Accelerating Innovation (I): Shaping systems to tap better into collective intelligence

ABSTRACT

We organize to solve problems collectively that cannot be solved individually. No one lives enough days nor has the span of expertise necessary to be inventive, innovative, or just plain productive at the scale and complexity required. So, we gather specialists and divvy up work among them. Yet, too often, "the system" underperforms. In development and design, programs are introduced and people energetically work on one thing or another. However, output is too slow, too infrequent, and often insufficient in quality and affordability. Enabling processes like engineering support take forever. Operations are disjointed and frustrating.

There's explanation and correction for this problem of hard work unfortunately coupling with disappointing results. Part of the cause is how we design and operate the processes through which individual efforts are integrated towards common purpose. Typically, we cluster experts for critical mass and economies of scale. This works if we overlay silos with delineation of how work should flow step to step. Mapping how value progressively gets created allows individuals to align local priorities with system level ones. Moreover, providing clarity of how work is expected to progress helps people know both their roles and responsibilities and also their *relationships*—on whom they depend and who depends on them. This clarity about shared interdependence allows rich collaboration.

Unfortunately, even if integrative mechanisms were once clear, they erode. Individuals lose sense of the larger context, priorities become individualized—not systemized, collaborative conversations fall in frequency and quality, and the collective becomes disharmonious, with a marked fall in the ability to tap into distributed and collective intelligence. Inevitably, managers are forced to became reactive crisis managers. Fragmentation is not only the specialists' silos out of sync with other silos. Within silos, specialists end up acting like sole practitioners.

The solution is to redraw (and actively maintain) those integrative workflows, thereby changing the conversations from isolated to integrative and the output from unreliable to effective and efficient. These points will be illustrated by looking at the transformation made by a team in early-stage drug discovery, cutting from a year to six months the time to traverse a key phase, while generating better outcomes. They will be elaborated with reference to high-tech design, military operations, and medical care delivery so readers see these lessons as general purpose, not situation specific, so they can better imagine application to their own situations.

BETTER, FASTER, AND EASIER WOULD BE BETTER

Developing new medications engages humanity's best. Scientists, engineers, and technicians tap and add to society's collective wisdom to invent treatments for ailments that afflict others. Ask people why they do this type of work, and you'll realize their commitments are personal. Mottos like "providing health for all," "helping people do more, feel better, live longer," "creating a new generation of transformative medicines for patients," or "restoring health and saving lives" translate to particular individuals for whom remedy is needed.

Though inspiring, this work (like many others) can be frustrating. Developing medications can take a decade or more, costing billions, affecting availability and timeliness of treatment. One can imagine such delayed gratification impacting workers. In contrast, one can imagine the societal benefits of better therapies developed faster, easier, in greater variety and availability, and the commercial advantages for doing so.[1]

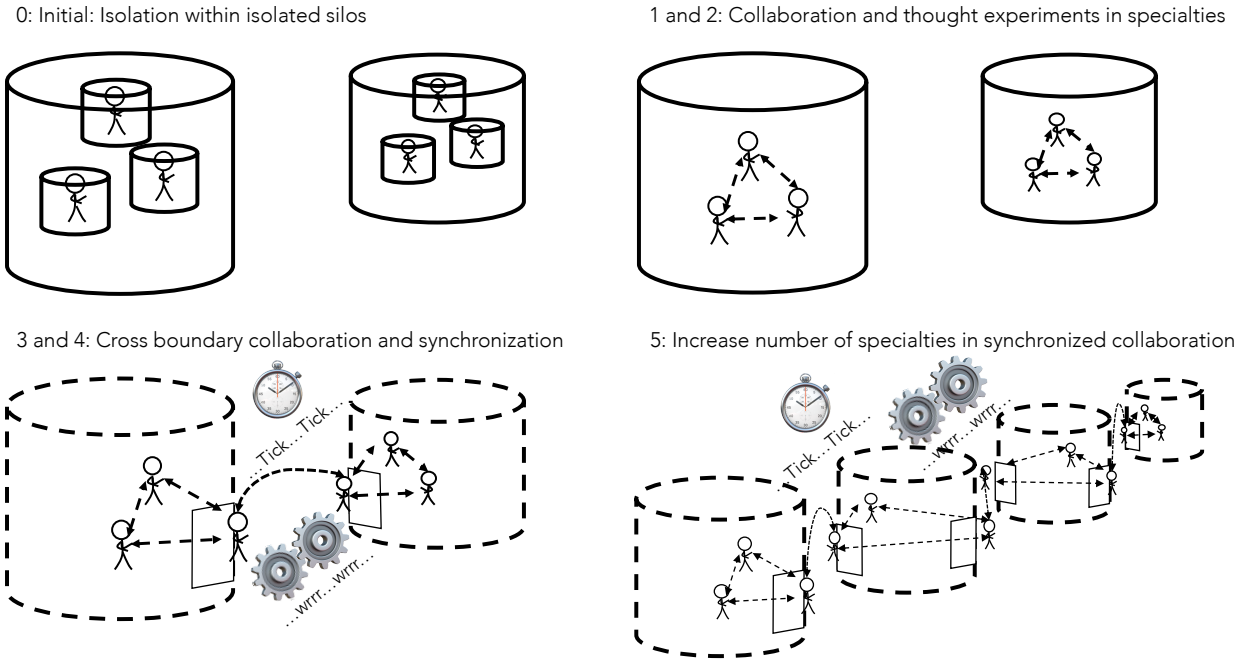
Of course, this gap between potential and aspiration, on the one hand, and reality on the other, is not limited to drug development. For many organizations, the whole is far less than the sum promised by the parts. So, just as the diagnosis of these gaps shouldn't be read as sector specific to the cases in this paper, the corrective actions should be seen as general purpose too.

