A "From the Board Room" Perspective by the Special Edition Co-Editors

Introductory Overview to Special Edition – "Building and Leveraging the Innovation Ecosystem and Clusters: Universities, Startups, Accelerators, Alliances, and Partnerships"

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ABSTRACT

This article focuses on the concepts of ecosystems and clusters, with an emphasis on their importance for building vibrant a vibrant and life science/biopharma industry. We illustrate the underlying principles through work published in academic articles and in the popular press. These are highlighted in brief overviews of several mature and emerging ecosystems in the United States, Europe and Australia. The US perspective is based on our own professional life experiences in Boston, Silicon Valley, San Diego, and Pittsburgh, and, with a shorter preview of Philadelphia where we've both done business and have close colleagues. The article ends with a look to the future in a concluding section titled "What's Coming Next". It is our attempt to look at the future of digitally enhanced collaborative innovation. This is based on our observations during the first 9 months of the Covid-19 pandemic, social distancing, and working from a distance. We ask, what is the potential impact of these emerging digital technologies on work and advancement of the agenda in the life sciences industries? Will the pandemic transform or disrupt the borders and mode of collaboration of traditional definitions of ecosystems and clusters as we define them today?

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INTRODUCTION AND OVERVIEW

Previous work has introduced some of the key concepts and definitions underlying Ecosystems and Clusters, and highlight the key ingredients for success. Herein, we use common definitions that have been reduced for simplicity, and applied to innovation with cross industry perspectives. Simply, clusters are industry groupings that originate and grow in the overall environment provided by the ecosystem that pertains to the entire region or city. More precisely:

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- An ***ecosystem*** is a sustainable economic region comprised of a community or critical mass of interacting organizations and individuals that produce goods and services of value to customers. The community attracts capital (monetary and human) and is generally composed of the entire spectrum of parties required to support the creation or products and services and to generate economic value for the firms and for its surrounding community.
- ***Clusters*** are geographic concentrations of firms focused largely on one industry of the overall ecosystem to produce innovations in a market segment. Generally, the firms

in a cluster support a particular industry like biopharma, med tech, digital health, technology, etc. Some also add the term "hub" to delineate the geographical concentration or location within the region, e.g. center of activity of a cluster.

Boni has previously taken an entrepreneurial perspective and suggested that there are three P's required to build and grow successful companies: *People, Processes, and Problems*. This may also be considered as a very simplified, high-level framework to view ecosystems and clusters. The "Problems would relate to specific areas or market segments of biopharma and med tech, or digital health. The Processes include synergistic collaboration between or among multiple parties located in the ecosystem or cluster. And, in the embedded entrepreneurial culture and approach as well as the financial resources required. People, includes the human capital needed inside each company, but also present in the surrounding ecosystem or cluster so that collaborative innovation can occur, and more importantly to reach critical mass. For, example this includes: public sector engagement and leadership of public/private partnerships, research universities and hospitals, a skilled workforce, a culture to support risk taking, and a strong financial sector with strength and diversity across the life cycle from startups thru mature organizations.

Rich Bendis (see his publication in Section Two of this special edition) suggests a short list consisting of the following success factors: 1) Strong Leadership; 2) Significant Industry Engagement; 3) Talent; 4) Access to Capital; 5) Research Assets and Facilities; and, 6) Market and Brand Awareness.

Research universities have been noted as a source of the technologies that fuel innovation. We also note that accelerators, either corporate or independent, have become an important part of the innovation ecosystem development in recent years, e. g. moving technology from the lab towards validation in New Cos. Brad Feld, a co-founder of Techstars is a luminary pioneer in the realm of accelerators having created Techstars first in Boulder, CO and then scaling nationally. His book, ***"Startup Communities: Creating a Great Entrepreneurial Ecosystem in your City"*** highlights some of the important principles for building and sustaining innovation ecosystems cross industry. He highlights the importance of entrepreneurial leadership and of welcoming everyone in the community to engage in "the entire entrepreneurial stack". That is "tech talk" for: first-time entrepreneurs, experienced entrepreneurs, aspiring entrepreneurs, investors (angels, VCs, corporate VCs, mentors, employees of startups, service providers to startups, and anyone else who wants to and needs to be involved, e.g. government, universities, independent accelerators like Techstars, and corporate accelerators like J-Labs. It's bottoms up, not top down. One other piece of advice (that we discuss later) is to have a 20-year time expectation and commitment! We consider Feld's guidance to be great advice for any aspiring region regardless of location on the globe.

