

Gastroenterology and Biodesign: Contributing to the Future of Our Specialty

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Innovations in biomedical technology have made a significant impact on the lives of patients, paved the way for new areas of research, and been a driver of economic prosperity. Advances in biotechnology and medical devices have been major forces in

shaping healthcare.¹ In the 2 decades leading up to this century, innovations in medical technology have been estimated to contribute >3 additional years to the average life expectancy in this country, with significant decreases in disability rates.² What is often neglected in this success story is that this country has not only excelled in being creative, but has also successfully brought innovations to the market place. In this regard, “medical entrepreneurship,” long considered a peripheral if not undesirable activity by academia, needs to be embraced as a critical mission that enables true translational research.

Among the different medical specialties, gastroenterology lends itself very well to the application of technology. Modern endoscopic techniques have rendered virtually every part of the gastrointestinal tract easily and quickly accessible for diagnostic and therapeutic applications. However, despite this favorable premise, innovation in gastroenterology has not kept pace with other fields, such as cardiology and orthopedics, and the potential of utilizing technology for the management of gastrointestinal disorders has yet to be fully realized. As reviewed elsewhere, there are many factors that have contributed to this state of affairs.³ In this commentary, we focus on what is perhaps one of the most important of these, namely, the lack of a trained cadre of individuals who can accelerate the pace of technology innovation, development, and commercialization. We propose to address this issue using a new model for training innovators based on

the principle that medical entrepreneurship can be taught using standardized curricula.

Although there are now many excellent programs throughout the world that provide such training, we focus on our experience with the Stanford Biodesign program, which is among the oldest and most successful of these programs.⁴ In a short span of just 11 years, the innovations developed by the fellows and students coming out of this program have resulted in 26 funded companies, created >500 jobs, and treated >125,000 patients.⁵ The Biodesign program is a unit of the Stanford-wide Bio-X initiative, but does not receive funding from Bio-X or any department. Financial support for Biodesign is through a combination of philanthropic donations, gifts, and grants from corporations and venture capital firms, foundation support, and some funding through special initiatives at the National Institutes of Health (NIH), such as American Recovery and Reinvestment Act funding. The companies that are formed from the program are primarily supported by external funding (“angel” and venture capital sources).

The Biodesign Process

The biodesign process is a systematic approach to finding unmet clinical needs, inventing technologies, and implementing the solutions.^{4,6} Contrary to popular belief, this process starts and ends with patients and not with technologies. The focus is on the needs of the patients to truly understand what is required to help them before thinking about any solutions. It further evaluates a proposed need from a business perspective, considering all the downstream challenges with respect to clinical implementation and commercialization to successfully translate inventions and discoveries into patient care. The process consists primarily of 3 steps (3 “I”s): Identification, invention, and implementation (Figure 1).^{4,6}

Identification of Unmet Needs

The distinguishing hallmark of the biodesign process is that it always starts with the identification of a