WHERE TIME AND YIELD IS LOST

Bringing these concerns to a practical level, scientists—at first, primarily chemists in one set of labs and biologists in another, in a phase called 'hit to lead'—asked, where they were losing time and yield, and where might they regain both? As we'll see, they recognized and remediated avoidable disconnects of individuals from the larger systems of which they were part. This created opportunity for richer collaboration—first within specialties ("1" in Figure 1), then across boundaries ("2"), and then to a wider swath of the specialties involved in the work ("3").

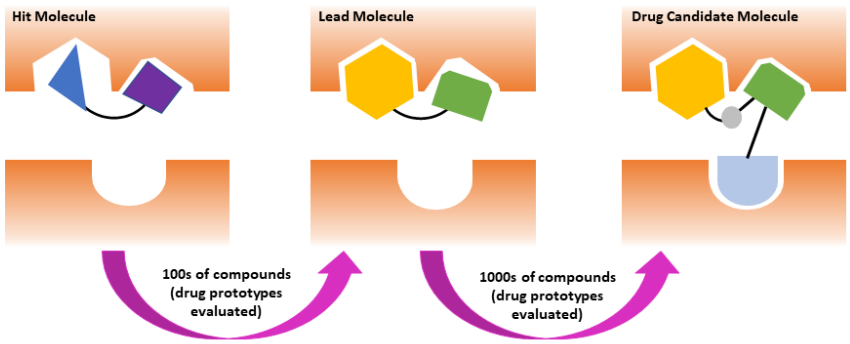
[1] In fact, it's not so hard to imagine, given the costs of waiting a year for the broad availability of a covid vaccine coupled with the amazement that several appeared years faster than normal. We'll return to this later.

Figure 1: expanding and improving the range of collaborative conversation



As background, 'small molecule' drug development has an overall workflow, as in Figure 4. In target selection, biologists identify misbehaving cellular proteins that might cause disease. In lead discovery, biologists—with processes like high throughput screening and computational chemistry—identify molecule types that *might attach* to the protein, causing it to behave better. Hits are developed so they *actually attach* and have effect, becoming 'leads' that are promising enough to be developed further. Our case is about 'hit to lead' phase, the first arrow in Figure 2; lead optimization is the second loop.

Figure 2: Progressing a hit to a candidate: the white space in the rouge protein is the binding pocket for the therapeutic molecule. The 'hit' molecule (blue and purple) has some ability to affix to the target. The hit molecule is a starting point for designing compounds with better attachment and modulation properties. The lead molecule (orange and green) has those better qualities.