Going forward, we blend these perspectives to highlight the following necessary ingredients needed for building strong ecosystems and associated industry clusters in biopharma, med tech and digital health. This perspective is developed based on studies of successful regions that are covered in this Special Edition. In effect, we blend Boni and Bendis to frame the following set of necessary and sufficient conditions for successful development and growth of ecosystems and clusters in cities and regions:

1. They embrace and reward an entrepreneurial culture, and has (or is able to attract) strong leadership in both the public and private sectors, and who work collaboratively with a shared long range vision
2. Has strong universities and world class hospital systems to provide an educated workforce and a source of technologies and spinoffs
3. Attracts people who want to live in the region since it's a great place to live and raise a family – and is affordable
4. Has the ability to grow and/or attract leadership for biopharma, med tech and digital medicine (or health) organizations across the life cycle
5. Home to a full spectrum financial industry for sources of risk capital across the company life cycle to start, grow and build strong industry clusters
6. Has, or is building, one or more world class anchor organizations to serve as role models and attractors
7. Well connected and networked to collaborate with other regions in the US and internationally
8. The region is patient and persistent, and has "the grit" to prevail over the long period required to develop and grow the regional ecosystem and associated clusters

Moira Gunn who is co-editor of this edition pursues this topic later in this volume thru an article that focuses on the more "popular press" perspective on ecosystems and clusters. This article is titled **"Thought Leader Insights on Innovation Ecosystems and Clusters".** Some of the authors covered there include *AnnaLee Saxenian*, "Regional Advantage"; *Leslie Berlin*, the building of Silicon Valley from "Troublemakers"; *Richard Florida* ,"The Creative Class" and, Greg Horowitt "Rainforest".

We recognize that collaborative innovation is (and always will be) a hallmark ingredient of the broad biopharma industry. It is well known that the industry has grown and sustained the innovation pipeline thru partnering and M&A activity. That fact has been discussed in two recent publications by Boni & Joseph (Vol. 24, No. 4 (2019), 14-22, and pp 23-31. The first article is titled "Aligning the Corporation for Transformative Innovation; Introducing Dashboard 2.0; and the second is "Four Models for Corporate Transformative, Open Innovation. In that work, it is pointed out that there are similar parallels in other industries undergoing transformation – for example the recent evolution of autonomous vehicle partnerships and collaborations. In that regard, look to emerging clusters for autonomous vehicles in Silicon Valley and Pittsburgh. Boston, the Bay Area, and San Diego have emerged similarly in the biotech field, attracting pharma partners to complement their strong university and VC systems. Then, in the recent JCB special edition on "The Promises and Business Model challenges on Emerging Transformative Innovations (Vol. 25 No. 4), we go on to reinforce the need for collaboration and partnering by reinforcing the evolution of partnerships between emerging companies (universities, startups, early stage companies and their larger/existing leading to the emergence of the biopharma industry (marrying pharma and biotech).

The "success ingredients" noted above are illustrated in this Special Edition, where we highlight both US, and also in several typical emerging international biopharma/MedTech ecosystems and clusters. We do not specifically discuss the time scale for development of thriving ecosystems because it depends on both initial conditions, internal factors and externalities. An order of magnitude estimate can be obtained by examining the various regions in the US. We would estimate that to be in the 20+ year range. So, we included "patience and grit" to our necessary conditions. We elaborate briefly in a short synopsis below, the differences between an ecosystem and clusters in the last 20+ years, using the California (Bay Area, San Diego) and Boston as prime examples of mature ecosystems. We also point out what has happened in Pittsburgh (a "rust belt" city) and the DC/Maryland/Philadelphia areas, but still adjacent on the Eastern Seaboard). The "Tale of Two Cities" in PA (Philadelphia and Pittsburgh are highlighted. Each of these regions is explored in much greater depth in the papers that appear in Section Two.