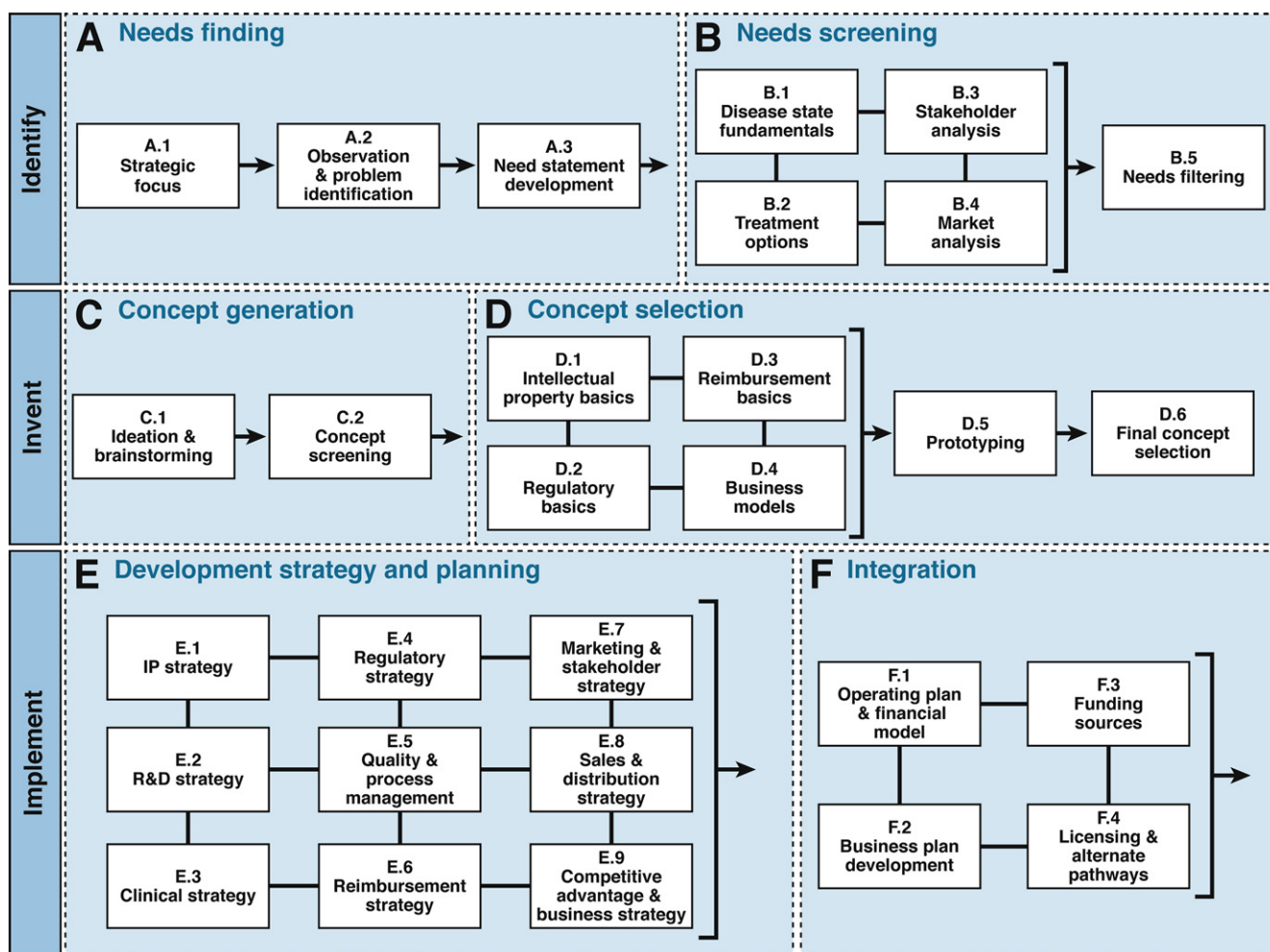


Figure 1. Biodesign process map shows the 3 major phases of medical technology innovation (identify, invent, and implement). Within each phase are individual boxes which highlight the areas for assessing core competencies. IP, intellectual property; R&D, research and development. Reprinted with the permission of Cambridge University Press.

clinical need, which if validated by a series of filters, leads to a search for the most appropriate technological solution. By contrast, “traditional” approaches to medical technology (medtech) innovation begin with an invention (the technology) and then search for the application (need). These 2 innovation processes are also known as needs-driven and technology push innovation, respectively. The biodesign process therefore begins with so-called observations, derived from the interactions of patients with the healthcare system that can occur in any setting. An observation is considered to be any interaction that is suboptimal and could include a complication from a procedure, uncertainty around a diagnosis, or annoyances and frustrations expressed by physicians or patients themselves. These observations, by their nature, are context dependent and thus unmet needs can vary significantly with both macro- (eg, socioeconomic) and micro- (eg, physical location) environmental factors.

As an example to illustrate the needs finding process, we can evaluate the observation of a patient being admit-

ted for post-endoscopic retrograde cholangiopancreatography (ERCP) pancreatitis. In this hypothetical case, ERCP was performed for choledocholithiasis, but required multiple cannulation attempts with inadvertent contrast injection into the pancreatic duct as well as significant trauma to the papilla. As a part of the biodesign need finding process, this observation is translated into a “need statement,” which is a single sentence that begins with “a way to . . .” and includes an intended action as well as a desired outcome. In this case, the need statement would be “a way to selectively cannulate the common bile duct via the ampulla to reduce post-ERCP pancreatitis.” Although this statement may seem satisfactory at first glance, a deeper analysis reveals the inclusion of a solution within the statement. This can result in an implicit constraint that leads to bias in the innovation process from the onset. Thus, using the need statement as a goal limits the solutions to cannulation via the ampulla (such as by improving catheter design) or by ways to make it easier to introduce a catheter into the

common bile duct via the ampulla. This essentially precludes any other solutions that might exist. Therefore, it is preferable not to embed even a hint of a solution within a need statement. An alternative and better need statement is “a way to selectively gain access to the common bile duct to reduce post-ERCP pancreatitis.” This opens up the solution space to include ways to bypass the ampulla completely and avoids locking into a particular approach. Every word in the need statement is therefore important, because this forms the blueprint for the future brainstorming sessions and technological inventions, as well as clinical study design.

