Virology Laboratory Guidelines

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ABSTRACT Starting work in a virology research laboratory as a new technician, graduate student, or postdoc can be complex, intimidating, confusing, and stressful. From laboratory logistics to elemental expectations to scientific specifics, there is much to learn. To help new laboratory members adjust and excel, a series of guidelines for working and thriving in a virology laboratory is presented. While guidelines may be most helpful for new laboratory members, everyone, including principal investigators, is encouraged to use a set of published guidelines as a resource to maximize the time and efforts of all laboratory members. The topics covered here are safety, wellness, balance, teamwork, integrity, reading, research, writing, speaking, and timelines.

KEYWORDS education, training, employment, environment, mentoring, guidance, career, advice, diversity, inclusion

Leaders of virology laboratories are responsible for the safety and productivity of their workers, both of which require significant training. Most of this training is accomplished person to person and relies on oral traditions and institutional knowledge that is not always physically documented. The social distancing required during the coronavirus disease 2019 (COVID-19) pandemic of 2020 and 2021 severely hampered this type of personal training because face-to-face meetings were no longer possible. In the absence of direct instruction, laboratories require other methods to train new members. To that end, presented here are a series of guidelines for working in a virology laboratory. While geared toward colleges and universities, some of this material may be applicable to government, industry, and pharmaceutical laboratories as well. New laboratory members will find these guidelines most useful, although they should serve as good reminders for more experienced workers and even for laboratory leaders and principal investigators (PIs).

The guidelines have been constructed for distribution and implementation at the laboratory level. Larger units (divisions, departments, schools, and colleges, etc.) generally have policies covering a subset of what is discussed here. However, having unique and personalized documents allows PIs to address laboratory-specific issues as well as to incorporate their own unique mentoring style. It also allows the individualized guidelines to be posted on a laboratory Web page (either internal or publicly available) or server for easy access and updating. Our laboratory guidelines are posted on our website (http://kalejta.virology.wisc.edu), along with our diversity-and-inclusion statement (see Teamwork for Advancement, below) (Fig. 1) and land acknowledgment (a statement of recognition, gratitude, respect, and admiration for the original curators of the land that one currently occupies).

These guidelines will no doubt require modification and customization by individual laboratories prior to adoption and implementation. Laboratories are encouraged to seek out additional examples to assist in the construction of their unique and personal guidelines. Unfortunately, while there are many news articles that cover this territory (that can be found with an Internet search for “how to be a graduate student” or “how to be a postdoc”), there are fewer publications in the scientific literature. Perhaps the most comprehensive set of such publications is the “Ten Simple Rules” collection curated by PLoS
Computational Biology (https://collections.plos.org/collection/ten-simple-rules/), which is highly recommended and many of which are cited here.

An alternative, or add-on, to laboratory guidelines is "onboarding" documents. These documents collect logistical information that new laboratory members will need, such as how to obtain a company/university identification card, ensure access to secure buildings, set up payroll and benefits, obtain an e-mail address and be added to relevant e-mail lists, order research supplies, and be assigned work and storage space (laboratory bench and freezer racks, etc.). Onboarding documents can also include material covered in these guidelines, such as safety information and laboratory culture and citizenship. Our laboratory onboarding document was created by Emily R. Albright, Ph.D., and is posted on our secure server. Having documents that collect and disseminate laboratory convention and culture, along with guidance and instruction published on company or university websites or in the scientific literature (1–3), provides interfaces that are approachable after-hours, when personally convenient, and when face-to-face meetings are difficult or impossible. The topics covered by the guidelines presented here are safety, wellness, balance, teamwork, integrity, reading, research, writing, speaking, and timelines. Each is discussed below.

SAFETY FIRST

Laboratories represent significant and specialized physical risks. Furthermore, working non-traditional hours (e.g., nights and weekends) introduces additional, different risks. The foremost concern for laboratory members is their safety. All laboratory members must be given detailed instructions on how to mitigate the risks associated with their work. It is the responsibility of the PI to ensure that all laboratory members are properly trained. If the training and instructions provided regarding laboratory safety are not fully clear, ask the PI for further clarification.