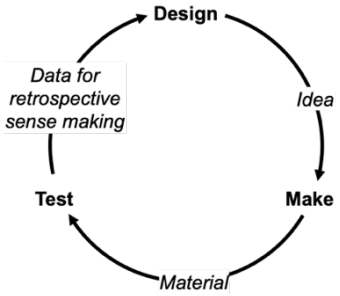


To put this in more familiar terms, think about these hits as being akin to the building designer's back-of-the-envelope sketch for a building on a plot of land, the sketch being the compound, the plot the targeted protein. These capture an inspiration, but they're hardly an answer. Sketches have to be developed into floor plans and elevations, replete with overlays of electrical, plumping, HVAC, with due consideration to building regulations, and budget. Similarly, hits need to be developed into actual compounds that can be synthesized and which test well. Other sectors—IT, new product development, manufacturing systems design—all have transitions from rough-cut ideas into detailed approaches for putting ideas into action.

With the biologists' hits in hand, the chemists create molecular designs (compounds) with the desired properties. Like the architect, who builds mockups and models and generates 2D and 3D renderings to test her ideas at small and quick scale, the chemists synthesize molecules in tiny batches, which can be run through complex tests. Those tests are created and administered by biologists (different than the group that generated the hits in the first place), working in another lab. Data from those tests are fed back to the chemists, who can use it to modify their designs and the synthesis processes they're developing.

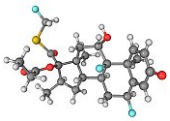
By running through cycles of Design (generate an idea), Make (actually synthesize compounds), and Test (run the trial compounds through tests to see their impact on how target enzymes and other proteins behave), the chemists and biologists arrive at designs that are 'leads' ready for 'optimization.' In optimization, there's further study and modification of the compound to improve its pharmacological effectiveness to justify expensive clinical trials of safety and effectiveness.

Figure 3: Design make test, one cycle



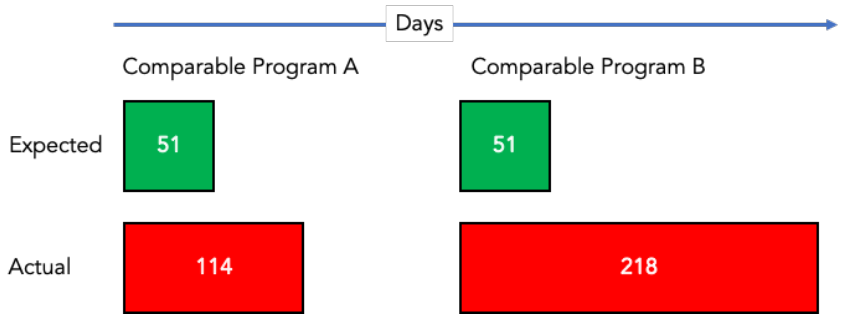
This is hardly a unique cycle for 'small molecule' medicines, which affect the behavior of proteins. Biopharmaceutical medicines are developed through similar iterative cycles of conceptualization (and reconceptualization), fabrication, and test to create new proteins that will change the behavior of a cell. Engineering intensive settings have their own recursive developmental cycles—for instance code, test, and debug for software and firmware. In turn, the handoff from lead-discovery to lead-development is akin to the architect who cycling through rounds of drawing and modeling before delivering construction documents to a contractor who can start creating a construction plan, IT developers kicking a beta version to engineers responsible for commercialization, and hardware engineers passing their best prototypes to their counterparts with more of a manufacturing orientation.

Figure 4: Steps in drug discovery

Stage	*Objective*	*Material produced*	*Compounds considered*
Target selection 	Find a cellular target protein on which a molecule can be attached to change biological behavior.		5,000 to 10,000
Lead discovery 	Earlier stage: identify compounds (called 'hits') which might attach to the target and alter its behavior. Later stage ('hit to lead'): Invent molecules (and how to synthesize them) that actually adhere to the target and show promise of effect in lab tests. These are 'leads.'	Micrograms, µg, one millionth of a gram.	
Lead optimization 	Identify the most promising of the leads and improve the process of synthesizing them. The output is a "candidate drug molecule."		
In vitro studies 	Test the candidate molecule for how well it performs in binding in the cell, how well it acts against (proxies) for the disease.		250
In vivo studies 	Test the candidate molecule in 'animal models' for efficacy and safety.		
Preclinical safety 	Animal studies to look for toxicity (both target and off target).		<5
Clinical trials 	Through three phases of study, check for efficacy and safety on human subjects.		1
Commercialization 	Produce at scale for commercial distribution.	Megagram (a million grams ≈ 1 ton)	1

