High-Impact Social and Ethical Reflection within Synthetic Biology Research

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Socio-Technical Integration. Around the world, policy demands for socially responsible development of critical yet potentially controversial areas of emerging science and technology have intensified. At the same time, social researchers are developing and testing new engagement methods for brining publics, stakeholders, and policy makers together in dialogue. Yet, as scholarly and public engagement around synthetic biology moves forward, it will be important to connect it with the actual practices of scientists and engineers. If this can be done, research pathways and technological trajectories will stand a greater chance of developing in ways that are responsive to public values and ethical concerns.

Socio-technical integration entails any process by which scientific experts account for the societal aspects of their work as an integral part of this work. At the heart of this idea is the proposition that scientific and engineering decisions play a crucial yet often overlooked role in the societal governance and shaping of emerging technologies. Routinely and explicitly reflecting on societal aspects during laboratory research can lead to opportunities to incorporate these considerations directly into technical decisions. This not only builds deliberative and anticipatory capacities into the heart of the scientific enterprise, in theory it can influence the direction of scientific and technological developments and thus help strengthen important links between science and society.

In practice, socio-technical integration faces numerous challenges and tensions: the connections between societal aspects and scientific practices are not always self-evident, meaningful collaboration between physical and social scientists can be difficult to achieve, and the idea of integration can trigger longstanding fears that it might harm scientific productivity and infringe on scientific autonomy.

STIR Project and Results. The Socio-Technical Integration Research (STIR) project coordinated 30 laboratory engagement studies in which social science and humanities scholars interacted regularly with scientific and engineering researchers working in nanotechnology, biotechnology and other basic and applied research areas. The project goal was to investigate the possibility and utility of socio-technical integration during routine laboratory practices. Following the "midstream modulation" framework, integration during laboratory research was conceived to take place *midway between* traditionally opposing categories such as research policy and technology regulation, promotion of innovation and its social control, social scientific observation and ethical advocacy.

STIR studies generally followed the same basic methodology, although several experimented with alternative approaches. In general, social researchers learned the theory and observed the methods of their laboratory counterparts; but they also were asked to introduce a decision protocol that was designed to unpack social and ethical dimensions of the lab science itself in a real-time, hands-on, collaborative manner. Ideally, the social researchers, their methods and inquiries became embedded in the laboratory during each 12-week engagement study.

In addition to co-authored publications and the acquisition of interactional expertise, the STIR project correlated several types of outcomes to its interdisciplinary activities: Nearly all of the 30 studies documented *heightened reflexive awareness* among research participants of interrelations among research developments, societal contexts, and laboratory decision-making. Similarly, a large majority of the studies also documented *deliberative reflection* on the societal aspects thought to be at stake in research. By comparison, only about half of the studies actually documented *practical adjustments* to research procedures and to laboratory strategic thinking that were correlated with the interdisciplinary dialogues. Approximately one-third the studies routinely used the semi-structured decision protocol that was originally designed to guide the interdisciplinary interactions. Interestingly, all studies in this sub-set documented *heightened reflexive awareness*, *deliberative reflection* and *practical adjustments*.

STIR project results suggest that thinking and talking about the societal aspects of their research while scientists and engineers went about their normal work routines did not entail a sacrifice in scientific productivity. Rather, reports of enhanced creativity and productivity during lab research were not unusual. Thus, integrative efforts to enhance societal responsiveness and scientific creativity can be mutually reinforcing.

Integration in Synthetic Biology. Diverse social scientific engagements with synthetic biologists have meaningful opportunities to develop the theory, refine the methods, and deepen the practical impact of integrative efforts such as those conducted by STIR. Projects and activities can vary the sites, participants, frequency, intensity, questions, and relative structuring of embedded socio-technical collaborations and interactions. Combined with other engagement tools and forums, diverse aspirations for integration and rationales for engagement can be both deepened and put to empirical test. Ideally, future efforts will attend simultaneously to the conditions under which collaborative skills are acquired, material configurations are shaped and normative concerns are articulated and negotiated.

It is important to acknowledge the numerous challenges and relatively high stakes involved in expanding both scientific and social scientific capacities for productive collaboration. STIR shows the importance of sustained interaction over time for catalyzing changes in trust, understanding, materiality and human agency. Essential tensions—typically viewed as barriers—between observation and action, social learning and material durability, and involving the instrumental, normative and interpretive roles of social science can also be viewed as design criteria and hence productive resources. The same might even be said about inevitable power relations and their imbalances. Above all, integration can both explore, and possibly seek to inform, the relationship between two central modern institutions: the social organization of science and its broader context of democratic norms and values.

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