All laboratory members must understand and use proper biological and chemical safety precautions. Most universities, government laboratories, and biotechnology or pharmaceutical companies maintain safety offices that provide guidance and instruction to help maintain compliance with relevant safety requirements published by governmental agencies (e.g., the Centers for Disease Control and Prevention [CDC], the National Institutes of Health [NIH], and the Occupational Health and Safety Administration [OSHA] in the United States; for other countries, equivalent local agencies with their own regulations exist). Each laboratory should generate a document listing the relevant safety offices with their contact information such as phone numbers and e-mail addresses. Furthermore, safety office Web page links should be published on laboratory Web pages or in onboarding documents so that everyone can access information regarding training, regulations, material disposal, personal protective equipment (PPE), and emergency reporting. Laboratory members will no doubt be required to complete various safety courses prior to working in the laboratory and to periodically renew those course approvals. The names of these courses, with links to the training modules, should be listed on laboratory Web pages or in onboarding documents.

Individual laboratories maintain separate, specific biosafety protocols in addition to
the general information offered by safety offices. Hard copies of the protocol should be made available in the laboratory, and an electronic copy should be made available on the laboratory Web page or server. The PI should ensure that all laboratory members read and comprehend the laboratory biosafety protocol. All new laboratory members should receive PPE and individual training from more experienced members, especially for handling virus and virus-infected cells. Laboratory members should not perform experiments alone until properly equipped and trained. If, for any reason, a laboratory member does not feel comfortable and confident in knowing and mitigating the biological and chemical safety hazards of their experiments or how to report accidents or spills, they should contact the PI immediately. Furthermore, if a laboratory member observes any conduct in the laboratory that they feel does not meet the precautions described in the laboratory biosafety protocol, they should promptly express these concerns to the PI.

In addition to laboratory safety, personal safety while at work is often addressed by work site police departments, especially on university campuses. There are likely additional safety resources at work, including student welfare offices and safety-specific news feeds. Each laboratory should identify and post, on websites or in onboarding documents, all the safety resources available to laboratory members, ensuring that these documents include relevant and current contact information and hyperlinks. The PI should encourage all laboratory members to familiarize themselves with safety resources and to use them when appropriate. In addition to normal safety considerations, there are situations where additional or alternative safety precautions may need to be enacted. A prime example is the COVID-19 pandemic. When such situations arise, look for additional safety resources, and update websites and onboarding documents accordingly.

WELLNESS ALWAYS

Laboratory work is demanding and stressful and can adversely affect one’s physical, mental, and emotional health and wellness. Wellness is a dynamic process of growth and change toward the goal of a healthy, productive, and rewarding life. Issues that subtract from an individual’s wellness can become impediments and obstacles to success and fulfillment both inside and outside the laboratory. Laboratory PIs should be aware of, and encourage laboratory members to use, wellness resources offered by the employer. Contact information and hyperlinks for wellness resources should be identified and published on laboratory websites or in onboarding documents. Laboratory members seeking guidance for wellness issues are encouraged to openly discuss their situation with their PI (if the laboratory member feels that the PI would be receptive). If the problem is with the PI, or if the laboratory member desires outside or anonymous assistance, they are encouraged to consult employee ombuds offices or another similar office whose mission is to provide free and confidential guidance regarding workplace concerns. Finally, many wellness resources can be found online (search “wellness”), and a few relevant articles on wellness have been published (4, 5).

BALANCE FOR ACHIEVEMENT

Scientific research takes considerable time and effort. Normal workweeks in the United States are considered 8 h a day (e.g., 9:00 a.m. to 5:00 p.m.), 5 days a week (e.g., Monday through Friday), and may be different in other countries. New laboratory members are often required to be present during normal work hours so that their techniques can be monitored for safety and effectiveness and to promote interactions with other laboratory members and the PI. More experienced and well-trained laboratory members have additional work hour options (evenings and nights) that can accommodate different schedules, although there will be times and reasons (laboratory meetings or seminars, etc.) where laboratory attendance during normal hours is mandatory.