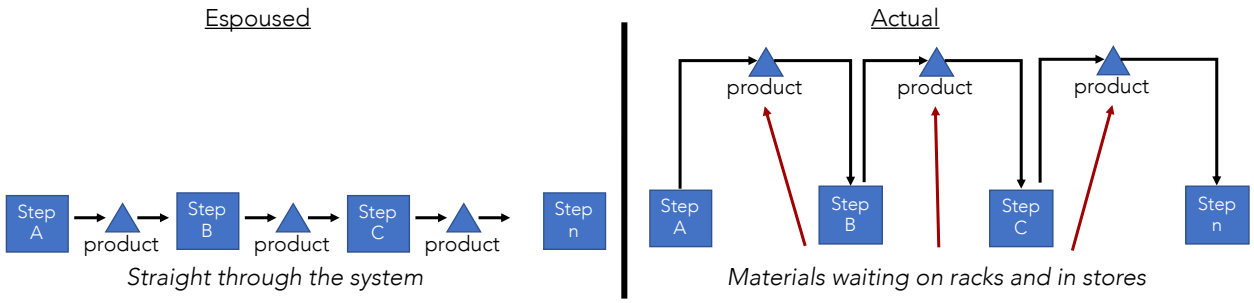
As a start in figuring out where time and yield might be lost, the team made their best estimate of how long three Design-Make-Test cycles would take (a reasonable number of cycles for ideas to converge based on experience). Their data weren't hypothetical; they used times recorded for tasks on previous, successful programs. 51 days seemed a reasonable approximation. Surprise then when they compared their summation of individual cycle times with actual start and finish transit time. One ran more than 100 days, another more than 200, 2X to 4X greater than the sum of the parts. (We imagine many are the readers looking nervously at their shoes, thinking that they too have such disparities between intention and outcome.)

Figure 5: Actual vs expected D-M-T cycles



The team looked closer for cause, realizing that though chemists were busy, they were not well coordinated. Individuals were not really working towards common objective. An idea would get started and instead of being picked up immediately for the next addition of value, it was put aside before being completed. Instead, other ideas got inserted into the system, with more stacking up. [This is reminiscent of poorly synchronized industrial processes that become inventory heavy. A simplified flow might seem rational, A—to—>B—to —>C, when in fact the actual 'flow' of products is in and out of storage racks, occasionally spending time at a work station. (Diagram inspired by *Dynamic Manufacturing*, Fig. 7-2, page 199.)

Figure 6: espoused versus actual work flows.

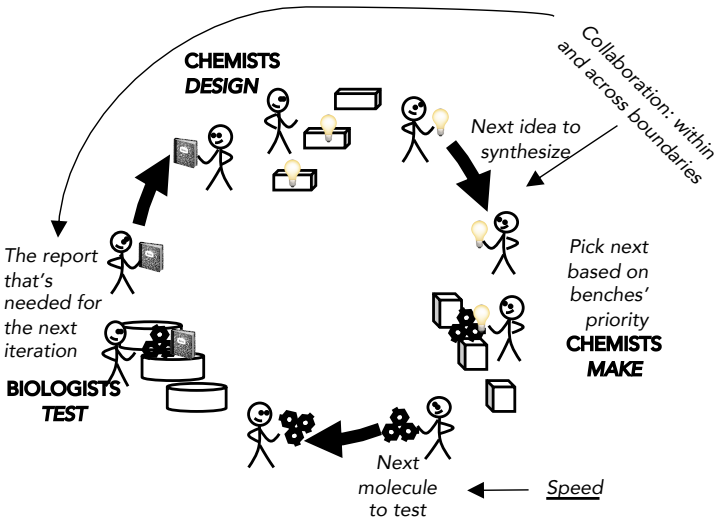


[In the book, *Team of Teams*, these are called "blinks," the gap between when something was first observed, but that information didn't move through the system fast enough to be actionable. We'll see how the strategies employed by the drug discovery team, below, match those used by the special operations command to radically compress the time between sighting and action.]

WHY TIME AND YIELD IS LOST

Here's why that happened. The company had groups formed around specialties—chemistry for different purposes, biology for different purposes, a variety of technical disciplines. Doing so makes sense. There's critical mass in having experts who can work together and economies of scale in using expensive equipment. Then, so long as there is clarity as to how the specialties fit together, we're consistent with the goal of increasing productivity and effectiveness.[2]

Figure 7: Organizing by function or domain (I)with expectation of in silo collaboration and cross boundary coordination.