AN EDITORIAL, AND PERSONAL "SNAPSHOT" OF SEVERAL ECOSYSTEMS THAT HAVE EVOLVED IN THE UNITED STATES IN THE LATE 20TH AND EARLY 21ST CENTURIES

This section is based on the personal experience of the co – editors from having lived and worked in all of the cities that we highlight in this From the Boardroom perspective. However, we've both done lots of business in Philadelphia, so we augment our personal experience with the input of our editorial board colleague Dennis Gross for an article included on Philadelphia. And for Pittsburgh, from Dennis Yablonsky who led economic development initiatives for the Pittsburgh Region, and then later for the entire Commonwealth of Pennsylvania as Cabinet Secretary of the Department of Community and Economic Development in the Rendell administration. Dennis Abremski and Paul Roben of UCSD also provide a perspective on San Diego the profound impact of UC San Diego on the emergence of San Diego as a great example of an ecosystem that has evolved into the leader in life science and other areas of advanced technology.

CBRE Group, Inc. (Coldwell Banker Richard Ellis) has recently highlighted the top life science clusters (ecosystems) in the United States, c. f. https://www.cbre.com/research-and-reports/US-Life-Sciences-Report-2020. They list the Boston/Cambridge area, the San Francisco Bay Area, San Diego and the Washington DC areas as the three top-tier clusters. Emerging areas include Pittsburgh as number one, followed by Houston and Austin. We highlight some of these below as a preview of more detailed summaries to be detailed later in this volume.

MATURE ECOSYSTEMS

Boston/Cambridge, MA – The "Hub"; historically a strong educational center with a strong economy, and with a historically world class system of higher education. This region also incorporates and a strong financial center, including venture capital, and built economic clustering in defense, technology and computing. The disruption of this computing and tech cluster by the microchip led to the decline and demise of industry stalwarts like Digital Equipment Company (DEC), Wang Laboratories, Computer Vision, and others circa 1990. Most of that shifted to Silicon Valley along with the microchip expertise. However, their regional strengths led to survival and regrowth: e. g., the educational community that is unparalleled with MIT Harvard, Boston College, Boston University, Northeastern, Tufts, etc.); a healthcare

system of world class stature (Mass General, Brigham and Women's, Beth Israel Deaconess, UMass, etc.), and an historical and very strong VC community with affiliated early stage funding vehicles. So, Boston always a "hub", re-developed an ecosystem and affiliated clusters that attracted pharma industry partners, that attracted significant investment capital in biopharma, med tech, robotics, etc. We'd note about a 20+ year transition period to rebuild the ecosystem around a new biopharma cluster adjacent to MIT and Harvard in Cambridge.

San Francisco/Bay Area – The "City by the Bay" has world class core strengths in education and healthcare (Stanford, Berkeley, UC San Francisco), strong VC and investment capital, entrepreneurial leadership and is perhaps the "gold standard" ecosystem with worldwide fame (and attempted emulation by many). The microchip revolution started in Silicon Valley which created a strong technology cluster starting in the 1970s, i. e. the tech-company cluster that currently exists in Silicon Valley, south of the City of San Francisco. And the world-famous Sand Hill Road, home to the most probably the largest concentration of VC firms, that is itself located adjacent to the Stanford University campus that is directly or indirectly responsible for a significant volume of startup activity cross industry. However, more recently, the younger generation preferred to live in the city. That trend, and the emergence of a biopharma cluster surrounding Genentech and UC San Francisco in South Bay led to the creation of a powerful shift to new clusters in the City of San Francisco starting in the early 21st century. That led to an interesting, not so subtle shift where many of the tech companies whose "younger employees preferred the city life" created operations there. This evolution continues with movement to the East Bay and closer proximity to UC Berkeley for both tech and biotech companies who need proximity to the City and Silicon Valley. Then, it spread even further east and north to build up the manufacturing operations required to support biopharma and technology. Of course, the VC system itself has migrated from Sand Hill Road in Menlo Park to cover the entire Bay Area ecosystem, including the City. So, we see multiple ecosystems and clusters that have emerged, and the greater San Francisco area is a "gold standard" for innovation. Critical mass occurred in this region over a similar 20+ year period and has refined and evolved over the next decade or so.

