Share and share alike

Samuel K Sia & Matthew P Owens

How the sharing economy is influencing biotech innovation and what it means for startups.

Taking a biotech invention from bench to market is an expensive undertaking. Starting with a promising drug target or device prototype, company founders face a series of hurdles relating to space, equipment, personnel and legal and accounting demands. Because the setting up of this infrastructure is capital and labor intensive, and it takes place before the achievement of key clinical milestones, the biotech model has traditionally relied on attracting a large initial round of investment to fence away intellectual property and support translation and commercialization.

Yet the business model for innovation by startup companies is undergoing a remarkable transformation. The past decade has witnessed advances in open-source software, cloud computing, rapid prototyping of hardware, logistics in transportation of goods worldwide and mobile communication, leading to the establishment of a 'sharing economy'. In the tech economy, startup companies can now access a co-working space, use cloud-based servers and collaborate with the larger community for coding needs. This sharing model is particularly effective when the resources involved are expensive, specialized or scarce[1,7].

In the biotech industry, challenges to access such resources are amplified. Companies can benefit from shared access to a variety of resources, including chemical synthesis, molecular biology, cell biology, animal testing and assay development services, instrumentation, and hardware and software development—and this is sparking a proliferation of capital-efficient startups that tap into an expanding ecosystem of service companies. Moreover, with increasing competition for academic positions, industry jobs and research funding[2], the talent pool of trained scientists who can offer their knowledge and skills to biotech startups on a freelance basis is growing. On the basis of the above evidence, we believe that a sharing model will become an increasingly popular one for biotech startups.

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Mine and yours

Biotech companies are already relying on outsourcing for DNA sequencing and planning of clinical trials[3]. Today, there are four large areas emerging for biotech sharing: physical space, equipment and supplies, knowledge, and financing. In the sections below, we take each in turn.

Space. Securing a workspace can be difficult for any early-stage company, given a lack of credit history, dearth of acceptable space to rent and rapidly changing needs. For life science companies, finding a workspace can be doubly challenging owing to the need for specialized infrastructure, such as chemical fume hoods and biosafety cabinets, and the production of medical waste. To address this, some universities are opening incubators on campus with wet-lab space[4], but such spaces are typically reserved just for startup companies generated by those institutions. In addition, there are also privately run co-working lab spaces[5], but given the high market rents (especially in biotech hubs), even a small dedicated footprint can be unaffordable to companies that have not yet obtained institutional financing (**Table 1**).

'Sharing' wet labs are also emerging, providing offerings at affordable prices and catering to early-stage companies[6], including Harlem Biospace, a biotech incubator in New York City that we run (**Box 1**). The sharing at these types of places extends beyond physical space into operational costs (utilities and routine lab and office supplies), lab infrastructure (freezers, hoods, purified water and gas) and equipment (for microscopy and cell counting). Equally important for biotech companies are community programs that expand their professional networks and increase their chances of obtaining financing or revenue. Programs include office hours with mentors, guest lecturers and regular internal meetings of the member companies. This connection to peers and mentors can be a critical support network for the teams of early-stage ventures, especially for those starting their first companies.

There are also accelerator programs, which offer combinations of office space, lab space and access to mentors and networks in exchange for

Box 1 Harlem Biospace's affordable shared biotech lab in Manhattan

As one of the costliest real-estate markets in the country, Manhattan has been a difficult place for young biotech companies to find a start, despite hosting seven premier academic medical institutions. With funding from the New York City Economic Development Corporation (New York, NY), we opened up Manhattan's first biotech incubator, called Harlem Biospace, in November. By providing an open lab where infrastructure (chemical hood, biosafety cabinet, gases) and equipment (fluorescence microscope, centrifuge) are shared, we allowed 20 startup companies to have access to space at a fraction of the cost of leasing and building out their own space ($995 per desk). Reflecting a community spirit, companies have largely chosen to share equipment that they purchase. Community events include biweekly internal member meetings in which companies share their experiences and advise each other, and seminars with experts open to the public. In the first year, companies at Harlem Biospace raised more than $10 million in external financing.

