Cell Stem Cell
Forum

Dear Student: Stem Cell Scientists' Advice to the Next Generation

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For the field of pluripotent stem cell biology to realize its promising future, current researchers will need to pass the torch to new generations. We asked a group of successful scientists in this area, "What advice would you give a young person considering a career in stem cell research?"

> "Besides lending great worth to a scholar's life, leaving spiritual progeny has undeniable social value, and is ennobling work."
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> —Santiago Ramón y Cajal, Advice for a Young Investigator (Ramon y Cajal, 1897)

As traditional disciplines such as cell and developmental biology, embryology, cancer biology, and molecular biology grow, they inevitably meet and create new disciplines. One of these new disciplines—stem cell biology—is characterized by its young age and transformative influence on the biological sciences. While research into pluripotent stem cells is remarkable for its rapid growth, it is also marked by ethical and political controversy. Scientists considering careers in embryonic stem cell biology not only had to weigh the uncertainties of jumping into a touchy area of biology, they had to contend with the vagaries of a vigorous and extended public debate where supporters sensationalized and opponents demonized their research. The prospect of policies that would criminalize or restrict certain types of stem cell research raised profound questions about the field's sustainability.

In academia, stem cell research has quickly become institutionalized. Research universities seized the opportunity to raise funds using stem cell and regenerative medicine imprimaturs. Buildings were raised, faculty recruited, and departments created. Establishment of a new field, however, requires that it be professionally immortalized by training students and fellows who then go on to further build the discipline. This is a deliberate process tied to funding, sociopolitical factors, laboratory environments, and curricula. In the face of unprecedented excitement and uncertainty, we asked 38 established stem cell researchers (see Table 1) a question designed to tap their expertise: "What advice would you give to a young person (student/postdoc/trainee) interested in a career in stem cell research?" We chose our interviewees based on the focus of their research and their stature in the field, and all but one had used human pluripotent stem cells in their research. To help young scientists shape their nascent careers, we talked to these working scientists about how they factor in their past and present experiences, and how they gauge these against the uncertainties of the future. We also addressed what is perhaps the "million dollar" question: would scientists who navigated the tumultuous development of stem cell research encourage a new generation to enter the fray?

Details about the interview process and approach are available in the Supplemental Information and Scott et al. (2011). The answers that we received spanned topics related to stem cell researchers' professional activities, their choices in research, and their relationships with ethics and policy. Taken together, these interviews provide young stem cell scientists with unique resource: an indication of what it takes to build a career in stem cell research, coming directly from well-established experts who have been successful themselves.

The Experts' Advice

Overall, the answers we received to our interview questions fall into two major thematic areas (see Figure 1). In one category, which we call "anticipation," scientists discussed their advice for trainees in reference to uncertainty about the future—namely, the future of political, regulatory, and funding environments. The second category, labeled "virtues and practices of scientists," includes advice about what values a scientist ought to embody and what a good scientist ought to do.

Anticipation

Anticipation is a vital element of science and science policy (Adams et al., 2009). Anticipating the future is a way that scientists minimize uncertainty in order to stay prepared and productive. Yet, scientific research is, by nature, poised on the edge of what is knowable. Anticipation means that scientists acknowledge future uncertainty and deal with it in the present so that their decisions and actions can manifest the future. This "moral economy" of uncertainty has played out for stem cell science through years of changing regulation, funding, and discovery.

It is notable and even surprising, then, that the stem cell scientists we spoke to were largely optimistic about the future of the field and the careers of its trainees, despite their own experiences with tumultuous policy and funding climates. One senior scientist described the present moment in stem cell science as a revolution of thinking:

> This would be my message: we are in the middle of a revolution of understanding about human development… and that it *only* exists because of having [pluripotent] cells… It's a complete renaissance of thinking, just because these cells are available. [Emphasis in original.]

