Encouraging innovation

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ABSTRACT **Innovation is central to the scientific endeavor, and yet the current system of funding in the United States discourages innovation, especially in the young. Subtle alterations to the funding system, guided in part by the success of the European Research Council, could have major effects on encouraging innovation.**

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When scientists sit around and talk about the current funding system, they will tend to say that it is broken. One particular problem is that it no longer encourages sufficient innovation. Beginning scientists feel they must build on their postdoctoral work, which forces them to continue along well-trodden paths. If they manage to establish a lab, they tend to get trapped in a cycle of renewals driven by detailed progress, and it may be years before they are able to take off in truly new directions. Meanwhile, publication in top journals tends to encourage the next obvious step rather than truly groundbreaking discoveries.

About a year ago, I wrote an editorial in *Science* in which I discussed the issues of how to fund innovative science. In it, I proposed the idea that all starting investigators should be funded based on track record and innovation. The central idea was innovation and creativity should become central to new investigator funding. Because this would not jibe with established investigator criteria, in which progress on research funded by a prior grant is an important criterion, new investigator awards would have to go through a separate funding stream, wherein reviewers are trained in recognizing and rewarding true innovation. I have floated this idea with postdocs and graduate students during seminar visits to the United States and have been met with enthusiasm. Imagine if the last postdoc years were spent not talking about how to get enough preliminary data but about innovative ideas.

One of the main problems associated with such ideas is how to fund them. One idea would be to use the Pioneer Award system. However, there are currently about 50 Pioneers per year, and this would clearly not be sufficient; also, the Pioneer awards seem to have been diverted to funding well-established principal investigators (PIs). I discussed this idea recently with Tim Mitchison when he visited Dresden, and he suggested that an innovator-friendly system could be build around the current K99 award system. The K99 system as it currently stands suffers all the problems of the R01 system. It requires preliminary data and discourages innovation. What about turning the K99 system into an innovator award system? The idea is that, after two to three years, postdocs who want to try the academic professor route would apply for an innovator K99 award. Success would be based on track record from their PhD and early postdoc work and innovation as manifest in their own ideas. True innovation would likely require that these ideas depart radically from their current postdoc projects but could also be linked if they depart from the direction of their current labs. A separate study section would be ideal for reviewing such proposals, with a broadly constituted panel selecting the best candidates from the whole spectrum of basic biomedical science. As with current K99s, there would be a review after a couple of years, and a bigger award would kick in if the postdoc had a job. I suggest it would work best if this second phase were peer-reviewed by the original panel, made truly competitive (e.g., with a success rate of ~50%), and unlocked an R01-sized budget for four years. A competitive second stage would allow the agency to focus second-stage funding on the proven innovators and get them off to a strong start. Awarded K99s already make a postdoc more attractive to departments recruiting junior faculty. Receipt of an innovator K99 would likely be a more potent qualification. This system would, of course, require that PIs allow postdocs to spend the last one to two years in the lab developing in their own direction. Not every PI would want to do this, but ambitious postdocs would select those with a track record. The innovator K99 would have to carry sufficient supply budget that the PI did not need to subsidize the research. One could imagine institutions competing by providing additional funds or special programs to bring together and support aspiring postdoc innovators—the Bauer Center for Systems Biology at Harvard is one such example. Indeed, the National Institutes of Health has a kernel of such a system in the

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Abbreviations used: EMBL, European Molecular Biology Laboratory; ERC, European Research Council; PI, principal investigator.

Early Independence Award, but here again, very few of these are available.

Why is it so important to shift to an innovation-based system, when the R01 system has been such a powerful engine of discovery? The year 2013 again saw three National Institute of General Medical Sciences–funded R01 recipients awarded Nobel prizes. I think it is for the following reason. After the molecular biology revolution, we are in a position to understand the protein mechanism underlying various biological problems that had been described in the previous 100 years. Although challenging, the directions and methodologies were pretty clear. Genetics played a huge role, coupled to the biochemistry and structure of individual proteins and their complexes. Because there were a large number of already-described processes, the system could continuously expand over ~50 years to fill all those niches. Now, however, the molecular biology revolution, with its associated cataloguing of gene function, is approaching maturity. The current Nobel prizes are being awarded for science done decades ago. To understand how cells and organisms function, biology must now branch out into new areas, incorporating physics, chemistry, and engineering. Perhaps we also need a new wave of descriptive research to define new problems—it is not clear that the classic descriptions were exhaustive. No one knows the right way ahead, but each new laboratory should be a small experiment in that direction. And exploration requires innovation.

Many of my ideas for improving the lot of young scientists in America come from my experience with the European system. When the biological sciences community in Europe was trying to free itself from the shackles of the past, it set up the European Molecular Biology Laboratory (EMBL). EMBL then created a group-leader system in which, apart from a few senior scientists to provide some stability, new researchers were directly funded for up to nine years to do as they pleased, before being required to move on to a senior job elsewhere. Because the junior group leaders received direct funding, this meant they were not competing with the seniors for funding. They were spared from competition throughout their junior faculty years and only had to compete with peers once they became tenured faculty members, in most cases. The seniors could relax and mentor the juniors, because their own funding was secure, and they were not competing with the juniors. This model was a success, in large part because this type of funding encouraged a focus on innovation, but also because it provided a separate funding stream in Europe for starting scientists.

Analogous thinking was beginning to take hold at other European institutions and funding agencies. For instance, my current institute in Dresden, the Max Planck Institute for Molecular Cell Biology and Genetics, was set up along The EMBL model, and other institutes in Europe, such as the Research Institute of Molecular Pathology in Vienna, were also early adopters. But in 2007, the European system moved an important step further with the introduction of the European Research Council (ERC). The ERC currently runs a pan-European competition that in 2012 funded 536 proposals after receiving more than 4700 applications from beginning group leaders, with each grant lasting for five years for as much as €1.5 million per year. This grant program is targeted to providing additional opportunities for young investigators who are "making the transition from working under a supervisor to being independent researchers in their own right" (http://erc.europa.eu/starting-grants). A crucial aspect of the ERC is that the reviewing criteria specifically focus on novelty, interdisciplinarity, and high-risk/high-gain research. The ERC runs separate competitions to fund intermediate-career investigators (called consolidator grants) and established investigators (senior grants). The ERC has not made the leap to fund independence at the postdoctoral stage. This would be an excellent addition to the program, although perhaps less important than in the United States, because of the role of institutes like EMBL in nurturing young talent and because of other postdoctoral programs funded by the European Union, such as the Marie Curie awards. Of course, there are still major problems in European funding. Too many scientists are not funded by these mechanisms, funding in different countries in Europe is very unequal, and getting more so, and there are challenges in moving from a starting to a senior position. Nevertheless, the fact that the ERC is now seen as a badge of success is forcing all funding systems to reexamine their models.

If we look back at 500 years of science, it is clear that innovation came mainly from the young. Anecdotally, this historic trend seems to have been reversed in U.S. biology in recent decades. We see new ideas mainly coming from long-established PIs. Surely this reflects the fact that only established scientists now have the freedom to innovate, and the young have been straitjacketed and blinkered by a jobs and funding system that rewards me-too research. Only by providing our new group leaders with real freedom to maneuver can we sow enough seeds to find the right way ahead. I believe that dedicated funding sources for young investigators that cater to their needs and encourage innovation instead of punishing it would go a long way to bring back innovation by the young and therefore to science as a whole.