare to what is planned
- » Acknowledging people's contributions to overall project success

Project plans, expenditure reports, and team meetings will not, in and of themselves, guarantee project success. 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. A project rarely sticks to a predetermined course. Projects flow and evolve; project management is a way of making sure that the key players remain motivated, and that their objectives remain aligned.

### **Key Premises That Lead to Project Success**

The greatest chances for project success are realized when PIs, acting as managers, embrace the following premises.

*Project management is a way of thinking and behaving, rather than just a way of analyzing and presenting data.* Managing a project effectively means thinking before acting, identifying and dealing with potential problems before they occur, and constantly monitoring to determine whether your actions are achieving their desired results. The goal is to internalize project management, to make it second nature, a way of thinking about the decisions you make in managing your laboratory.

*Attempting to control all aspects of a project assures the greatest chance of success, but you will never succeed at controlling everything. That's okay.* Project plans represent your current thought, at any given time, about how the goals of the project will be achieved. Even if anticipated approaches have never been tried before, it is important to describe what you propose to do, how you expect the project to unfold, and the results you hope to achieve. The less certain you are that the plan will work, the more closely you should monitor ongoing performance to identify deviations from the plan as quickly as possible. If a planned approach seems not to be working, clear choices should be made about how to modify existing plans and guide the work in new directions.

*People, not numbers and graphs, create successful projects.* The major purpose of project management is to align and motivate people and to support their decision making. It is people's creative insights and performance that will ultimately lead to project success, not a number or a graph. So keep your people on the same page, but make sure they're happy and have room to breathe.

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## LAB SAFETY REQUIRES TRAINING AND COMMITMENT

by John K. Borchardt

**W**hat can go wrong? What can I do to minimize risks of an experiment? What do I do if something *does* go wrong? Researchers need to ask themselves these questions whenever they begin a new experiment, advises James Kaufman, president and CEO of the Laboratory Safety Institute, a provider of safety training and other services to academia and industry. "The frequency of academic research lab accidents is 10 to 50 times greater than in industrial labs. So there is a lot of room for improving safety." Whereas the university can and should take very seriously the safety of their students, postdocs, and other workers, it would be foolish for those in the lab to depend on others to take care of things, Kaufman suggests. Keeping researchers safe is ultimately the responsibility of researchers themselves.

### Before You Start

Researchers, of course, often have other things on their minds—like research. Furthermore, they usually lack specific training in the difficult task of keeping themselves and their laboratories safe—especially early in their careers. It's natural for young scientists and science students to assume that the institutions where they're training will take care of them, but that's a potentially dangerous assumption. So how should people in the laboratory go about rising to the challenge of keeping themselves and their colleagues safe?

The first step should be to learn their institution's policies and practices, says Michele Johnson of the University of Utah Environmental Health and Safety Department. Johnson proposes three questions of her own that researchers need to answer before the work in the lab gets started:

- » What safety training do I need?
- » How do I get it?
- » Who do I go to if I have safety concerns?



“Researchers themselves must maintain labs from a safety perspective.”—Jim Kapin, 2006 chair of the American Chemical Society Division of Chemical Health and Safety

This last question is important because it is the key to finding answers to the first two. On some campuses, principal investigators (who rarely have rigorous safety training) have the responsibility for ensuring a safe working environment. On other campuses it is the facilities manager. Why does it matter to researchers who’s in charge? Ralph Allen, Director of the University of Virginia’s Office of Environmental Health and Safety, puts it this way: “They need to protect themselves since the lab is a place where things are inherently dangerous. So it’s important to know where to go for safety information and know whom to consult.”

### **In the Lab**

“Nine times out of 10, lab accidents are caused by operator error,” observes Johnson—and operator error, in turn, is often due to operator fatigue, inattention, or haste. Other common causes of laboratory accidents are improper use of equipment, the use of the wrong tool for the job, and poor equipment maintenance.

At the University of Virginia, organic chemistry students were storing samples they prepared in an unlabeled refrigerator that was not explosion proof. When the refrigerator exploded, the doors to the main lab were blown to the other side of the room where they hit an apparatus used to purify solvents.

