



Cover story

The drug delivery field needs a well-diversified technology portfolio



This issue of the Journal of Controlled Release (JCR) presents 12 articles, and all of them deal with nanomedicine. It is time to reflect on the work done the last few decades on nanomedicine, in particular, in relation to drug delivery. It has not been uncommon to have most of the articles in each issue of JCR deal with various forms of nanoparticles for drug delivery. Having such a large number of articles on nanomedicine is a blessing as it represents extensive efforts of drug delivery scientists around the world. This, however, is also a cause for concern to the field.

The progress made in nanomedicine for the last few decades is breathtaking. The number of publications on “nano*” and “drug*” during the period of 1986–2016 is close to 80,000 according to the Web of Science. The number of annual publication surpassed 10,000 in 2014. More than 30% of these articles are classified under “cancer”. Such extensive publication indicates widespread training of the next generation of scientists in nanomedicine throughout the world. This seemingly impressive output, however, needs to be viewed in light of the ultimate goal of doing research with nanotechnology-based drug delivery systems. Many agree that it may be too early to expect the clinically effective formulations on the market resulting from nanotechnology. As described in a recent review article in JCR [1], none of the formulations on tumor-targeted nanomedicine-based therapeutics under clinical studies have been approved by the United States Food and Drug Administration. Doxil® and Abraxane® have been routinely cited as examples of nanotechnology-based products, but crediting nanomedicine for both products is like giving credit to a general who fought in the Vietnam War for the victory in the Second World War. This brings a cause of concern on what and how we do in the nanotechnology-based drug delivery research.

Currently, by far the majority of the nanomedicine research has been focused on tumor-targeted drug delivery. The top-10 causes of death in the United States include diseases of the heart, malignant neoplasms, chronic lower respiratory diseases, cerebrovascular diseases, Alzheimer's disease, diabetes mellitus, influenza, and pneumonia [2]. Yet, almost all nanomedicine research has been focused on tumor-targeted drug delivery. A simple question arises, “Is nanomedicine useful only for tumor-targeted drug delivery?” To answer this question, one review article in this issue deals with the potential benefit of treating Alzheimer's disease using polymeric nanoparticles, lipid nanoparticles, liposomes, nanoemulsions, microemulsions and dendrimers [3]. It may be the time to critically review what has been done with nanomedicine, and change the course of the future research as necessary. As all investors know, it is not wise to place all your eggs in one basket. Supporting research is an investment for the future, and it will be prudent to pursue other drug delivery technologies to tackle various diseases. The scientists' invisible gorilla syndrome is larger than it seems [4]. When we keep rationalizing what we are doing, we miss the real opportunities of finding something really new. On an individual level, this may not be a big deal, but on a societal level, not to mention on the global level, the consequences may be unimaginable.

Another concern with the lack of diversity in drug delivery technologies is that the training of future scientists is limited only to the tumor-targeted drug delivery, which at best may exist in mice and at worst is not relevant to humans. We need to provide young scientists with an environment where they can explore various new ideas beyond nanomedicine. Why do we confine their infinite possibility and brilliant minds in such a narrow topic? The lack of diversification will limit innovations, which in turn, will limit the progress of making new drug delivery systems that are clinically relevant. After decades of the potential and the promise of nanomedicine, it is time to move beyond a single topic and encourage scientists to diversify their focus. The talents of many researchers can be brought into reality when a proper environment supports them. Such an environment becomes possible when we all show the courage and willingness to try something new and different. National funding agencies need to change how they support diverse research projects and young scientists, and universities need to update the tenure system to encourage independent thinking. The researchers need to be boldly courageous to stand up against the establishment which was designed for only those who benefit from the system. It is the researchers who come up with new ideas, write proposals, conduct difficult experiments day and night, and prepare the report summarizing the results. The researchers need to control the exchange of ideas and results and evaluate the quality of the data.

The drug delivery scientists are a part of one great community connected by invisible threads, and we are all responsible for one another. We should feel blessed when we are in a position to help or support others [5]. We will help each other to promote the diversity of ideas to define the right problems and to find the right solutions. Quoting the lyrics of a Musical *Hamilton*, “Look around, look around. How lucky we are to ‘do drug delivery research’ right now!”

References

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