

SPOTLIGHT

Improving the visibility of developmental biology: time for induction and specification

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ABSTRACT

Developmental biology is a prominent field that has captured the imagination of many scientists. Over the years, research in the area has seen a steady number of amazing accomplishments, with peaks in activity following the development and application of new technologies. Although the field continues to flourish and produce excellent work, I have recently noticed difficulty with its perception and visibility. Having joined the developmental biology community during the early 1990s, and contributing since as a stem cell researcher, cancer biologist and an MD, I have a unique perspective on these challenges. Here, I discuss these issues and challenges and offer potential solutions for a field that is very important to me.

I recently had a discussion with some colleagues at a stem cell meeting about impact factors and the conversation morphed to the topic of developmental biology journals. It appears that the impact factors of all classical developmental biology journals (*Development*, *Developmental Biology*, *Genes and Development*, *Developmental Cell*, etc.) have been declining over the years. Thus, although the field continues to publish excellent studies in top tier journals, the general area of developmental biology may need help. Of course, impact factor is not a great measure of real importance, and authors may be artificially infatuated with these numbers, as they are thought to impact promotion and other academic criteria (discussed by Pourquié, 2018). However, to me, the numbers are consistent with my perception that much of developmental biology research has not been as appreciated by other fields or the public as it used to be. I left the table feeling pretty depressed and wanted to figure out what could be done to improve the general visibility of developmental biology to scientists.

So how did this happen? Historically, developmental biology has been very successful, spawning a remarkable number of new fields such as stem cell biology, single cell genomics and chemical genetics (reviewed by Gilbert, 2017). Strangely, it appears that these new areas were not fully embraced and I believe it is this lack of inclusiveness that is the key to the problem. For example, stem cell research came from developmental biology but then, as the stem cell community grew, it was only welcomed by a few of the classical developmental biologists and journals. Stem cell journals were established and became successful and, although developmental biology journals tried to recover the stem cell field, the damage was already done. Organoids are also becoming very popular models, but are often not considered as a major area of developmental biology, or even stem cell biology. Will there be separate journals or

societies for organoids? Given that all of these fields are close to each other, it would make sense – with regard to outside perception – to be as inclusive as possible by pooling them together and trumpeting all of their successes.

Notably, the stem cell field was able to grow very quickly. This was because of excellent science and, of course, the medical potential of stem cells, but it was also because of inclusiveness and clever marketing. Stem cell biologists figured out how to market developmental biology. When I started the International Society of Stem Cell Research (ISSCR) as the first President, I invited many well-known developmental biologists to join the board. At our first meeting, several of them felt that we should not talk to the press about our work. This group was worried that the press might misrepresent their views and this could affect public perception. I made the point that if we didn't provide the public with accurate information, then there would be misinformation in the public eye and this could instead create long-term problems. The decision was made to have all of the board talk about stem cell science to as many groups as possible, including the public, government officials and other scientific groups. When creating our first meetings, we were as inclusive as possible, including many talks on animal model systems and plants. I was very happy to include one talk on stem cells in trees at the first meeting. We formed an alliance with Cell Press so that we could establish a venue for publishing our top papers (in the journal *Cell Stem Cell*) and the field was very supportive of progress. We engaged funding bodies and governments, and included members of various foundations on panels and committees. Ethical guidelines were put in place. Lastly, we involved physicians who might be able to translate our basic research into the clinic. Overall, we tried to be as inclusive as possible and developed an educational strategy for the public, funders, governments and scientists.

Based on my experience, I think there are a number of steps that could be taken to improve visibility of the developmental biology field:

- (1) As a field, we should consider marketing the attributes of developmental biology. There are several different audiences – potential students, post-docs and other researchers, grant funders, editors, general scientists, and the public – and we need to develop a different message for each audience. We also need to point out the successes and technologies of the field and say why it is so important for everyone to know about developmental biology and why it is a great area to be part of. Perhaps a video series could be used to illustrate great examples of success or future directions. These should also clearly state what the field is trying to accomplish now. Is there medical relevance? If so, we need to say it loudly. Overall, better marketing will make developmental biology more attractive, which will hopefully lead to more papers being published, and this will expand the community's impact.