San Diego, CA – "America's finest City" – Traditionally a region with a strong military and aerospace supported economy, known as "America's Finest City" and a great place to live visit, and enjoy an enviable "Mediterranean climate" on the Pacific Ocean. General Dynamics (Astronautics and Convair), General Atomic, Salk Institute, and Scripps Institute of Oceanography were key components of the economy in the 1960-1970-time frame. And that led to a pivotal move – the formation of the now world class UC San Diego with its strong engineering and science programs, medical school and healthcare system. The emergence of this university to top tier US and International status occurred on an unprecedented short time frame. The entrepreneurial community was robust (albeit not in biotech). Science Applications International Corporation (SAIC) emerged as a technology services powerhouse that anchored an emerging, cross-industry technology cluster (the city wa a "unicorn" with a national and global footprint before that term became commonplace in the tech community).

Strong regional leadership recognized the need for change in the 1960's era, and the need for diversifying the economy. Major community initiatives started in the mid to late 1980's to support the development of an innovation ecosystem in San Diego led by a city-wide consortium of private and public sector leaders. UCSD Connect, and Tech Coast Angels emerged. The region worked collaboratively and since the 1990's, the San Diego Convention Center has hosted the annual international BIO meeting several times. That ecosystem is still growing with evolving concentrations or clusters in biopharma and technology. VC investment still lags their "competitor to the north", but a strong early stage investment and angel community has evolved, as has UCSD as a top tier university that attracts a large pool of potential entrepreneurs and innovators. And of course, San Diego is a great place to live and attract the workforce needed to grow the ecosystem. But the region is still waiting for the pivotal "magnet" company in biopharma. J&J located JLabs there as is Biogen Idec is located in Carlsbad in North County. And, Illumina is notable on the diagnostics side. As this paper is being written we find a recent announcement – a life science development firm has unveiled plans to transform eight acres along San Diego's waterfront into a mixed-use hub that could attract leading edge companies to the city. This is a significant investment, potentially signaling that the city may be at a growth inflection point. Most biotech companies are located currently in the Torrey Pines area adjacent to UCSD. https://www.10news.com/news/local-news/san-diego-news/massive-biotech-hub-planned-for-waterfront.

Philadelphia, PA. – A traditional center for the pharmaceutical industry with local anchor companies like Merck, GSK, and others, and with a strong educational/healthcare system at U. Pennsylvania and a strong and diverse base of highly regarded educational institutions like Drexel, and Temple. The region responded to the migration of pharma to other places in the 2000+ era, but retained their healthcare culture and workforce. So, in some respects the region responded more quickly than Pittsburgh with an entrepreneurial community

approach. And continues to emerge since then with emphasis on scientifically driven innovations in healthcare. The region has responded with pride to the recent acquisition of Spark Therapeutics, a gene therapy company by Roche. And note the analogy of Roche's acquisition to that of Genentech as an anchor firm in San Francisco.