Table 1 Shared lab spaces, including co-working labs and accelerators

Name	Opened	City	Partners and affiliates	Square feet available	Number of ventures	Membership fees
Co-working laboratories						
Alexandria Science Hotel	2011	New York, NY	Alexandria Real Estate Equities	17,500	10	Market rent for 1,700-square-foot lab suites
Bayer CoLaborator	2012	San Francisco, CA	Bayer Pharmaceuticals	6,000	5	Market rent
CURE Innovation Commons	2015	Groton, CT	Pfizer (space donation), 454 Life Sciences, Triumvirate, VWR	24,000	9	Not yet announced
Downstate Biotech Incubator	1992	Brooklyn, NY	State University of New York, NYCEDC	50,000	25	NA
Harlem Biospace	2013	New York, NY	NYCEDC, WilmerHale, Olympus, AWS	2,300	15	$995/month (desk + shared bench)
Hershey Center for Applied Research	2007	Hershey, PA	Wexford Science Real Estate	80,000	20	Market rent
JLabs	2012	San Diego, CA (one of four US sites)	PerkinElmer, internal J&J expertise	40,000	25	Market rents with flexible leases
Lab Central	2013	Cambridge, MA	Massachusetts Life Science Center	28,000	35	$3,720/month (bench) + $420/month (per added desk)
StartX	2014	Palo Alto, CA	QB3, Stanford	2,000	10	$1,500/month (bench)
Science Center Port Incubator	2011	Philadelphia, PA	Wexford Science Real Estate	35,000	NA	Market rent
QB3@953 (one of five sites nationally)	2013	San Francisco, CA	J&J Innovation, GE, Autodesk, WuXi	24,000	45	Market rent with flexible leases
Accelerator programs						
Illumina Accelerator Program	2014	San Francisco, CA	Illumina sequencing resources and expertise	NA	5	Free for duration of 6-month incubator
IndieBio Accelerator	2014	San Francisco, CA	SOS Ventures, Amazon AWS, P212121	5,000	10	Free for 4-month duration of accelerator program
YCombinator	2005	Palo Alto, CA	AWS, Transcriptic, YC Research	0	18 bio-related	No lab, but credit toward out-sourced work provided

AWS, Amazon Web Services; GE, General Electric; J&J, Johnson and Johnson; NA, not available; NYCEDC, New York City Economic Development Corporation; QB3, California Institute for Quantitative Biosciences.

an equity investment (**Table 1**). An example is SOS Ventures (San Francisco, CA), whose IndieBio accelerator offers $250,000 and four months of community lab space in return for a fixed 8% equity share of supported ventures. There are others, such as Accelerator Corp (operating in Seattle and New York), which takes an active role in setting up a company in return for higher ownership stakes. For a biotech company, deciding among these programs can come down to whether founding scientists prefer to take the long path of building a company themselves versus serving as advisors to a team brought in with the help of investors.

Pharmaceutical industry players are also launching accelerators of their own to help identify future strategic investments or acquisitions. One example is Madison, NJ–based Johnson and Johnson, which runs Janssen Labs (JLabs; **Table 1**). Similarly, equipment vendors are experimenting with offering space, cash investments or in-kind equipment to build relationships with future clients and push the technical capabilities to propel product development. The Illumina (San Diego, CA) accelerator program is one of these, through which startup companies gain access to sophisticated genomics equipment. It is worth noting that these corporate programs usually require less equity than investor-run accelerators, and they can offer access to expertise and resources otherwise out of reach at an early stage. Care must be taken, however, to understand the objectives of the sponsoring corporation so as to ensure a strategic fit, as these companies will typically ask for long-term licensing rights should technical milestones be met.

Equipment, reagents, tools and services. Sharing of equipment, reagents, tools and services allows sellers to gain revenue from excess capacity of equipment and labor, and buyers to gain access to a wide array of capital-intensive and specialized resources (**Table 2**). Already, contract research organizations, animal facilities and sequencing labs have been offering outsourced resources and services. New models of open marketplaces are being developed that can empower startup companies to more efficiently offer and purchase specific lab equipment and services.