Often, laboratory personnel will work nights and weekends in addition to normal work times. Working more than the customary 40 h per week is not mandatory but is
often encouraged because it accelerates both the pace of discovery and advancements to measurable benchmarks (e.g., publications, degrees, and job offers). Working at night can significantly shorten the time in which experiments can be completed. Working on the weekend allows novel ideas or techniques to be tried at a leisurely pace and in the absence of interrupting meetings, classes, or seminars. The motivation to work additional hours should come from within, from an innate desire to better understand the biological problem being investigated and the practical ambition to learn, achieve, and advance one’s career. Laboratory members should not feel pressured to work nights and weekends by the PI or other laboratory members and should discuss any feelings of coercion with relevant employee resources, for example, a department chair or an ombuds office. (More information about laboratory balance can be found in reference 6.)

For industry, government, and university employees, vacation, personal holidays, sick days, and maternity or paternity leave are generally spelled out in employment contracts and must be honored. However, graduate students and postdocs often do not have defined allowable periods for such times away from the laboratory. The laboratory PI, in consultation with department or employer administration, should define the number of days of vacation, sick leave, and maternity/paternity leave allotted to graduate students and postdocs and post this information on laboratory websites or in onboarding documents. The number of days should be comparable to what employees receive. In the United States, this might be 2 weeks of vacation per year, 12 sick days per year, and 6 weeks of maternity/paternity leave, all with full pay and benefits. These leave times should, of course, be in addition to normal, officially recognized holidays and may be different in different countries. Laboratory members should be encouraged to discuss any questions regarding leave times with the PI.

TEAMWORK FOR ADVANCEMENT

Laboratories are at their best when each member provides their individual commitment to the group’s effort. When laboratory members work together toward a shared, common vision, the group’s accomplishments will far exceed what any one person could do on their own. Remember, no single laboratory member is as smart as the combination of all laboratory members together, and everyone needs help to reach their goals. Teamwork can be exemplified in many ways. First and foremost, be aware of what others are doing. Encourage their pursuits, applaud their efforts, support their struggles, and acknowledge their success. Silence is the enemy of teamwork. Laboratories should establish defined lines of communication, both in person and electronically (7). Communications with each other must be free, honest, constructive, timely, and designed to build up and not tear down. It is important to remember, when giving or receiving critiques, that people are not criticized, but experiments, data, and conclusions are criticized to make them better.

All laboratory members should strive to be good laboratory citizens by returning reagents to their proper places, keeping common areas clean, doing their laboratory jobs faithfully, actively participating in laboratory meetings, and ordering supplies before they completely run out. Always respect other people’s experiments and their use or reservation of common equipment. Be sure to inform the PI or proper authorities of any misconduct that you witness (if you see something, say something). For research misconduct, inform the PI or the department chair. For criminal activity, inform the local police department. Hate or bias incidents should be reported to police departments or human resources.

The PI should encourage laboratory teamwork by ensuring that critiques from peers or mentors are constructive, insisting on and acknowledging good laboratory citizenship, and explicitly stating that bullying, discrimination, and sexual harassment are strictly forbidden in the laboratory. All laboratory members should agree to adhere to their laboratory’s accepted code of conduct. The PI can foster a welcoming laboratory environment (8) by constructing (ideally in cooperation with laboratory members) and publishing (on the laboratory website or in an onboarding document) a diversity-and-inclusion statement (a declaration of a group’s commitment to building and maintaining a welcoming, all-encompassing work environment). An example derived from our laboratory’s diversity-and-inclusion statement (http://kalejta
Team-building activities outside the laboratory (e.g., nature hikes, bowling, and parties to celebrate published papers, etc.), while respecting laboratory members’ free time and other commitments, can help build a cooperative laboratory culture.

In addition to the importance of intralaboratory communication, interlaboratory communication can help form collaborations and build connections. Collaborations are becoming more important as the interdisciplinary nature and complexity of scientific research increase. Furthermore, as team science becomes more prominent, displaying an ability to work and thrive in a group undertaking is emerging as a consideration in job offers and promotion decisions. Effective collaborations, whether with another laboratory member or another unit in your department or a national or international collaboration, all have shared characteristics (9). Good collaborations have defined goals, specific delegated responsibilities, and expected outcomes. Ideally, these are codified in writing (such as a letter or an e-mail). It is important to discuss publication strategies and authorship inclusion (and order) early in a collaboration and to have a plan to resolve differences. Communication is important, of course, and it should be regular, honest, unambiguous, and empathetic.