PREVIEW OF AN EMERGING ECOSYSTEM IN THE UNITED STATES

Pittsburgh, PA –The "Steel City" was the "capital of the world" for leveraging its natural wealth that was stored underground – coal, limestone and natural gas. And, it capitalized on its network of navigable waterways to facilitate export. A strong industrial, manufacturing culture emerged in the early 1900's, consisting of coal, steel, and glass organizations, and led by an entrepreneurial cohort of industrial leaders, e. g. Carnegie, Mellon, et al. While the founders were entrepreneurial, those who led these mature organizations were less so. And, the entrepreneurial culture "disappeared", as the city became a home for Fortune 500 companies. And, fortunately for the city, for the large concentration of philanthropic Foundations formed from the fortunes of the former "barons of industry". Then crisis came, led by 'foreign competition' in the steel industry. The industrial steel base consolidated, leading to a drain of talent, and an economic collapse in the 1980's. Community leadership did finally come together in the early to mid-90's, led by the Allegheny Conference on Community Development, and multiple strong philanthropic foundations created from the wealth of industry leaders (and they supported entrepreneurial activities). In the early to mid 1990's, these organizations formed a coalition along with Carnegie Mellon University (CMU) and the University of Pittsburgh and its newly emerging medical center (UPMC Health System which has since emerged as an international force). This guiding coalition responded to build a new "meds and eds" economy that is just now being recognized internationally. Currently, we see the emergence of a strong Robotics/AI/ML cluster emerging from Carnegie Mellon. And, a nascent life sciences cluster (along with a very strong medical robotics cluster that serves both the technology and biopharma industries). Slowly, but surely the ecosystem is still evolving to support a large number of companies emerging from both CMU and the University of Pittsburgh. University and Commonwealth of PA funded "accelerators" (Innovation Works/Alpha Lab, Pittsburgh Life Sciences Greenhouse and more recently LifeX) were formed to support early stage companies. Both universities have built top tier technology transfer and entrepreneurial education programs over the last 20+ years.

What is still in development for Pittsburgh? – attracting significant growth capital, and company leadership to grow the new life science, med tech and digital health companies into industry leaders. This would be a precursor to the creation of a few, highly visible "anchor" companies in life sciences and tech e. g. a Genentech in the Bay Area, a Millennium or Moderna in Boston. And, to their partnerships/alliances with global companies in biopharma – companies like Roche, J&J, Merck, Amgen, etc. However, we do note that in Pittsburgh that "missing link" has started in tech with the autonomous vehicle evolution; Argo, Aurora, Aptiv, Uber and Lyft – and their global partnerships with automotive companies like VW, Ford and GM. We note that the UPMC Health System has made a significant investment in forming a venture capital organization thru the UPMC Health System.

NOTE – See expanded, more detailed case studies in later papers in this volume, e. g. Pittsburgh Ecosystem by Dennis Yablonsky, the Philadelphia Ecosystem by Dennis Gross, the Baltimore/Maryland/DC/Philadelphia complex by Bendis, and Darmody, and the Boston/Cambridge Ecosystem by Joseph, Windham-Bannister, and Mangold.

WHAT'S COMING NEXT? – DIGITALLY ENABLED COLLABORATION AND INNOVATION "BEYOND THE BORDERS" OF COMPANIES, ECOSYSTEMS AND CLUSTERS

In this concluding section, we look ahead to the emergence of virtualization and collaboration that has been noted over the last year, but accelerated during the Covid-19 pandemic. Our premise it that this trend of "digital collaboration will continue to proliferate even after Covid-19 has been brought under control. In a sense this might be extend our current world of ecosystems and clusters. That remains to be seen. "Creative destruction a discussed by Schumpeter is underway". As Tom Friedman said in a recent New York Times editorial dated October 21, 2020 quoting Ravi Kumar, CEO of Infosys; "because the pace of technological change, digitization and globalization just keeps accelerating, two things are happening at once: the world is being knit together more tightly than ever — sure, the globalization of goods and people has been slowed by the pandemic and politics, but the globalization of services has soared — and "the half-life of skills is steadily shrinking," said Kumar, meaning that whatever skill you possess today

is being made obsolete faster and faster. So, education is also being disrupted.

So, we included this short summary section developed to highlight a number of potential future opportunities. Some of these emerged earlier and have had limited traction. Others have become apparent in 2020 during the COVID-19 pandemic. Our intent is to provide a provocative summary of "what's coming next?" in our industry. Clearly these disruptions provide opportunities for innovation and extension of the ecosystem and cluster concepts utilized digital methodologies. Additionally, our intent is to use this section as a short preview that may encourage an on-ongoing set of articles and "From the Boardroom" perspectives for publication in subsequent issues of this journal.