The scientists we interviewed indicated that the availability of pluripotent stem cell

Table 1. Participant Demographics Survey

		Junior	Senior	Total
Sex	female	3	6	9
	male	13	16	29
Educational background	M.D.	1	6	7
	Ph.D.	13	13	26
	M.D./Ph.D.	1	3	4
	graduate student	1	0	1
Sector	academic	15	20	35
	private	1	2	3
Location of training	Asia	1	2	3
	Europe	5	2	7
	USA, central	0	0	0
	USA, midwest	1	1	2
	USA, northeast	1	5	6
	USA, southeast	1	0	1
	USA, west	4	6	10
	multiple locations	3	6	9
Location when interviewed	Asia	1	1	2
	Europe	1	3	4
	USA, central	0	2	2
	USA, midwest	3	2	5
	USA, northeast	4	2	6
	USA, southeast	0	0	0
	USA, west	5	14	19
Total		16	22	38

Junior refers to an academic position at or below an assistant professorship or a corporate position below senior or director level. Senior refers to an academic position at or above an associate professorship or a corporate position of at least senior or director level.

lines signifies the potential for generating knowledge where there was none and should be met with scientific excitement. In many respects, for our participants, anticipation of discovery far outweighed the potential negative impacts of regulatory or funding uncertainty in their advice to trainees. They weathered the storm and forecasted a bright future for the next generation of scientists. More than a bright future, they saw this moment in stem cell science as a turning point—a "renaissance"—when public and scientific excitement are at an all-time high while regulation, at least in the USA, is the least prohibitive it has been in over a decade. Even when hurdles in stem cell research were acknowledged, it was alongside the powerful force of hope and anticipation of significant benefit: "[Trainees] are certainly going to face hurdles and barriers, but I think lots of people who made significant contributions to society *did* face those at some level." (Emphasis in original.) The challenge for scientists may lie in maintaining the momentum and optimism of the field and minding barriers in the quickly evolving research and political environments.

Participants also cautioned that stem cell trainees should be aware of their surroundings within and beyond the lab. In particular, trainees should consider political, funding, and scientific environments; they should choose their labs and tools wisely; and they should understand the extraordinary rigors of a research career. Exemplifying the importance of being aware of the political and funding environments, one senior scientist described the far-reaching impacts of past politics on the present:

> It is a phenomenal time! And yet, again, George Bush crippled research in this area— he crippled NIH research by under-funding it.... We're just beginning the possibility of recovery from this catastrophe.

Although we are now well past the Bush era, the participant's example of past policy underscores how past administration ripples forward. Certainly, this sentiment (expressed with vehement language) fits with recent evidence that, though past US regulation centered on the use of embryos in research, researchers working with all types of stem cells felt the largely negative effects of uncertainty in the wake of the federal circuit court case (Levine, 2011; Owen-Smith et al., 2012). In addition to policy and regulatory environments, scientists also emphasized the importance of the funding environment in establishing new institutions and careers. As another scientist noted:

> The reality of this stem cell initiative [California Institute of Regenerative Medicine, in California] is that they've been able to have their pick of recruits. I got a call from a guy at *The Wall Street Journal* just last week, and he called me because I *wasn't* in California, and said, "Tell me how it feels to NOT be in California." I said, "Terrible. Poor."

Respondents frequently cited funding as a source of concern, feeding into scientists' advice that students choose their labs and cell types carefully to ensure consistent funding. Scientists also advised interested trainees to be fully aware of the realities and rigors of research work, such as the formidable time commitment and physicality of nurturing cell lines.

Virtues and Practices of Stem Cell Scientists

Participants gave general advice about what it means to be and act like a good scientist and described a clear ideal of the "good" scientist. Our analysis of this advice in the context of surrounding interview sections revealed nuance in what the scientists' described as their role in science, ethics, and policy. For example, some scientists felt strongly that stem cell scientists have a moral duty to act as advocates for research—to champion funding and oppose crippling regulations:

> If I think something is important, we have to find a way to do it, and you have to fight for it in the worse case. If we want to… make scientific

progress and we're going to help our patients—that is what should be the driving force and not whether some project might be easier or is fundable.

Others, in contrast, argued for a disentanglement of science, religion, and politics, and instead insisted that a scientist's rightful role is as a scientist alone, above the fray of more subjective debates. One scientist argued for a middle ground in which scientists have a duty to public engagement and science communication but not advocacy. Another suggested that, while senior scientists may have the stature and staying power to protect them from the potential backlash of advocacy, junior scientists should not be expected to jeopardize their careers by speaking out in social-political debates.

