Training the kit generation

Young scientists must learn not just how to use a kit, but how it works.

Modern molecular biology would be impossible without commercial kits. Countless scientists find these prepackaged protocols indispensable for such workaday tasks as amplifying DNA, isolating plasmids, extracting RNA and purifying protein. The sheer number of experiments that one scientist alone can perform has thus skyrocketed. Kits break down the barriers to daunting experiments, allowing scientists to venture beyond their training. They also standardize procedures, allowing results from different experiments to be more effectively compared.

Ready-made experiments are a relatively recent phenomenon. Before the availability of kits, researchers had to buy—or produce—particular enzymes and make their own buffers. Because every process was so labor intensive, the purpose and necessity of each step was heavily scrutinized. Even as senior scientists acknowledge benefits of kits, including massive time savings and easier access into complex biology, they decry kits as dulling the scientific skills they hope to instill in their trainees. The use of kits is blamed for undercutting researchers' ability to recognize artifacts and for making young scientists more inclined to trust their results than to question them.

A summer undergraduate program in synthetic biology at Johns Hopkins University is a good example of how to keep kits from luring young scientists into complacency. Students start by "roughing it," going through procedures without using kits, getting a sense of just how many components might actually be in a prepackaged reagent tube. They also read the patents upon which kits are based, an exercise, says program advisor Jef Boeke, that has led to modifications of the protocol that have improved products' performance.

Unfortunately, time pressures often sideline such training. Graduate students and their advisors are all too eager to get to work on projects that will lead to publications, and doing that does not necessarily require an understanding of what Reagent A is made of, let alone why chilled Buffer B should be added to Tube C, or why Tube D should rest in a heated water bath for at least half an hour.

But even if such knowledge will not make an obvious difference to the results of a particular experiment, mentors should insist that their trainees acquire it. Any self-respecting scientist should be able to say what is happening at every step of a protocol. How else can a researcher troubleshoot or optimize methods for a specific application? There is even a case to be made for performing some experiments without kits. Nontrivial knowledge and intuition comes with watching transformations at each step, yielding an understanding of which steps are robust, what should be emphasized and what shortcuts can be taken.

Kit manufacturers also have a duty to scientists. Many companies provide clear, thorough information; others could do better. Supplying kits is a competitive business, of course, and so companies understandably need to hold on to some secrets. But the risk of withholding information is also real. Literature supplied with the kit should explain not only what to do at each step but what is happening and what the reagents are. Better descriptions will engender scientists' trust, promote the development of better protocols and lead to repeated sales. When deciding which kit to purchase, scientists should consider the quality of information in the manual and troubleshooting guides. Arguably, reading such information is as important as following the peer-reviewed literature.

Puzzling through a kit's protocol may delay the first experiments, but the gain in understanding is well worth it. Labs that initially set up a methodology and subsequently turned to kits use them far differently than labs that have not developed methods themselves. Experimenters may run samples through the relevant buffers twice, for example, or lengthen the incubation periods of certain steps. Such productive tinkering is impossible without a thorough understanding of the processes involved. This understanding is also essential to training the future generation of methods developers. Researchers who have had to use several alternative methods and done a lot of troubleshooting are likely to have a better sense of how to improve a methodology or develop an alternative approach.

Even when delving into a protocol does not lead to the development of new methods or bring faster or more sensitive results, researchers who understand kits gain other prizes: the security to trust their results, and a deeper understanding of biology. Ultimately, science will move forward faster when scientists know how experiments work outside the box.