In the following section, we start with a short summary of selected and potentially important "editorially noted" trends that have arisen from our observations. Each potential trend is then followed by annotated comments provided by our relationships with experts in these areas, interviews or their comments, and/or extracted from industry reports. **As we mentioned above, we encourage these and other authors to contribute articles on these and other emerging trends and developments.**

"The Virtual Classroom" enables "The on-line Conference" – Over the last decade we have followed and been personally engaged in the creation, evolution and utilization of on-line education and communication platforms. This experience came from our personal experience at Carnegie Mellon University and started nearly 10 years ago coincident with the roll out of on line education programs by Coursera, Udemy, Khan Academy, etc. This hybrid MBA program is currently ranked in the top 3 MBA programs as is at the leading edge of on-line curricula platforms as described below. It would follow that such a platform could be adapted to the creation of virtual conferences, conventions, meetings, etc.

For the MBA program, the Tepper program consists of part time MBA students located throughout the country. There are 3 components: Synchronous Classes held once per week live and on-line; Asynchronous classes for pre-recorded content, that can be completed as convenient for the student; and, Access Weekends held at convenient locations at the beginning of each class/program. The IT platform also permits team meetings since student teams regularly meet to work on collaborative projects as part of their course work. We'll cover that in the next section.

Similar programs are now being rolled out cross campus as on-line education became necessary with Covid-19. We believe that these platforms can be scaled and adapted to provide interaction and collaboration with distributed teams in organizations that have learned that "work from home" is a viable option. Going into the office is often not necessary, especially on a daily basis. Employees can now live in the mid-West and work for organizations located in the larger innovation ecosystems like the San Francisco Bay area, or live in the East Bay and work remotely, but perhaps with a weekly visit to the office. Perhaps this is the new normal and technology can enable these modes of work and education.

"The Virtual Collaborative Team" – As an extension of the on-line education platforms, leveraging, connecting and leading distributed teams remotely located, could lead to the "Zoom era of virtual collaboration", and use of social media to connect, communicate and collaborate, e. g. Facebook, Instagram, etc. But in this case, it is applied to business operations, not education or conferences. Some insights in this regard might follow from one of our colleagues in the Organizational Behavior and Theory group at the Tepper School of Business. Anita Wooley et al. at CMU/Tepper who studies collective intelligence; see recent Wired Article – https://www.wired.co.uk/article/remote-work-collective-intelligence. This article describes "what makes people work well together so that teams become more than the sum of their parts". We urge interested readers to read the entire Wired article. Below, we extract a few quotes from Wired and Wooley.

"Woolley observed that if a group performed well on one task, they tended to perform well on the others. This wasn't predicted by the maximum nor the average intelligence of the team members. Instead, Woolley found a collective intelligence score, "c", with predictive power: when the teams were brought back to the lab to play a video-game simulation, their performance was correlated to their c factor. The study, published in 2010 in the journal *Science*, was one of the first to suggest a metric for collective intelligence".

Competition within a team actually lowered its intelligence. One finding was that teams with more women outperformed male-dominated ones. "You have a benefit to having a majority of women, but you still need some men," she says. "The teams that are consistently more intelligent are gender diverse."

For Woolley, this represents the first sketch of what the productivity software of the future might look like: a facilitator that's running in the background, picking up on the fact that people are good at different things and prompting them when they are available. It's about managing individual skills and the allocation of effort, she says: "The tools help prompt that conversation." We might add, that might well be an analog of the teacher or professor in the "flipped classroom".