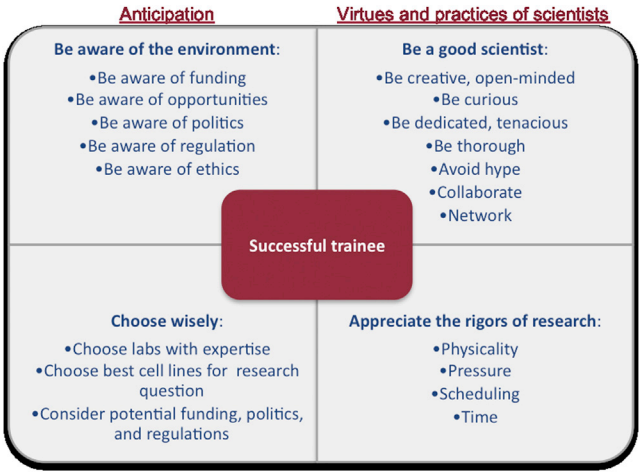

Figure 1. Visual Summary of Scientists' Advice for What Makes a Successful Trainee

Despite diverging beliefs about the appropriate role of scientists in nonscientific domains, participants converged on—without disagreement—the idea that researchers have a duty to *be* and *act* like good scientists. Participants suggested particular traits or virtues that scientists should possess, including dedication, drive, curiosity, and open-mindedness. Undoubtedly, most people would find such traits desirable (stem cell scientist or not), but participants nonetheless highlighted these as particularly valuable to success in this field. To live up to ideals of a good scientist, interviewees advised trainees to act like good scientists by doing ethical and scientifically rigorous work, networking and collaborating extensively, and avoiding the hype of stem cell research. Not meeting these standards could professionally limit individual scientists and negatively impact the field. For example, one participant explained that not having an open-minded approach and a supportive network of collaborators would constrict a researcher in adapting to quickly developing scientific and policy changes. Another participant detailed how mismanagement of scientific excitement and hype debilitated a similar young field:

> The hype is very, very difficult to manage, and I think we don't have to look more than a decade in the past with gene therapy to realize the pitfalls of this… one negative result, one negative publicity can kill an entire field for a decade or more. *That* makes me very nervous because, as scientists, we're very bad at policing ourselves. We want to move things forward. And when we move things forward too fast and the bad things happen, there will be a backlash that we won't recover from, as gene therapy hasn't been able to.

Participants' advice about character and conduct is, to some extent, intuitive and applicable to scientific research on the whole, but these examples emphasize the stakes for individual careers as well as stem cell research broadly and the motivation to imbue trainees with shared values. As one senior scientist summarized: "I think 99.9% of researchers out there are very ethical, considerate people. But, of course, like anything else, you always want to protect against that 0.1%."

Participants described some level of engagement with ethics in their mentorship of young scientists. One senior scientist explained that he makes time to discuss ethical and legal issues: "I'm in constant dialogue with all my staff members. We have a weekly lab meeting, and I have a monthly joint lab meeting with other labs, and we have sometimes a weekly hospital general series." The impetus to discuss ethics issues early on, one scientist explained, was to make sure that her prospective trainees would be prepared not only to handle their lab's particular work with human embryonic stem cells but also to leave the lab at the end of the day and handle interactions with "family and the public and everything." To be clear, however, discussion of ethics and the challenges of public interaction and perception were not limited to human embryonic stem cell researchers. Although there may be practical reasons to stay abreast of ethics issues in stem cell research, such as anticipating public and policy-maker reactions, the explanations of some scientists suggested that their reasons for engaging in ethics were more deeply rooted in their moral intuitions and sense of obligations. Another senior-level researcher stated simply: "I think if you are doing experiments which are ethically suspect in some way—embryonic stem cells are just one particular arena in which you could be doing that—if your work is suspect, then I don't think you should be doing it, frankly."