Academic core facilities (such as animal facilities, clean rooms and microscopy facilities) offer shared resources that have traditionally been reserved for internal use, but are increasingly welcoming paying outside users to help make operations self-sustainable. Although these arrangements are often based on hourly usage rates, biotech companies must discover these facilities and contact their managers to gain access. Private facilities offering equipment are also becoming available. For example, TechShop (Menlo Park, CA) offers machine shops and hardware prototyping equipment in eight cities across the United States, with hourly usage and fixed membership cost models.

At present, individual labs often share equipment with labs at the same institution, especially where the researchers know each other well. This model could expand and is in fact changing, as database efforts, such as Kit-Catalogue (http://www.kit-catalogue.com/projectpages/), help institutions to internally take stock of and share equipment. Emerging open marketplaces, such as San Diego, CA–based Lab Fellows (http://labfellows.com/) and New York–based Synaptic (http://synaptic.bio a digital platform from Harlem Biospace; **Table 3**), could also enable efficient discovery of and access to equipment within and across institutions and private companies.

In terms of research costs, a large driver, particularly in drug development, is the production and maintenance of specialized reagent libraries. Initiatives to share these resources across companies include the Molecular Libraries Small Molecule Repository (MLSMR; http://mli.nih.gov/mli/secondary-menu/mlscn/ml-small-molecule-repository/) in the United States and the European Lead Factory (ELF; https://www.europeanleadfactory.eu/) in Europe. These consortia of academic, private and government organizations share chemical libraries and best practices for high-throughput screening to increase the chances of picking the right targets to pursue for costly further development. Participants share the cost of establishing and maintaining libraries and then pay at cost for checking out compounds from the library.

Efficiency gains from sharing are not limited to physical resources such as reagents or equipment: open exchanges and collaborative development of software tools can produce dramatic impact. For example, when labs adopt versioning systems (such as git) or publish software and data to public repositories (such as github or bitbucket), other labs can incorporate the projects into their own experiments, in exchange for reviewing the code and suggesting improvements. Nonprofit research institutions such as Sage Bionetworks are helping to structure collaborations across institutions for disease research as well as providing open software tools for collaboration. Cooperative development does not preclude the original author from licensing the code. For example, Broad Center's (Cambridge, MA) Genome Analysis Toolkit (GATK) is open source and licensed, such that basic researchers can use it for free, whereas commercial users pay for use, which ensures funding to maintain the project.

Labs are also pooling data sets rather than holding onto private but redundant data collection. In certain cases, labs have decided that the benefit of obtaining a more complete pooled data set outweighs any competitive risks. For example, in the Accelerating Medicines Partnership (AMP), a public-private partnership also involving the US National Institutes of Health (Bethesda, MD) and Food and Drug Administration (Rockville, MD), pharma companies and nonprofit organizations share data toward identifying biomarkers and understanding the underlying mechanisms of neurodegenerative diseases.

Although certain types of experiments can be readily outsourced to dedicated third-party vendors, most experimental steps cannot. Yet increasingly, customized research protocols, too, can be shared. Science Exchange (https://www.scienceexchange.com/) offers a marketplace for industry and academic researchers to identify other researchers able to perform specialized or complex experiments, with a review system to ensure reliable providers. Experimental protocols that can be highly standardized, such companies as Transcriptic (Menlo Park, CA) and Emerald Cloud (S. San Francisco, CA) provide automated and programmable robotic laboratories that are capable of performing repeatable experiments for life science research.