There’s a happy ending. The solvent-purification setup was made of metal; similar setups, in laboratories across America, are made of glass. The metal purification system was damaged, but if it had been glass a fire probably would have resulted, causing far more extensive damage.

No one knows who chose that old refrigerator, but many people over the years—PI’s, administrators, countless students, postdocs, and other lab staffers—could have recognized the threat it posed and switched it out. But until this accident, no one did.

After the accident, the university traded out all their old refrigerators for explosion-proof models and replaced glass solvent-purification systems with metal ones. If faculty members lacked funds to replace their unsafe equipment, the university paid the tab. It took a near catastrophe to identify the problem, but the UVA is now a safer place for the workers in its laboratories.

Recognizing such risks isn’t easy, but it is essential if labs are to be safe places to work. “Researchers themselves must maintain labs from a safety perspective,” advises Jim Kapin, 2006 chair of the American Chemical Society Division of Chemical Health and Safety and senior staff scientist with Advanced Chemical Safety, a firm that conducts academic research lab safety inspections and training programs.

In a laboratory at Ohio State University, solvent bottles fell from the top shelf of a four-shelf flammable-solvent storage cabinet because the clips used to secure the shelf failed. The clips had been modified improperly, probably in the distant past by a researcher whom no one remembers. An accident had been stalking the lab ever since.

When it finally pounced a spill resulted, and the supply of spill-control agent proved inadequate to absorb the spill. Solvent vapors forced the students to retreat and the building was evacuated. An explosion and a fire followed, destroying the laboratory. Fortunately, researchers suffered only minor injuries, but the damage was extensive.

This incident demonstrates how the choices scientists make affect not just their own safety but also the safety of their colleagues, for years to come. It also shows how important—and how hard—it can be for researchers to identify unsafe conditions in their laboratory. Improperly modified shelf supports would be hard for anyone to spot in a routine inspection, but an attentive staffer might have noticed, when placing a bottle on the shelf, that the supports seemed weak or unsteady. If she had, the problem might have been solved before the accident occurred. Laboratory workers and managers—and safety inspectors—made another serious mistake, this one far more routine and easier to spot: They failed to make sure the laboratory's spill-kit was adequate for the volume of spills that were likely to occur.

### **Interdisciplinary Risk**

Interdisciplinary research labs may present more risks than labs doing work in established disciplines, says Kapin, because the range of risks is wider. “Chemists know how not to blow things up,” he notes, “but often don’t know the biological hazards of working with laboratory animals.” Mixed environments also mean more opportunities for reagents, supplies, equipment, and researchers to mix in unpredictable ways, creating new risks. The only real solution in such environments is extra vigilance. “Constant vigilance and regular inspections offer the only hope for spotting these problems,” says Kaufman.

### **Safety Glasses**

Fortunately not all safety-related judgments are hard. One thing that’s very easy to do—and that students, postdocs, and other lab workers can take responsibility for—is always wear safety glasses in the lab. Risks to researchers’ eyes, notes Kaufman, include “impact from objects such as broken glass, heat, dust, chemicals, and optical radiation.” So “researchers should use the appropriate safety glasses for the particular hazards associated with their experiment.” For more severe chemical splash hazards, Kaufman recommends wearing goggles and a face shield.

It’s important to look beyond your few feet of bench; chemicals can splash, and glass shards can fly, a long way. “You may need safety glasses, not for your own work, but for someone else’s near you,” says Allen. “So pay attention to what’s going on around you, not just your own experiments.” And always remember that safety glasses can protect you from risks you may not have even thought of—so wear them even when there isn’t an obvious reason.

In 1987, the U.S. Centers for Disease Control and Prevention issued a bulletin recommending that researchers working with monkeys wear safety glasses. Ten years later, 22-year-old researcher Elizabeth Griffin was working at Emory University’s Yerkes Primate Center. She was not wearing eye protection and a macaque monkey’s urine contacted her eye. Ms. Griffin wiped her



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eye with a wet paper towel and flushed it 45 minutes later. It was too little, too late: She contracted the herpes B virus and died within two months.