Within the process of needs finding, students are encouraged to generate numerous such need statements from different observations during an initial period of clinical immersion. Diligence is then performed on every need by analysis of the underlying disease state, current and emerging treatment options, stakeholders, and market opportunity. This ensures that any solution that is eventually developed creates a clear and positive value for the key stakeholders. During this period, the need statements are refined iteratively to further optimize the definition of the problem and desired outcome. This list of needs is then prioritized using an unbiased scoring matrix that allows the students to select the best needs to work on based on objective criteria, which may or may not be the most interesting problem intellectually. This phase of the innovation process is often the most important initial step because it validates the significance of a need. The analysis performed during this phase also helps to create the need specification document that outlines the criteria that must be met for any future innovation to be successful. At this stage, students are encouraged to make a conscious effort to avoid thinking about any potential solutions, so as not to prejudice the selection procedure.

Invention

After a priority list of clinical needs has been developed, we enter the second phase. This phase utilizes a creative team-based brainstorming approach to generate a large number of solution concepts for every need and draws on expertise from clinical, engineering, and business. These concepts are then passed through the filter of the need specifications document, as well as other criteria including technological feasibility and clinical validity as well as considerations about intellectual property exclusivity and protection, regulatory challenges, reimbursement pathways, and the business model. Rapid prototyping with testing in bench top and animal models are important aspects of the process of refining the concept into a technology solution. This narrows the field considerably and the surviving concepts are then taken to the next phase.

Implementation

The last phase focuses on strategy and involves a more in-depth consideration about the technology feasibility, clinical development plan, intellectual property viability, and business and financial models while preparing for various funding strategies. The various funding strategies range from traditional “angel” or venture investments to corporate partnerships and licensing.

Biodesign Training: Beyond Medtech

It is clear that, to accelerate the pace of innovation, we need individuals with transformative ideas who are not biased with the current dogma and are willing to challenge the status quo. Trainees early in their career are well-suited to adapt to this approach of innovation because they are not constrained or prejudiced by a set way of thinking and doing research. However, these advantages are not restricted to medtech innovation. First, learning the fundamental skills and tools required for innovation through a formal training program can lay a strong foundation for future innovation endeavors, whether it is in bench science or clinical research. Indeed, if one examines the biodesign process closely, it bears marked similarity to the “filters” that the NIH applies in scoring a grant application: Significance (unmet need), innovation (novelty, intellectual property considerations), approach (needs filtering, implementation), investigators (invention team), and environment (regulatory and reimbursement considerations).

Trainees who are taught principles of biodesign will also learn how to identify unmet needs independently and be better able to shape their research focus going forward. This is in contrast with the current system, where mentors often provide their trainees with research questions to investigate during their research training. Biodesign training also has other benefits: Trainees are encouraged to explore and investigate subject areas that may be beyond their comfort zone. They are constantly challenged to question the norm and have to quickly adapt to changing situations while working in a collaborative and team-based learning environment.

Bringing Biodesign Into the GI Training Curriculum

Based on these considerations, the GI Division at Stanford initiated an effort towards biodesign leadership and a track was created within the GI fellowship in 2010 that has been designated as the “biodesign track.” In keeping with other tracks in the fellowship, the first year of this track is devoted to clinical training. During the second year, the fellow joins the Stanford Biodesign class as a regular biodesign fellow, with the exception of having 1 day a week devoted to ongoing clinical training to be compliant with clinical training guidelines. In the

third year, the fellow spends his or her effort either taking a selected biodesign project to the next level, or working on other projects in gastroenterology that are felt to be important. Throughout the second and third years, a designated mentor and guidance committee monitors the progress of the fellow and provides crucial feedback. The core mentoring group consists of hybrid university/business faculty. The faculty members are drawn from clinical departments, engineering (mechanical and bioengineering), and the business school. Each of these faculty members has had experience in medtech startups, several as founders of companies. In addition, there are 4 adjunct faculty members who have primary business roles as founders of medtech companies and/or venture capitalists, but dedicate a considerable amount of their time to working with the fellows and student teams. Some of the projects that have come out of this track include an innovative technological approach for chronic peritoneal drainage, a novel method to deliver drugs in inflammatory bowel disease, and a patient management smart phone app for irritable bowel syndrome. It is gratifying to observe that by 2014 we will have produced 3 fully trained gastroenterologists who will be ready to seed our specialty with their unique approach and inspire others to follow them.

