Realizing Positive Network Effects in Synthetic Biology

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The emerging field of synthetic biology holds great promise for generating biological solutions to address many of society's most pressing needs. Advances in DNA synthesis and assembly technologies, innovations in computer-aided design, and the creation of automated strain engineering platforms and associated technical standards are improving efficiencies in the design, construction and testing of biological systems. As such, the tools of synthetic biology can help address unmet grand challenges in health, energy, environment, and agriculture.

Despite remarkable achievements in recent years and the creation of a vibrant, global synthetic biology community, research and development efforts in synthetic biology remain disconnected, duplicative, and delayed in the face of difficult common challenges. It is problematic that the infrastructure within which synthetic biology research is being conducted operates as a closed, guild-like system. Individual researchers, academic institutions, and companies typically are not rewarded for sharing, and instead are rewarded by sequestering information and materials until a paper is published or a patent issued. Career advancement for individual researchers, at least in academia, depends on first-author publications and the ability to competitively secure grant funding. Many academic institutions hold tight to any discovery or technology development that could potentially bring in revenue. And companies rely on the exclusivity provided by patents and trade secret protection to secure investment and obtain market advantage.

The silo mentality created by the current infrastructure impairs the ability of researchers to collaborate with one another and discourages cooperation between organizations, thereby losing the benefits of positive network effects. As a specific example, synthetic biology researchers in both academia and industry are often unable to freely share the biological parts they develop. When sharing biological parts with others outside their own laboratories (Figure 1, left side), most academics need to have a manuscript submitted or accepted for publication, while most industry researchers need to have an agreement in place. On the other end, when requesting biological parts created by others (Figure 1, right side), researchers or their institutions often

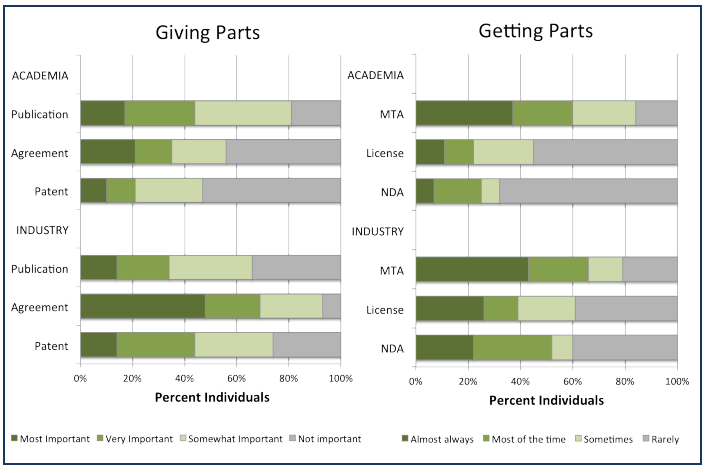

Figure 1. Considerations for sharing and accessing biological parts among synthetic biology researchers in academia and industry. Data from the SB6-State-of-The-Art survey, Kahl et al., manuscript in preparation.

are asked to sign material transfer, licensing or non-disclosure agreements. Importantly, researchers do not always receive the parts they request. When requesting parts as tangible materials, 26% of academics and 57% of industry researchers report having been denied access due to concerns about property rights. Property rights are not the only barrier to access, however, since 32% of academics and 50% of industry researchers reported having been denied access due to other concerns (e.g., competition, failure to fill requests, inability to clear customs).

The inability of academic and industry researchers to freely share biological parts has had a negative impact on synthetic biology research. Among academic researchers (Figure 2, left side), 50% believe their research has not been affected by difficulties in obtaining agreements. However 37% reported their research had been delayed, 26% chose alternate technologies, 6% abandoned ongoing research projects, and 11% chose not to pursue a new research project due to difficulties in obtaining agreements. Among respondents from industry, the impact on research is far greater (Figure 2, right side). Only 14% of industry researchers reported their work had not been affected by difficulties in obtaining agreements, 49% reported their research had been delayed, 54% chose alternate technologies, 9% abandoned ongoing research projects, and 17% chose not to pursue a new research project due to difficulties in obtaining agreements.

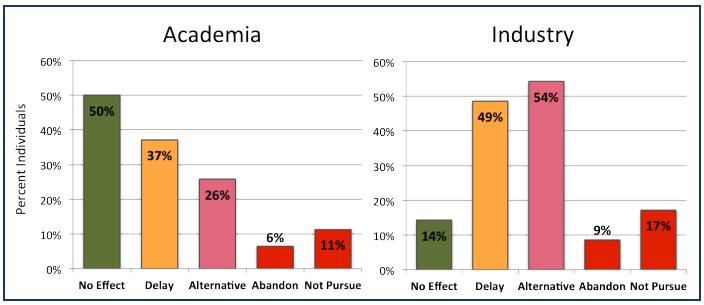

Figure 2. Synthetic biology researchers in academia and industry are impacted by difficulties obtaining licensing or material transfer agreements**.** Data from the SB6-State-of-The-Art survey, Kahl et al., manuscript in preparation.

It is critical that researchers, together with academic and industry leaders, funders, investors, and policy makers, fundamentally rethink how synthetic biology tools and knowledge are shared and disseminated. Realizing the full potential of synthetic biology will require an infrastructure that enables researchers to share and access information and materials that reside outside the boundaries of any one organization. To benefit from the positive network effects inherent in the engineering of biology, new collaborative platforms and policy initiatives are needed that will reward the sharing and dissemination of data, materials, methods, and practices across institutional and international boundaries.

The types of collaborative platforms and policy initiatives – e.g., convening forums, funding streams, publication venues, and associated rewards systems – that could help ensure social benefit from positive network effects in synthetic biology is a topic for discussion at this Workshop on Research Agendas in the Societal Aspects of Synthetic Biology.