Collaborations outside a laboratory or institution are often established within one’s network of contacts. Establishing such contacts (networking) is a career-long activity that often is not easy or enjoyable for novice or introverted scientists. Conferences provide numerous opportunities to network, including coffee breaks, meals, poster sessions, excursions, and evenings at the bar (if this is not your scene, you can take a friend with you, and leave early). If you have someone who you specifically want to talk with or meet, grab the first opportunity to do so (you might not get another chance), or set something up beforehand with an e-mail. Do not be afraid to approach the leaders in the field, but be prepared when you do so. Be respectful and polite. Tell them something specific that you like about their work, and ask them a specific question. Tell them about your skills, confidently but humbly, and invite them to your talk or poster, all of which help them view you as a new colleague. Be brief (if the situation requires brevity), and follow up after the conference with an e-mail, but do not wear out your welcome. Importantly, do not just confine your networking to the leaders in the field or to PIs, but also network with students and postdocs (they are the future of your field and can introduce you to their networks) and in all areas of science (academics, government, industry, and publishing). The goal is to create a large and diverse network of contacts who may someday become your collaborators, colleagues, or employers.

While conferences are great places to network, they are certainly not the only places to do so. Department seminars with invited outside speakers are great places to network. Usually, specific time slots (often lunches) are purposefully set aside for speaker meetings with students and postdocs. Take advantage of them both for actual networking and as practice for networking at conferences (and for job interviews). Additionally, committing to volunteer or leadership positions in professional societies is a good opportunity to build important and lasting connections. Finally, social media has revolutionized scientific networking. The rapid evolution and constant change of social media platforms preclude an in-depth discussion here, except for one word of caution: think before you post! More information and advice about scientific networking are available online (e.g., see https://crosstalk.cell.com/en/cell-mentor and https://www.sciencemag.org/careers).

INTEGRITY OF PURPOSE

The scientific method (https://en.wikipedia.org/wiki/Scientific_method) is built on observation and experimentation to test a hypothesis, not to prove a predetermined model. Always remember that the goal of research is to understand biological truths, not to show that an idea is correct. To reveal biological truths, all laboratory members must work with honesty and integrity. Scientific misconduct of any kind will never be tolerated and will ultimately result in dismissal. Research misconduct does not include...
Research misconduct is officially defined by the U.S. Department of Health and Human Services Office of Research Integrity (https://ori.hhs.gov/definition-misconduct) as fabrication, falsification, or plagiarism in proposing, performing, or reviewing research or in reporting research results. Fabrication is making up data or results and recording or reporting them. Falsification is manipulating research materials, equipment, or processes or changing or omitting data or results such that the research is not accurately represented in the research record. Plagiarism is the appropriation of another person’s ideas, processes, results, or words without giving appropriate credit.

Examples of fabrication include generating line or bar graphs from data that do not exist. Examples of falsification include image manipulations (splicing together different images to represent a single experiment, changing brightness or contrast in only part of an image, or concealing part of an image), removing outlying data points, and selecting data points or images that are not representative of the experiment or experimental series. Examples of plagiarism include copying word-for-word from a previous publication and failing to reference prior relevant work.

Scientific misconduct is often reported to be motivated by career pressure. Careers advance upon publishing high-profile papers (e.g., in journals with high impact factors), which can lead to external or internal pressure to fabricate or falsify results. If such pressures tempt you toward scientific misconduct, talk with your PI or department chair (if the pressure is coming from your PI). Know that most journals now routinely screen submitted images for evidence of manipulation, and many require all primary data associated with a paper to be publicly available in a data repository. The motivation to work with honesty and integrity should be the love of science and the desire to seek the truth, but know that with the ever-evolving forensic tools and increased scrutiny of scientific research, it is now inevitable that if you cheat, you will get caught, and it will end your career.