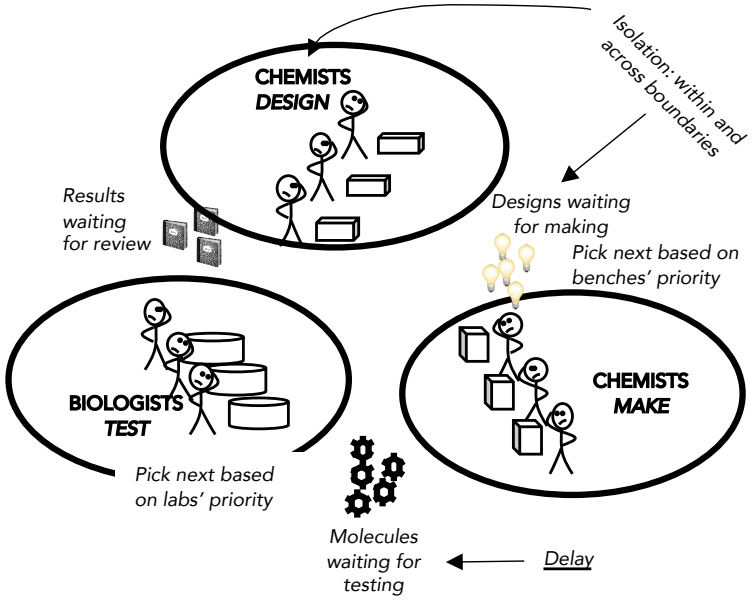
Maybe good in theory, but not in practice. The problem was, how work flowed through the hands and minds of the various specialists wasn't terribly clear, and how different inquisitive tasks should be prioritized and staged wasn't so obvious.

That meant that scientists might pick up work based on what's next in line, what's most interesting, what's easiest, but not necessarily what's on the critical path. This is why you would get work going 'on and off shelves,' like in the right side of Figure 6, rather than flowing from start to finish,

[2] The book, *Leaders*, gives partial credit for Albert Einstein's enormous productivity in 1905 to Max Plank, who used his editorial position with *Annalen der Physik* to create a collaborative community which served as a sounding board.

uninterrupted. And, with flows of work not clarified, indicating what was done by whom for whom, isolation occurred. It wasn't even just across boundaries, chemists to biologists. It extended to disconnects even within silos, which, of course, is contrary to why we even form around specialties.

Figure 8: Organized by function or domain (II) which become isolated islands



As an example of poor contextual understanding and its consequences, a chemist had an idea for a molecule that he could make easily, but which wasn't critical. Since it was easy and interesting, he made it. This inadvertently pushed back design and synthesis of more critical compounds that he could have been doing instead. This would have been bad enough if this was just a chemistry and biology two-silo problem; however the process of getting a newly synthesized compounds tested in a biological assay also required contributions from other groups whose contributions are required to purify, dispense, route and archive these "extra" samples. This was, in reality, a wildly complex, multi-silo problem (or even more confounding—multiple silos in multiple silos).

This problem of disconnect is hardly peculiar to these scientists, of course. Rife are situations were coders in the same department work in isolation, with someone working on a feature in which they take great pride, only to discover the feature wasn't even wanted. Or, as happened, a firmware debugger invested time and effort fixing something, only afterwards learning that a colleague had created a solution to just such a problem.

SIMPLIFICATION (CLARIFICATION), SYNCHRONIZATION, AND CHANGING THE CONVERSATION

The chemistry team lead arrived at a remedy that had impact on both speed and quality of idea development, because it allowed a much richer tapping of collective intelligence.

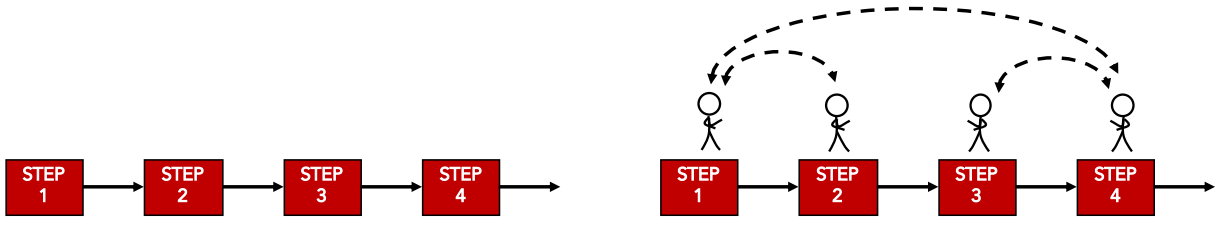
Before commencing this pilot program, she and the chemistry team mapped the development of ideas within and across the silos. If there were several compounds under consideration, who would be responsible for which was determined. If different portions of a particular compound needed attention, who would work on which section could be declared.