Table 2 Sharing of equipment, services, reagents and software

Name (URL)	Year founded	Description
Equipment		
BioSurplus (http://www.biosurplus.com)	2002	Clearinghouse for used equipment including direct sales and auctions
Kit-Catalogue (http://www.kit-catalogue.com/projectpages/)	2011	Open-source software for cataloging and sharing equipment deployed initially at a consortium of ten UK institutions
Lab Fellows (http://labfellows.com/)	2014	Open marketplace of labs offering on-demand access to specialized equipment
LabX (http://www.labx.com/)	1995	Business-to-business marketplace focused on classifieds and auctions for used scientific equipment
Seeding Labs (http://seedinglabs.org)	2007	Organization that facilitates donation of used but functional equipment to new or under-resourced labs
Synaptic (https://synaptic.nyc/)	2015	Platform enabling discovery and sharing of specialized equipment and expertise within a trusted network
TechShop (http://www.techshop.ws/)	2006	Nationwide network of community machine shops enabling equipment access with a simple monthly membership model
Reagent and sample banks		
Molecular Libraries Small Molecule Repository (MLSMR; http://mli.nih.gov/mli/secondary-menu/mlscn/ml-small-molecule-repository/)	2005	NIH-sponsored collection of diverse compounds for use in high-throughput screening of biological assays
European Lead Factory (ELF; https://www.europeanleadfactory.eu/)	2013	Consortium of seven pharma companies pooling resources including a library of compounds and chemistry assets
Information sharing and software		
Genome Analysis Toolkit (GATK; https://www.broadinstitute.org/gatk/)	2011	Cloud computing toolkit for analysis of genetic data sets maintained as an open-source project by the Broad Institute through commercial license revenue
TransCelerate BioPharma (http://www.transceleratebiopharmainc.com/)	2012	Nonprofit that creates standards for collecting and reporting clinical-trial data.
Accelerating Medicines Partnership (AMP; http://www.nih.gov/science/amp)	2014	Public-private partnership among US regulatory and funding agencies, nonprofits and commercial pharma to share information for validation of disease targets
Other		
Craigslist (http://www.craigslist.org)	1995	Tried and true online classifieds system often used to advertise research positions, including contract positions
Science Exchange (https://www.scienceexchange.com/)	2011	Online marketplace of scientific services from contract research organizations and academic labs seeking supplemental revenue; review system helps identify reliable providers
Transcriptic (https://www.transcriptic.com/)	2012	Robotic research platform capable of carrying out common lab experiments on demand from a library of reagents
Emerald Cloud Lab (http://emeraldcloudlab.com/)	2014	Automated lab platform that facilitates repeatable batteries of standard experiments

Table 3 Online platforms to enable collaboration

Name	Launch	Estimated monthly unique visitors to site[a]	Description
Authorea (https://authorea.com)	2012	NA	Tools for collaborative writing and editing of research papers with support for equation editing, version control and citation management.
Plotly (https://plot.ly/)	2013	281,000	Platform enabling collaborative data manipulation and visualization.
Mendeley (now part of Elsevier; https://mendeley.com/)	2008	217,000	Reference manager and academic social network. Tools to help discover, organize and efficiently cite research papers and discuss with peers.
Standard Analytics (http://standardanalytics.io/)	2014	NA	Publishing platform with tools for linking data sets seamlessly and facilitating transparent reviews.
Academia.edu (https://www.academia.edu/)	2008	3,100,000	Social network for sharing research papers that provides detailed statistics on traffic to shared work.
Benchling (https://benchling.com)	2012	29,000	Suite of tools for collaboratively designing experiments and analyzing data. First tools include CRISPR guide design, gel image analysis, among others.
ResearchGate (https://researchgate.com)	2008	1,900,000	Enables researchers to share papers and data by uploading PDFs of their articles and searching a database of what others have submitted.
Synaptic (https://synaptic.nyc)	2015	2,000 (limited beta)	Collaboration and resource-sharing platform enabling research labs and science-based ventures to share equipment and expertise.
Figshare (https://figshare.com)	2011	41,000	File repository for storing research outputs and data available in a citable and shareable manner.

NA, not available. [a]Most data from Compete.com May 2015 traffic estimates.

For business services, in Avalon Venture's Community of Innovation (CoI), experienced scientists, chief financial officers and other senior talent are hired to split their time among the cohort of supported ventures. This arrangement enables ventures to access more senior or specialized talent than they could individually afford. On the other side of the table, the hired individuals can hedge their professional risk by getting to know a set of early-stage teams and, based on this perspective, picking one to eventually join full time.