Three years later, the Coulston Foundation, which also used monkeys for disease research, was cited for lack of safety eye-glasses and other personal protective equipment. And even today, Kaufman observes, the use of eye protection “is not as high as one might reasonably expect.” The proper use of eye protection seems to depend, more than anything else, on the example set by the PI and senior lab personnel (see the related story<sup>1</sup>).

### Inspections

Frequent and regular lab safety inspections are “the only hope for spotting problems” according to Kaufman. Johnson agrees that “external inspections every six months or so are essential”—but, she says, they are not sufficient. Johnson recommends that research groups do their own internal inspections once a month, and that responsibility for those inspections be placed on a postdoc or senior graduate student rather than a PI; many principal investigators, Johnson observes, may not have enough recent experience in the lab to recognize the hazards. And just as airplanes undergo a safety check before every flight, Kaufman notes, most laboratory equipment should be safety-checked before every use.

### Training

Aren't most researchers already aware of the risks they face in the laboratory? That, says Allen, “is a dangerous assumption.” Specific training is essential; in laboratory safety, common sense can only take you so far. It is important that all incoming students and postdocs undergo safety training that goes beyond which form to fill out and who to report an accident to. “New researchers need to consult with their principal investigator to determine what specific training they need to do their research and how to get this training,” advises Johnson. They need to become well versed in the specific risks the research they'll be doing presents, and in industry-standard methods of mitigating these risks. Also, they need to know what to do whenever the most likely and predictable accidents occur.

But even this kind of training is insufficient. Researchers need to learn to improvise, and to evaluate their surroundings for potential hazards—like hazardous electrical wiring and weak shelf supports—beyond those listed in user manuals, training courses, and materials safety data sheets. Such hazards are best evaluated using common sense and an attentive eye.

“Researchers' best bet to work safely is to educate themselves about the hazards of their laboratories and know who to go to for information that they can't find themselves,” advises Kapin. “Take the time to find out what can go wrong,” says Allen. Determine “what you can do to be prepared and don't assume anyone else will be looking out for you.”

### **Reliable Sources of Lab Safety Information**

Besides your own university's safety Web site and the references your principal investigator or lab safety officer recommends, the following are useful sources of reliable information:

#### **Web sites**

- Advanced Chemical Safety<sup>2</sup>
- Lab Safety Institute<sup>3</sup>
- U.S. Department of Labor – Health and Safety Topics: Laboratories<sup>4</sup>
- American Industrial Hygienists Association – Health and Safety Committee<sup>5</sup>
- Where to find Material Safety Data Sheets on the Internet<sup>6</sup>

#### **Books**

*Handbook of Laboratory Health and Safety*

R. Scott Stricoff, Douglas B. Walters

Wiley-Interscience; 2nd edition (March 20, 1995)

*Improving Safety in the Chemical Laboratory: A Practical Guide*

Jay A. Young (Editor)

Wiley-Interscience; 2nd edition (June 1, 1991)

*Handbook of Chemical Health and Safety*

Robert J. Alaimo (Editor)

ACS Handbooks (Hardcover)

American Chemical Society Publication (April 19, 2001)

*OSHA Medical Radiation Safety Guidebook*

Bruce Gordon, Daniel Farb

UniversityOfHealthCare (July 2005)

*Safety Sense: A Laboratory Guide*

Cold Spring Harbor Laboratory

Cold Spring Harbor Laboratory Press (September 1, 2001)

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2. Advanced Chemical Safety: <http://www.chemical-safety.com>
3. Lab Safety Institute: <http://www.labsafety.org/>
4. U.S. Department of Labor – Health and Safety Topics: Laboratories: <http://www.osha.gov/SLTC/laboratories/index.html>
5. American Industrial Hygienists Association – Health and Safety Committee: <http://www2.umdj.edu/eohssweb/aiha/accidents/>
6. Where to find Material Safety Data Sheets on the Internet: <http://www.ilpi.com/msds/index.html>