Scientific misconduct is often detected by colleagues (fellow trainees or supervisors) with knowledge of experimental protocols and access to primary data. Colleagues who suspect scientific misconduct are encouraged to report their concerns to the PI or, if it involves the PI, to the department chair. Universities or companies may also have offices or other mechanisms for reporting scientific misconduct, and these may vary by country. All suspected instances of scientific misconduct are taken seriously and investigated thoroughly, and confirmed cases are handled appropriately (education and training for mistakes in good faith and dismissal for knowing acts of misconduct). Many organizations now offer or even require that employees complete ethics training courses, either online or in person. The PI should ensure that all laboratory members complete the required ethics training.

Finally, sustained governmental funding of scientific research requires public confidence in the research record and in the processes through which it is generated. Any conduct that erodes public trust or contaminates the research record diminishes us all. The PI should insist that all members conduct their research with honesty and integrity and avoid any instances of scientific misconduct. An annual reminder at a laboratory meeting and a declarative statement on a laboratory website or in an onboarding document are ways that the PI can communicate their insistence on research integrity.

READ DEEPLY AND BROADLY

Reading the scientific literature is critical for developing hypotheses, learning new techniques and approaches, and expanding your scientific thinking (11). It should start with the literature generated by one’s own laboratory and then expand on to collaborators, colleagues, and competitors. Laboratory members should read deeply about their own specific projects and closely related fields. Review articles are good introductions, but primary research articles must be read and critiqued (and cited in publications). Reading deeply in one’s field is required, but one should also read broadly to learn about new areas, generate new ideas, and view one’s own project from a new perspective.

To identify papers to read, arrange to have prominent, broad-spectrum, high-impact
journals, as well as specialty journals within your field, e-mail you when a new table of contents is published. Similarly, you can arrange to get updates from PubMed or Google Scholar based on submitted keywords. Periodic, manual searches of PubMed also work and can be initiated when you have time to track down and read the papers. Social media is becoming an increasingly viable way to identify new and noteworthy papers.

When reading a paper, start with the title and abstract to get an idea of what the authors believe that they have shown. Next, read the introduction to make sure that you have the background to understand the authors’ hypotheses and approaches. Spend the most time on the results section, with most of that time spent examining the data. Read the text of the results so that you know what was done and what the authors’ conclusions are, but be sure to look at the data yourself, make up your own mind, and draw your own conclusions. Read the discussion, which should integrate the findings into the current paradigm and look to the future, but know that it will often be mostly the authors’ opinions and speculations. Look at the materials and methods (or the figure legends) to understand how the experiments were performed and if you need specific information (viral strain and primer sequences, etc.). Keep notes on the papers that you read, indicating hypotheses, methods, and conclusions. Share outstanding or controversial papers with your colleagues. Establish journal clubs to stimulate your reading and hone your critiquing skills. Apply what you have learned from reading the literature to your project.

**RESEARCH DESIGN AND METHODS**

Laboratory experiments must be designed to test a hypothesis, not to prove a specific model (yours or your PI’s). They must always have proper scientific controls (https://en.wikipedia.org/wiki/Scientific_control), both positive controls (something that you know will provide the expected result) and negative controls (something that you know will not provide the expected result). The best experiments are quantitative and analyzed for statistical significance (12, 13). Experiments must be repeatable. At least three independent experiments are required (three biological replicates—a completely separate experiment performed on a different day). Whenever possible, perform more than one type of experiment (e.g., use a small-molecule inhibitor and separately use RNA interference to decrease the activity of a protein) so that hypotheses can be tested in more than one way, providing a robust approach.