Despite our initial success, one should not minimize the challenges to the incorporation of biodesign into traditional medical training programs. Perhaps the most important of these is a conceptual barrier; in the ivied halls of many academic institutions, medical entrepreneurship has until now been viewed as outside of the mainstream for the most part and in some instances even stigmatized as part of the commercialization of medicine. However, this view is changing as it is becoming clear that biodesign is not about teaching physicians how to make money, but rather how to address unmet needs in a practical way, which in our society translates into commercial viability. One approach is to consider biodesign as a related issue is the career path for physician graduates of the biodesign program. None exists at the present time and we encourage our graduates for now to choose among the existing faculty tracks (clinical educator or clinical research), with the knowledge that their biodesign training will prepare them well to approach problems in their field.⁷ The fellows in the biodesign track will be following conventional academic tracks in terms of specialization within GI after completion of this program. Therefore, biodesign could be considered more of a “mindset” and an important tool than a specialty. However, in the absence of a designated faculty track in biodesign, issues of promotion and tenure may arise. This has tempted many trainees to make the leap to the “outside” by becoming founders or partners in startup companies or other ventures. However, it would be a

great loss to academia if this was to happen, because these innovators are the very people who may be critical to the future of our institutions.

We realize that not all institutions have existing biodesign programs that they can partner with for training physicians. Even those that do can be discouraged by the lack of funding options for creating such tracks. In the case of possible funding of trainees on NIH T32 grants, it would be important to confirm first with the NIH program officer whether a biodesign fellow qualifies for such support. Further, the projects that are generated by biodesign programs often require substantial amounts of capital investment. Typically, innovation projects are spun out of universities as startups with the help of venture funding. However, with the current economic climate, venture funding is increasingly difficult to obtain. In addition, it is often challenging to get venture funding for early stage ideas. Although other nondilutive funding (ie, which does not require equity in the enterprise) opportunities do exist for these projects such as the Small Business Innovation Research (SBIR/STTR) grants from NIH/DOD (Department of Defense), they also require that the science and technology be reasonably proven and the commercialization path well developed.

Recognizing this gap in funding and realizing the importance of creating centers to translate research knowledge into clinical care, the NIH has created the Clinical and Translational Science Awards program, which is now part of the National Center for Advancing Translational Sciences (NCATS). The NCATS mission states that it is a hub for catalyzing innovation in translational science and works closely through partnership with academia, private sector, regulatory agencies, and nonprofits to overcome the hurdles of translating science into effective treatment and cures.⁸ In this regard, helping the “implementation” phase of the biodesign process can be viewed as a very appropriate and important application of funds.

There are also a number of nonprofit and philanthropic organizations that provide support for innovation and entrepreneurship in biomedical technology. The National Collegiate Inventors and Innovators Alliance with the help of the Lemelson Foundation is one such example that provides seed funding for technology innovations involving students and faculty. The Coulter translational grant is another example (provided through the Wallace H. Coulter Foundation) that gives multimillion dollar grants to bioengineering departments and their clinical collaborators.

Although professional societies have been primarily geared towards basic science and clinical research projects, a case can clearly be made for them to include biodesign funding in their portfolio. The recently created Center for GI Innovation and Technology by the American Gastroenterological Association was established to

guide medical device innovators through the technology development and adoption process, and will be a useful platform to provide funding for projects in the implementation phase.

Future of GI Device Innovation

With the rapidly changing healthcare environment, there is an even greater need for innovation and medtech growth in gastroenterology. The focus will have to be on value-based innovation where new technology will have to deliver the best possible health outcomes at the lowest possible costs. Early on in the innovation process, the innovators will have to gain deep insights about the key value drivers of different stakeholders and understand the economics of their innovation before committing time and resources on implementing the solution. The biodesign innovation process implicitly forces the innovator to think through the various elements that are vital to make their innovation successful. To make this innovation process viable within universities and academic medical centers, new models of research and training will have to be created and will require strong collaborative leadership with clinicians and bioengineers being at the helm of driving the innovation process. Incorporating the principles of biodesign into our “DNA” therefore will be of huge value to our specialty.

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Conflicts of interest

The authors disclose no conflicts.