Online platforms for collaboration. Collaborative research is on the rise to advance multidisciplinary subjects (consider the rising numbers of coauthors in research publications[8]). Online platforms for peer-to-peer exchange of expertise and ideas, specific to the needs of the biotech community, are also increasing (**Table 4**). Such tools as Mendeley (https://www.mendeley.com/), Authorea (https://www.authorea.com/), Academia.edu (https://www.academia.edu/) and Standard Analytics (http://www.standardanalytics.io/) enable collaboration based on sharing and authoring research publications, data visualization (for example, Plotly; https://plot.ly/), data analysis (for example, Benchling; https://benchling.com/) and data archiving (for example, Figshare; https://figshare.zendesk.com/hc/en-us—a service receiving funding from Digital Science of the Holtzbrinck Group, which is also an owner of Springer Nature, the publisher of *Nature Biotechnology* and Bioentrepreneur). In addition, online platforms, such as ResearchGate (http://www.researchgate.net/) and Synaptic (https://synaptic.bio/), are connecting researchers who share common interests or who have specialized expertise.

Financing. Beyond the pitching of biotech concepts to select groups of investors, the landscape for investing in biotech startup companies is also shifting[9]. Platforms such as the crowd-sourcing site Poliwogg (http://www.poliwogg.com/), FundersClub (https://fundersclub.com/) and AngelList (https://angel.co/) are emerging to facilitate matching of life science companies to accredited individual investors who desire to contribute to medical innovation but would otherwise have limited visibility into available opportunities (**Table 4**).

Small investments can be especially important when impactful, cost-effective milestones are identified[10]. In the earliest stage of a project, where there may be insufficient data to attract accredited investors, life science crowdfunding platforms, such as Medstartr (http://www.medstartr.com/) or Dodo Funding (http://dodofunding.com/), allow the general public to support a venture's product validation work with small donations. For funding basic research, Experiment.com (https://experiment.com/) connects scientists directly with donors who receive updates on the progress of the research, and the platform Thinkable (https://thinkable.org/) allows the public to be patrons of research by giving small

Box 2 How Celmatix leveraged sharing from founding to revenue

In 2009, Piraye Beim obtained her PhD from Weill Cornell Medical College and, with a colleague, started Celmatix, a company aiming to use molecular and clinical information to provide personalized treatments focused on women's fertility. The lack of lab infrastructure hurt their chances for Small Business Innovation Research (SBIR) grants, and even a modest-sized award would not have been sufficient to purchase their own sequencing instrument. Instead, they followed a 'lean' philosophy. They first worked at home, but after an angel investment allowed them to hire three people, they moved into co-working spaces in New York (Sunshine Suites, then WeWork). For sequencing, although many companies were not interested in partnering with them because of their small scale, they were able to persuade two companies to let them use their sequencing services (Basel-based Roche's 454 and Aliso Viejo, CA–based Ambry Genetics). In 2013, Celmatix raised $13.5 million in a Series A financing round, and today the company works with 3,500 patients across three clinics with earned revenue. Celmatix continues to use external companies for storing samples (BioStorage, run out of Rutgers University in New Jersey), sequencing (the New York Genome Center) and cloud storage of genomic information (Amazon Web Services). They are now building out their own space for the first time: a 10,000-square-foot office with a small wet lab for laboratory-developed tests consistent with US Food and Drug Administration quality control.