Bringing this back to our architecture example, this is like a design team coordinating attention about the handful of sketches that had to be developed into bona fide designs, or it is like that same design team splitting responsibility among themselves for different portions of the overall design—meeting rooms versus offices, cafeteria versus washrooms. There was benefit to this, in terms of a cascade of ever better collaborative, creative conversation.

But before we get onto that, let's just address two potential mis conceptions. First, this is not a question of the chemistry lead being more clear and more forceful in establishing priorities and responsibilities, as if the solution to time and yield in this complex, collaborative, conceptual work was just some cliched table-top banging. First, no matter how hard the pounding, most likely the chemists would have pushed back, their professional pride affronted. They all had PhDs too and years of bench-time doing cutting edge work. Even if such theatrics actually were effective, the ideas would have been hers alone, reflecting individual, not collective intelligence.

Second, some might say that this is just a matter of constructing a 'value stream map' or 'process flow.' To that, yes and… Typically such diagrams are created to capture the 'tasks' in a process, the steps on the pathway from start to finish. That informs discussions like: "Do we have the right tasks?" "Are they in the right order?" "Are there <non-value adding> tasks that can be removed?" (a big issue in the 'remove waste' ethos of the lean community?" "Are there tasks that are too slow, so are bottlenecks?" (a big issue in *The Goals* 'theory of constraints.')

Figure 9: mapping flow to highlight where collaborative conversation should occur.



Typical: is the task structure right?

This: are the right conversations occurring over gaps in the task structure?

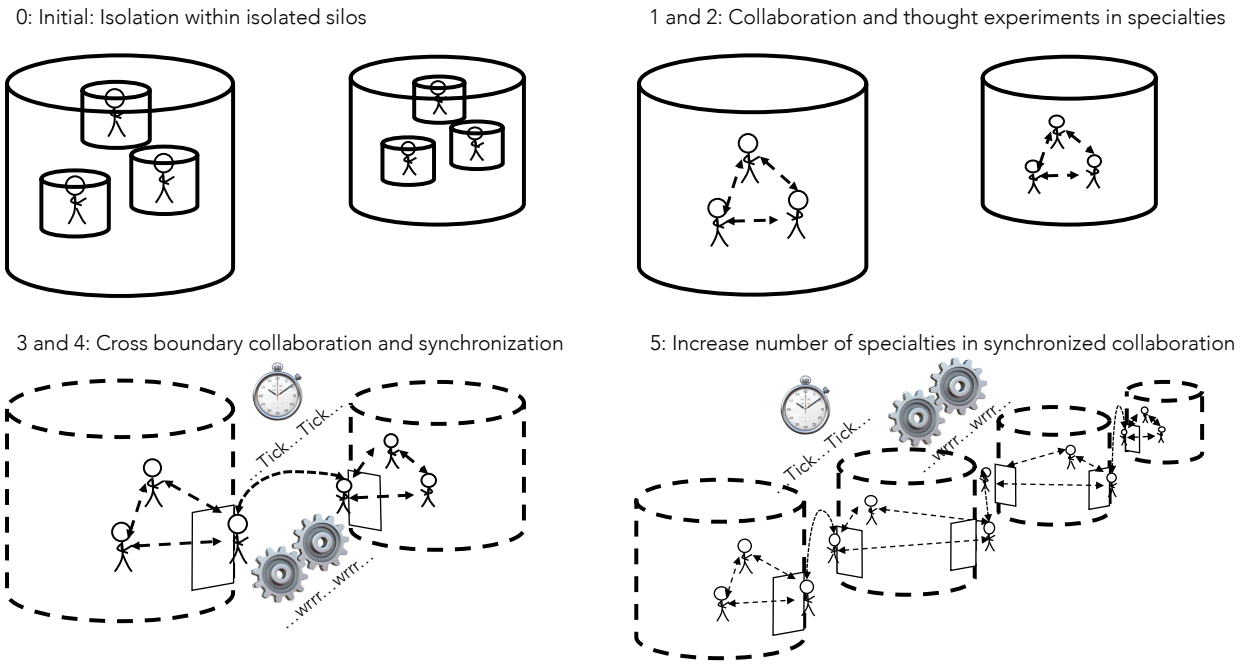
Those were issues not to be dismissed. However, the prominent issue for the chemistry lead was not just whether the tasks were assigned; it was whether people with particular responsibilities knew with whom they were in a relationship to have the productive collaborative creative conversations. If the typical map focuses on the boxes (in the left side of the drawing), this effort was to make sure that the connective tissue was in place and was healthy.