Experimental write-ups should be generated in advance so that you understand not only what you are doing but why you are doing it and so that you can be sure that all the reagents are available, the proper controls are included, and obstacles, potential results, and future directions can be anticipated. These write-ups should state the general hypothesis, the purpose of the experiment, and the expected outcomes. The rationale for the experimental design (virus strain, multiplicity of infection, cell type, and drug concentrations, etc.) and the supporting precedent or literature need to be listed. The reagents needed (primers and antibodies, etc.), with identifiers where appropriate (manufacturer and catalog number, etc.), and methods used (quantitative PCR [qPCR] and Western blotting, etc.) should be listed. Make sure that you understand why every step of the protocol is necessary and the purpose of every reagent that you use. This type of understanding is critical for both interpreting results and troubleshooting when things go wrong. If you do not understand everything about your experiment, ask someone who does. The positive and negative controls should be specified. Sample tubes should be labeled with the date and a specific identifier (not 1, 2, and 3, etc.). Finally, the outcome of the experiment should be listed, along with any conclusions, future directions, and troubleshooting comments.

These experimental write-ups will form the basis of your laboratory notebook, which must be detailed, accurate, and current. All entries should be dated and written in the language of the laboratory. This record will be used by you to repeat and troubleshoot experiments and to generate figures as well as materials and methods sections for papers. It will be used by others in the laboratory to repeat your experiments and to model their own new experiments after yours. Include not only what you did but why you did it (the thinking,
rationale, and hypothesis behind the experiment). Presenting representative data accurately is extremely important, so having a meticulous record of your experiments is necessary. Many journals are now requiring that all primary data associated with a paper be deposited in a data repository and be freely available to the scientific community and the general public. Therefore, saving data from all biological replicates in an annotated format is critical. At regular intervals (e.g., monthly), copy files to shared laboratory servers. Organize these files in such a way that someone other than you can understand them. Make sure that you list not only the reagents that you used but also where they can be found (−80°C freezer or refrigerator, etc.). Remember that your laboratory notebook is the property of the laboratory and will remain with the laboratory when you leave. Therefore, you should make personal copies of all your protocols and reagent lists.

**WRITING IS FOREVER**

Write accurately, succinctly, boldly, and in the active voice. For example, write "virus X kills cell Y" instead of "cell Y is killed by virus X." Accuracy is required because a major goal of scientific writing is to allow others to understand exactly what you did so that they can repeat your work and debate your conclusions. Therefore, your write-ups of results, figure legends, and materials and methods should leave absolutely no ambiguity or confusion as to what you did, how many times you did it, and what results you obtained. Your writing is an eternal record of your research that must stand on its own without you there to defend it, and you have only one chance to get it right! Your writing must be detailed, complete, and correct. Brevity is required to showcase the most important parts of your work so that they do not get lost in lengthy prose. Writing succinctly is difficult and takes practice. Most scientific writers, whether a novice or a professional, are often able to return to a written piece the next day and cut it by as much as 30% without sacrificing accuracy or appeal. Boldness is required to make your work interesting, provocative, and memorable and your writing style personal and unique. Bold writing is eloquent and articulate, not arrogant or vain, and for the reader should be intellectually challenging, persuasive, and even inspirational.

Titles must grab the reader’s attention and make them want to explore further. Are they going to attend your talk/poster or go get a coffee? Will they click on the link to your paper or keep scrolling through the journal’s table of contents? From your title, people will decide (rightly or wrongly) whether your work is a complete story or a work in progress, mechanistic or descriptive, important or mundane, groundbreaking or incremental, novel or derivative, and, ultimately, worth their time or not. Abstracts need to quickly convince readers of the importance of your work. You have 30 seconds of their undivided attention. Give them enough background and detail so that they understand what you did and why you did it, but also convey why you are excited about the work. The emotion generated by your abstract could be the difference in whether you are giving a talk or a poster at a meeting or whether an editor will send your paper out for review or reject it on the spot.

Grants need to make sure that the reviewers know exactly what you will do and convince them that you can do it. Most importantly, grants must persuade reviewers that what you are proposing absolutely, positively needs to be done and that you are the perfect person to do it or, better yet, the only person who can do it. The “why” is much more important than the “what” and the “how,” although those things are certainly necessary. Provide reviewers with the context that they need by telling them what is known, what are the gaps in our knowledge, why it is important to fill those gaps, and how you are uniquely qualified to do exactly that. Grants test hypotheses. Make absolutely sure that reviewers can locate and understand your hypothesis, realize why testing it is important, and follow how you will test it. Tell the reviewers what you will do if your hypothesis is correct and what you will do if your hypothesis is wrong. Finally, make sure that reviewers see the paradigm-shifting potential of your proposed work and how someday the outcomes will be described in a science textbook (14). Sell your ideas, your vision, and your abilities (Table 1).