Table 4 Emerging funding options

Name	Launch	Description	Funds raised and platform fees
AngelList (https://angel.co/)	2010	Platform connecting angel investors with projects. Prominent investors can also lead syndicates that pool funds of other investors. Not life science specific, but nearly 90 companies are listed in "therapeutic" category.	Investments in 243 companies totaling $104 million in 2014 alone. AngelList receives a 5% carried interest on profits, and lead investors can choose to take an additional carry of up to 20%.
Dodo Funding (http://dodofunding.com/)	2013	Biotechnology-focused crowdfunding platform. All or nothing model means that funds are transferred only if the project raises its stated goal. Rewards to backers are encouraged.	Listing a project and making a pledge is free, but for funded project DoDo charges a 5% commission plus PayPal processing fees.
FundersClub (https://fundersclub.com/)	2012	Online venture capital platform consisting of a curated network of accredited investors who cooperate to vet ventures they will collectively invest in. Recent life science investments include BioBots, Sano, Notable Labs and Sanguine Bio.	159 companies funded to date since launch, with a 1.8% acceptance rate for ventures applying for funding. Company reports total investments amount to $40M/year with biotech interest growing.
Medstartr (http://www.medstartr.com/)	2012	Crowdfunding site designed to collect donations for healthcare oriented innovations. Provides service option of active support to teams unfamiliar with running their own funding campaigns.	As of early 2015 Medstartr reported 100 projects funded since launch. Fees amount to 5–11% of funds raised depending on level of campaign production support and marketing.
Poliwogg (http://www.poliwogg.com/)	2012	Investment platform for the stock of private healthcare, biotechnology and life science companies that seek direct investments. The company also operates exchange-traded funds (ETFs) focused on young public biotech firms.	Listed companies receiving direct investment pay undisclosed cash + equity fee to platform. Managed ETF charges investors a management fee of 2.5% of invested funds.
Experiment.com (formerly Microryza; https://experiment.com/)	2012	Crowdsourcing platform for donations to scientific research projects. Also facilitates updates on research status to supporters.	Since launch, has raised $5.1 million across 373 funded projects with an average project size of $12,042. Fees are 5% of raised funds.
Thinkable.org (https://thinkable.org/)	2013	Platform allowing the general public to become patrons of research by pledging a small monthly donation.	Charges a fee equal to 10% of sponsorships plus payment processing fees of 2.4–3.4%.
VentureHealth (https://www.venturehealth.com/)	2013	Investment platform enabling a group of accredited investors to co-invest with the life science venture fund Incube Ventures at smaller amounts than would be typical for limited partners in a venture fund.	Charges an undisclosed management fee and typically receives 20% carried interest on the proceeds of investments of the fund when such profits are realized.

amounts each month. Such direct, peer-to-peer marketplaces are expanding the pool of capital available for seed- and early-stage life science companies.

The revolution is now

This article has focused on the increasingly important role of sharing in biomedical innovation and commercialization. Many have argued that there are differences between business models for software, which are open, and those for biotech, which are usually closed. Compared with software development, in which online collaboration is common, biotech inventions are often patented and more difficult to replicate and steal, and thus there could be more to gain from sharing experiences and expertise.

To address the centrality of intellectual property in biotech innovation, sharing platforms can be structured in flexible manners and need not be exclusively open or closed. Open and private sharing models (for example, with embargoes on data release that allow patenting) can coexist to promote collaboration while safeguarding intellectual property. Indeed, venture and industry investors often share domain expertise among companies in their accelerators and among their portfolio companies.

The traditional route for biotech innovation limits innovation to a small number of individuals (typically, those with an established reputation or track record) whose ideas are selected by a small number of gatekeepers (that is, traditional venture capitalists). At the same time, more universities are participating in biomedical research and training PhD scientists[11,12]. These scientists have highly developed expertise but are competing for a small set of traditional academic and industry positions. The sharing model thus presents an opportunity for a larger number of scientists to pursue promising technical concepts funded by novel mechanisms (**Box 2**). As a result, more ideas with more technical data will have a chance to be vetted for further investment. Ultimately, the biggest winner could be the general public, which benefits from the pursuit of a large number of technical concepts for diagnostics, therapeutics and medical devices.

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The authors declare competing financial interests: details accompany the online version of the paper.

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Erratum: Share and share alike

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In the version of this article initially published, in Box 2, the company name Celmatix was misspelled twice as Celmatrix. The errors have been corrected in the HTML and PDF versions of the article.