"The Virtual Laboratory" – Doing laboratory work in biopharma remotely thru robotics. A few years back some former student who had moved to California to do their doctoral work in San Diego and Palo Alto. After their graduations, D. J. Kleinbaum and Brian Frezza

started Emerald Therapeutics with funding from Peter Theil and the Founders Fund. A great achievement for two young entrepreneurs. Emerald Therapeutics was launched in South San Francisco to pursue "antiviral therapeutics for diseases such as HPV and HIV". During this time, they experienced frustrations with laboratory hardware and software. To simplify laboratory testing, the group wrote centralized management software for the different laboratory machines and a database to store all metadata and results. This may be viewed as a "laboratory operating system" including the ability to directly control instrumentation and manage inventory and procurement. Recognizing the value this type of system presented outside of their own development goals, Kleinbaum and Frezza launched this service in 2014 under the name Emerald Cloud Lab. In 2016, Emerald Cloud Lab and Emerald Therapeutics were spun off from one another, and both are independent corporations. Wikipedia reports that "as of July 2020, Emerald Cloud Lab offered full control of over 150 laboratory instruments, with plans to expand capabilities through 2021".

Having visited ECL and DJ many times over the years, we believe that the potential for the Emerald Cloud Lab solution would appear to be huge and as yet unexplored in full. ECL is still in its early stages of market penetration to innovators and early adopters, but it would seem that the "virtual laboratory" might have a large role in advancing the early stages of drug development with more consistency and capital efficiency – and the drug development company could be located in Oklahoma, Shanghai, Abu Dhabi – or San Diego.

Now, even more recently the robotically-enabled laboratory has seen a new innovation coming along that has significant potential for drug design and manufacturing. At the Lab of Professor Lee Cronin at the University of Glasgow, Professor Cronin have developed software that translates a chemist's words into recipes for molecules that a robot can understand. "Cronin and his colleagues described their machine's capability to produce multiple molecules last year, and now they've taken a second major step toward digitizing chemistry with an accessible way to program with the machine. Their software turns academic papers into "chemputer"-executable programs that researchers can edit without learning to code. This innovation was announced earlier this month in *Science*. The team represents one of dozens of groups spread across academia and industry all racing to bring chemistry into the digital age". These developments could lead to safer drugs, and fuel transformation in the biopharmaceutical industry (and others as well).

"The Virtual Expert Interview" – Many have expounded over the years regarding the importance of obtaining consumer and market insights through questioning, observing, networking and then using associative thinking to vision new products to test their hypotheses, c. f. Dyer, Gregerson and Christensen in The Innovators DNA. So, why not use AI/ML and data mining, as for example has been attempted using IBM Watson? We are aware of two emerging companies founded by close friends and colleagues, both coincidentally located in Pittsburgh and who tapped into the AI/ML expertise at Carnegie Mellon University to do just that. This is another example of using emerging digital technologies to anticipate need, including products and services driven by Covid-21.

We first provide publicly available descriptions of Civic Science and 113 Industries, and then go on to postulate how these solutions could be extended to develop and test products and services in the Covid-19 era and beyond – remotely and digitally!

In 2007, **Civic Science** emerged from the vision of founder and CEO John Dick that market research and opinion-gathering needed a new solution. Consumer and public-oriented businesses that had long relied on traditional polling and survey techniques found those methods were growing tired and less effective in reaching a representative audience. The emergence of social media sharing brought convenience and immediacy of the public's voice to the table, but also inherent biases and untrustworthy information.

Our ambitious goal was to develop a revolutionary new way to connect the real-time opinions of consumers to the decision makers who need that information every day – but to do so with depth, breadth, and reliability.

The company built their first survey website in early 2008 and, through extensive experimentation, database engineering, and software development, created what is now the fastest, most sophisticated, and most democratic survey solution ever invented. Today, we provide software and services to the world's leading brands media companies, and investors, while giving a trusted and powerful voice to all people.

Moving on to **113 Industries**, another Pittsburgh-based early stage company and taken from their website – "It takes some powerful AI technology, Natural Language Processing and even IBM Watson to sift through all the discussions happening across the web and identify high value segments, unarticulated needs and compensating behaviors. This is how we begin forming the foundational insights that go into effective product innovation and brand marketing. Is it technical? Yes. Is it also brilliant? Most definitely".