Mapping the work flow (development of ideas) within and across functional units (chemistry and biology) led to a cascade of improved collaboration, which is listed here and developed below.

1. Context: By helping scientists see where each compound being developed fit into the larger program and where different portions of a particular compound fit into its development, data could be used collectively, not just individually to set priorities.
2. Low cost 'table top' thought experiments: Conversation about harmonizing on priorities created the chance for powerful thought experiments as precursors for actual experiments in the laboratory.
3. Harmonization/synchronization: With shared priorities more obvious, work within and between labs could be better synchronized.
4. Collaboration: Better sense of within lab and across lab priorities plus better synchronization of work created the opportunity for better collaborative problem solving. Rather than just 'ship' data from the biology lab to chemistry, the biologists started attending sessions to explain subtleties.
5. Expansion of collaboration and synchronization: as the work among chemists and between chemists and biologist become more tightly meshed, opportunities to sync with other elements of the overall workstream became apparent.

What we'll see is that the 'simple' act of identifying relationships invited collaborative conversation, which revealed opportunity for even more communication structures and collaborative mechanisms.

Figure 10: expanding and improving the range of collaborative conversations (Figure 1 reinserted for convenience).



1: CREATING SHARED SENSE OF LARGER CONTEXT

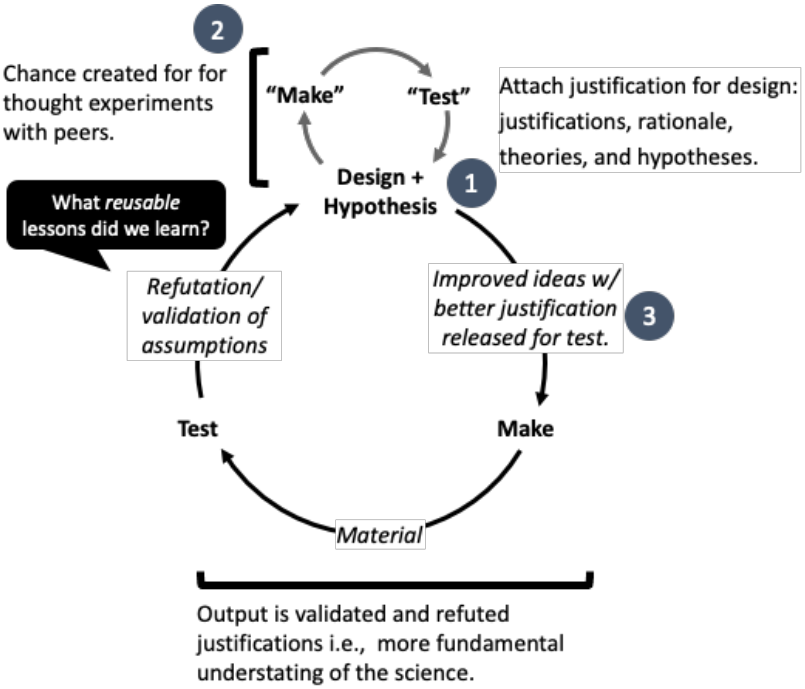
Making clear who was dependent on whom for what information created opportunity for collaboration and integrated problem solving that previously had been overlooked.

Within chemistry, the team starting talking through the overall objectives of the program, prioritizing compounds and aspects of different compounds as first, second, third to go through the system. [As for translating this to other fields…this is akin to the coders having collaborative debate about what feature had to be prioritized, what the test data meant for individual features and how the system was coming together. This is akin to an architectural team prioritizing drawings dependent on from which sub-contractors' bids are needed, to which regulatory authority information is owed, etc.]