Papers are permanent, everlasting proof that you existed and excelled as a scientist.
Writing papers is arguably the most important thing that a scientist does. If the data that you generate are not viewed or appreciated by others, then they never really existed. When writing a paper, first develop the data set, including figures, tables, movies, files, and other relevant modalities. Define the narrative or story that your data set tells. Write the results section succinctly and accurately. Decide if you need additional experiments to complete the story. Tell readers exactly what you did and exactly your results, because these two things will always be correct and unassailable. Next, tell them what you conclude from the data. The conclusions that other people make from your data may be different than yours, and your conclusions may change over time based on new data or an evolved understanding, but you need to state your current conclusions with conviction. Next, write the introduction. Tell readers what they will need to know to understand the importance and significance of your work. Write the discussion succinctly but boldly, looking both backward, by describing the issues that your work solved (without simply retelling the results), and forward, by stating the exciting new questions that your work revealed. Admit limitations, but focus on strengths and potential. Finally, write the title and abstract, accurately, succinctly, and boldly. Make people want to read what follows (15–17).

**SPEAK TO INSPIRE**

Presentations are your time to shine and your time to show people the fruits of your hard work. Initially, they are daunting and cause anxiety, but the more talks you give, the more comfortable you will become with telling your story (18, 19). And be sure to present to your audience a story and not just a collection of experiments and cartoons. You must tailor your talk to the specific audience based on their previous knowledge. Are they virologists, molecular biologists, or high school students? Do they work on something similar to you or something completely different? Are they considering you for a job or just there to hear great science? As you speak, engage your audience with eye contact, voice inflection, and movement. Speakers who stare at their notes or the screen, talk in a low monotone, and hide behind the podium rarely convey their messages effectively. The best talks are based on high-quality data. Remember, a slick presentation will never make bad data look good (so spend most of your time at the bench generating great data), but a poor presentation can make good data look bad. Show mostly primary data and save the cartoons for models, summaries, and conclusions. Make sure that your images and text are visible from the back of the room (by the eyes of an emeritus professor, not a second-year graduate student). If you can, go to the room, project your slides, walk to the back, and see for yourself.

Stick with one major concept per slide, and do not make slides too busy with crammed figures or jammed text. Slide headings should be declarative statements (X needs Y to accomplish Z), not descriptive (analysis of X and Y during process Z) and not questions to be answered (Does X need Y to accomplish Z?). Good talks start by

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<td>Tip</td>
<td>Describe the quality of the training environment</td>
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**TABLE 1** Tips for writing graduate and postdoctoral fellowship applications

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<td>Tip</td>
<td>Always have future directions; show the reviewers where you are going</td>
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<tr>
<td>Tip</td>
<td>Describe the quality of the training environment</td>
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telling the audience what you are going to tell them, continue by telling it to them, and end by telling them what you told them. Impress your audience with the quality of your work, not the quantity. In a talk, less is usually more. Always adhere to your time limit. Nothing is worse than a scientific talk that never ends. Leave the audience wanting more. Be personable. Make the audience feel smart. Allow them to like you. Teach them something.

GENERALIZED TIMELINES

Tables 2 and 3 present milestones that laboratory members should strive to achieve in the noted time frames. These time frames are based on laboratories in the United States and may be different in other countries. Furthermore, remember that everyone is different, and every project and career is different, so use these as guidelines, not demands. Do not compare yourself with others, but ask yourself if you are giving your best effort and focus and utilizing the training and guidance provided by the PI and other members of the laboratory to the best of your ability.

CONCLUSION

Individual virology laboratories should modify and use guidelines such as these as
they see fit. The desire is simply to have a readily available document, specific for each laboratory, that covers necessary logistics, safety, expectations, and laboratory culture. Such documents should supplement, not replace, personal, face-to-face meetings, instruction, and training.

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REFERENCES