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- (2) We also need to think more carefully about the scope and aims of developmental biology meetings. Although the meetings are highly attended by developmental biologists, it would be beneficial to aim higher and reach out to those who are at the periphery of the field, or those in the newer disciplines that run the risk of splitting off from the core community. Consider that many researchers who study human disease might rather attend a meeting about their tissue, technology or cell biology than go to a broad meeting about developmental biology. Maybe we could create a new meeting or retrofit an old meeting to be more inclusive. Perhaps this could be centered on developmental biology techniques. We have seen huge advances in bar coding and single cell techniques, for example, and many of the questions that are being tackled using these techniques are now about organ development and function. This is an opportunity to bring interesting papers into the field. The term ‘applied developmental biology’ has been used in the past (see Maartens, 2017), but perhaps we should re-visit this idea and do a better job of marketing ‘applied developmental biology’ and including it in meetings. In general, meetings should be used to show off: invite every editor possible, invite every program officer for funding, get the heavyweights of the field to attend as well as the newcomers...and do not be scared to have 2000 people there.
- (3) The field of developmental biology could also benefit from reaching out and inviting the medical community into the group. Twenty-five years ago, I was invited into the developmental biology community by some really excellent scientists. It made me want to become part of a group that included rigorous scientists with bold ideas who wanted to extend their concepts to a young doctor. I am now very proud to be part of the community. So, moving forward, we should make sure we invite more medics and translational researchers to developmental biology meetings. Companies should also be invited to participate: there is a lot of developmental biology in companies right now and they are increasingly recognizing its importance. For example, one company that I founded (Scholar Rock) works on making antibodies to members of the TGF- β family for therapeutics, and it often discusses the developmental biology that is regulated by these ligands. Developmental biology is clearly relevant to companies, so it will be important to interact with them and foster good relationships.
- (4) The ‘journal experience’ is becoming very important when deciding where to submit a paper, so this is also something that, as a community, we need to improve. Much of developmental biology work is inherently harder to do *in vivo*, and experiments take a long time. The field, as a whole, needs to be more wary of this. Reviewers should recognize that, sometimes, descriptive *in vivo* work is just as important, revealing and fascinating as complicated molecular manipulations. As such, the same level of experiments that would be requested for a more accessible and/or manipulatable system may not be appropriate. As an author, you may need to remind your editors of this and liaise

with them to streamline the crucial experiments that are requested before a paper is published.

- (5) Finally, we also need to educate funding bodies and the general public about the value of basic research in developmental biology. Pointing out the impact of basic biology on the development of clinical therapies has great effect. Checkpoint blockade for cancer therapy, for example, could not have been initiated without a significant literature on T-cell developmental biology. Anti-cancer therapies that target the Hedgehog pathway would not have been possible without basic research into how this pathway functions in normal development (discussed by Ingham, 2018). Collecting a number of these anecdotes works, but researchers should also consider how their own studies add to this impact, establish novelty and push the field forward. Indeed, in a recent commentary it was pointed out by Claude Desplan that the reuse of the same signaling pathways in most developmental processes created reader and reviewer fatigue (discussed by Desplan, 2017). The fact that *NOTCH* mutations cause lymphoma as well as congenital heart defects may be less exciting than finding a new pathway that causes cancer, but if you are the patient with a *NOTCH* mutation, you will no doubt be thanking the developmental biologists for bringing some understanding of its action. Driving research forward in this way, and highlighting the importance of this progression, may help with how the field is perceived. The newly developed single cell profiling approaches open up huge research, diagnostic and therapeutic avenues to study stem cells, organ development, regeneration and cancer. We should be telling the public about this work now and claim victory when new mechanisms are found or when new applications occur. This is something that everyone can do; we all need to be advocates for the field.

In summary, it is clear to many of us that developmental biology continues to establish new principles and techniques that are helpful to many other fields. It spawns areas of research that become fields themselves. My perception is that the community could do better to enhance its visibility to other researchers and to the public. Inclusivity is very important and enhanced marketing strategies could be helpful in sending out the right signal. Much like Spemann’s organizer, we need this signal to ‘induce’ change, to ‘specify’ more developmental biologists, and to invoke a ‘community effect’ to bring as many groups as possible together to show how exciting the field is.

Competing interests

L.Z. is a founder and stockholder of Fate Therapeutics, CAMP4 Therapeutics and Scholar Rock, and a consultant for Celularity.

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