Demographics

Although we interviewed more males (29) than females (9), this proportion (31%) reflects the current gender imbalance in publishing patterns for molecular and cellular biology generally (http://www.eigenfactor.org/gender/). The participants' educational background varied as well, with Ph.D.s (26) outnumbering M.D.s (7) or M.D./Ph.D.s (4). We characterized interviewees as "senior" (22) if they were associate professors or higher or if their corporate position was senior or director level, and "junior" (16) if their academic appointment was at or below assistant professor.

Ideas about professional duties, values, and fiduciary responsibilities varied among the participants. Most training and current labs were clustered in Europe, the northeast USA, and the

western USA, while few scientists trained or were currently located in the southeast or central regions of the USA. Twenty scientists moved away from their region of training to their current location. Although this may be a common practice since academic culture often encourages trainees to leave the nest, professional migration (popularly called "brain drain") has been raised as a serious concern for stem cell science as regulatory and funding changes threaten to widen intellectual divides between nations, states, and institutions (Levine, 2006; Longstaff et al., 2013). It is reasonable to think that participants' experiences in different educational and geographical environments would shape the advice they pass on to the next generation navigating those environments. However, in most instances, we did not see clear-cut differences that could be attributed to participants' region of work, the cell types they studied, or other demographic factors.

Limitations

Some of the advice emerging from our analysis is certainly true for science generally. However, this optimism is particularly surprising in light of interviewees' own experience with regulation and the uncertainty of future politics and funding. It is also possible that our choice of interviewees led to a certain bias toward optimism, as they were selected based on publication in high-impact journals. The advice might therefore be colored with a "senioritis" effect—that is, participants may be more cavalier about their advice to young people because they have already met with success in the field. Participants' general optimism related to the future of stem cell science, particularly in light of the current permissive regulatory climate, not necessarily the ease of finding a job in the current market. Our interviews also took place before the USA sequestration program took effect, and thus did not take into account its impact on funding for all research. It may be useful to do a comparative follow-up study involving students and fellows in the current environment.

Conclusion

Despite a turbulent regulatory record and ever-changing research environments, the stem cell scientists that we spoke to were confident about the future of their field and the potential success of its trainees. In their anticipation of a bright future and subsequent encouragement of young talent to enter the field, scientists move the field toward the fulfillment and institutionalization of their own prophecy. The advice our interviewees offered represents a convergence of this anticipation with their sense of professional duties and values. The advice itself is straightforward and not necessarily unique to stem cell science—act like a good scientist, be a good scientist, be aware, choose your environments and tools wisely, and understand the rigors demanded by stem cell research. However, it is significant insomuch as its optimism defies the field's peculiar history of uncertainty and it also indicates current scientists' desire to shape a new generation that is deeply motivated to advance the new field while being mindful of policy, environment, and ethics in their research. Our participants believe that incoming trainees will rise to the challenge. As captured by one senior scientist: "I'm very, very much impressed by how the young generation is knowledgeable, willing to bring the field forward, and fearless in many ways."

SUPPLEMENTAL INFORMATION

Supplemental Information for this article includes Supplemental Experimental Procedures and one table and can be found with this article online at http://dx.doi.org/10.1016/j.stem.2013.05.007.

WEB RESOURCES

The URL for data presented herein is as follows:

Gender composition of scholarly publications 1665-2011. http://www.eigenfactor.org/gender/

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REFERENCES

Adams, V., Murphy, M., and Clarke, A. (2009). Subjectivity *28*, 246–265.

Levine, A.D. (2006). Nat. Biotechnol. *24*, 865–866.

Levine, A.D. (2011). Cell Stem Cell *8*, 132–135.

Longstaff, H., Khramova, V., Eijkholt, M., Mizgalewicz, A., and Illes, J. (2013). Cell Stem Cell *12*, 517–519.

Owen-Smith, J., Scott, C.T., and McCormick, J.B. (2012). J. Policy Anal. Manage. *31*, 714–722.

Ramon y Cajal, S. (1897). Advice for a Young Investigator. N. Swanson and L.W. Swanson, translators (1999 Edition). (Cambridge, Massachusetts: MIT Press), p. 129.

Scott, C.T., McCormick, J.B., DeRouen, M.C., and Owen-Smith, J. (2011). Cell *145*, 820–826.