"All of our data is organic – consumers volunteer the information on forums, blogs, websites, and social media – anywhere public and online. Then, through pattern extraction and a Split-Sample methodology (blind analyses run on split samples of the data), we verify the accuracy and impact of consumer behaviors in the market".

"But when it comes down to it, no one gets humans like humans. That's why we leverage a hand-picked group of strategists with unique backgrounds (everything from material science engineer to psychologists to journalists) to discover the real human story in the data". These would be the "experts or interpreters" as defined by Verganti in his classic book, "Design-Driven Innovation".

Our point in including Civic Science and 113 Industries in this section, is that they both use digital, AI/ML technology to define consumer need and behavior just be monitoring behaviors and needs remotely via web, social media, and other digital means. In a Covid-19 world, why travel to do interviews as products and services are being developed? What is on the minds of people as new drugs and vaccines are being developed? How can the population that does not believe in vaccines be motivated to use them? Or masks!

"THE VIRTUALLY MANAGED CLINICAL TRIAL"

Endpoint news recently reported the Covid-19 motivated efforts of an early-stage, Los Angeles – based company, Science 37, c. g. https://endpts.com/pharma-giants-back-a-leader-in-virtual-clinical-trials-as-covid-19-blights-sites/. The digital platform developed by this company "connects clinical trial participants to researchers via telehealth and a network of home-health nurses. Patients can pick up a cell phone to participate, rather than risking a visit to a clinical site" many of which are operating under restrictions during the pandemic.

"Not all Science 37 trials are fully remote. The company's model allows researchers to opt for a virtual arm to traditional sites. But the pandemic has only exacerbated the need for remote trials". Investors in the recent financing included Novartis, Amgen, Sonofi Ventures, LuxCapital, Redmile Group and PPD.

"The Virtual Doctor's Office" – The emergence of telehealth has been accelerated during Covid-19 pandemic. A quick web search provides a broad definition that is useful:

"Telehealth is the use of communications technologies to provide health care from a distance. These technologies may include computers, cameras, videoconferencing, the Internet, and satellite and wireless communications. Some examples of telehealth include: a "virtual visit" via phone or video; remote monitoring at your home and communication to the provider; use of robotic technology by the provider remotely; alert sensors that communicate distress to the provider.

If you've been examined by a primary care physician or ophthalmologist recently you've probably had a telehealth service.

Conclusions, Extrapolations, and Validations – So, what's coming next? All of the above and more – enabled by entrepreneurs and innovators who anticipate need and leverage technology to find solutions to real opportunities. We predict that digitization and automation will drive the creation of new markets. Recall the definition: market = the job to be done + the executors + the context. In this case, the context has shifted due to the Covid-19 restrictions and constraints in many cases. The jobs to be done and the executors are more invariant. Some of these have been summarized briefly above, but there are many more.

Remote is in, and likely to remain for the near future. Our answer to this opportunity is to leverage technology that has been coming available, but perhaps the timing has not been right. There are many new opportunities coming for those who seek them in our industry.

As this article is being written, McKinsey just issued a new report that contains the responses of 800 executives. This report suggests and supports that a disruptive period of workplace changes lies ahead due to acceleration of automation, digitization, and other trends. See for reference: https://www.mckinsey.com/featured-insights/future-of-work/what-800-executives-envision-for-the-postpandemic-workforce?cid=eml-app.

We predict that ecosystems and clusters will continue to be the building blocks for our industry, but somehow the borders may shift as technology evolves and the workforce and regions adapt to change and opportunity. In this regard, we note recent shifting, and perhaps disruption of some ecosystems. A recent NY Times article by Margaret O'Mara published on Dec. 28, 2020 is titled "Is Silicon Valley Over? Not So Fast". O'Mara states that the obituary for California's tech industry has been written before, and it will be rewritten again and again and again. This is prompted by movement of some tech firms from SV to Texas, e. g. Oracle, Hewlett-Package Enterprise, and Elon Musk himself! Stay tuned in the biopharma, MedTech and digital health segments.