Scientists knew with whom to work on the design of which compounds and where help was needing creating or running a synthesis. When data came back from biology, it could be discussed in the larger context of the program, not just what that data meant about the individual compound, but how the compound fit into the larger body of work. The same logic applied to the biologists developing and conducting their tests and generating and interpreting their results. That helped overcome stagnation and added to speed. It wasn't quite yet the trees being able to see the whole forest, but at least their perspective was starting to widen.

2: CREATING CHANCE FOR 'TABLE TOP' THOUGHT EXPERIMENTS

Figure 11: Design Make Test ....converted to... Design + Hypothesis Make Test



With the chemsists discussing prioritization of different compounds, they created the chance to discuss with more clarity the motivating rationales for competing points of view. In effect, the team was able to do 'table top' experiments, bona fide use of the scientific method, even before they went through the time-consuming physicality of making and testing. Someone could offer that they'd done trials based on similar assumptions and they had reason to believe there was validation or refutation. So, designs were already iteratively refined before being made and tested.[3]

3: CROSS BOUNDARY SYNCHRONIZATION

With chemists now using meetings not just for updates but for bona fide constructive give and take, data from biology labs had greater value. The data wasn't just used by individuals to update their understanding of their own efforts. Rather, that data could give better understanding of how individual compounds were aligning within the larger mix. This meant shared priorities could be updated and collective creative efforts realigned.

[3] When actual data came back, it was not screening of a particular molecule as pass or fail. Those reports helped build a repository of validated ideas to be reused and refuted ones to be avoided. Similarly, when the boundary crossing discussions between biology and chemistry picked up, the back and forth about "why this compound?" "why this test?" and what was validated or refuted by the test data could become richer too

Because of this, once the chemists starting putting the biologists' input to better use, they became more sensitive to synchronizing their own internal discussions with the arrival of new information. Rather than meeting every other week (which largely had been just individuals giving progress reports on their own work), they starting meeting every week for the shared discussion of the group's overall effort. After increasing the frequency with which it held meetings, the team then shifted when they met to align better with when the biologists' reports arrived. That way, there'd be less latency.

4: CROSS BOUNDARY COLLABORATION

With biology data being discussed more frequently, more quickly and with more energy, the chemists started realizing that the data needed contextualization. So, the next modification was having the biologists participate in the chemistry meetings. They'd give deeper explanation of how and why particular tests were developed to measure the impact on some protein's behavior, and they could give a richer explanation of how to interpret the data. With that widening of communication bandwidth, what next emerged was the opportunity for the chemists to explain with greater nuance what they hoped to learn from the biology lab. So, when the biologists developed tests, they were better informed about the reactions for which they were screening.

5: EXPANDING THE COORDINATION, COLLABORATION, CONVERSATION TO OTHER SILOS

There was cascading benefit from collaborating and synchronizing better, to tap into collective intelligence. Initially, recall, it was within the chemistry lab that people became increasingly sensitive to how individuals' work fit into a larger whole. That heightened their awareness of how they could better sync the chem lab's efforts with those in biology—both in terms of timing and content. That made it obvious to synchronize better with purification.

Eventually, this sensitivity to timing and content expanded to the group responsible for the safe, reliable provision of raw materials into the labs. Now that the labs were operating at higher tempo and more predictable cadence, their sensitivity to the right materials in the right place at the right time rose too.

That tapped the creative involvement of the head of chem stores. He engaged with the technicians for whom he was responsible, collectively harmonizing flows of information, location of materials, means of delivery so it was easier to be supportive of the labs' work. Then, with chem-stores operating too at a higher tempo and with coupled cadence, attention was turned to spanning the boundaries with external vendors to better tune the ordering and delivery of sophisticated materials needed in the various labs.

Back to a point with which we started this paper, that the invention of therapeutics is a lofty undertaking, one that should both deliver value to society and also provide pride in important work done. Tighter integration of chem and biology labs, linking both to purification, and then onto chem stores and external suppliers meant that more and more people had direct and more obvious connection to the endeavor of providing comfort and cure to those in need.

Stabilizing to Reduce Disruption

You might notice that there was potential for substantial increase in conversation within and across boundaries, much of it opportunistic, based on data that was discussed or other knowledge that got shared. Were scientists to be too tightly scheduled, there wouldn't be time for these extemporaneous inquiries.

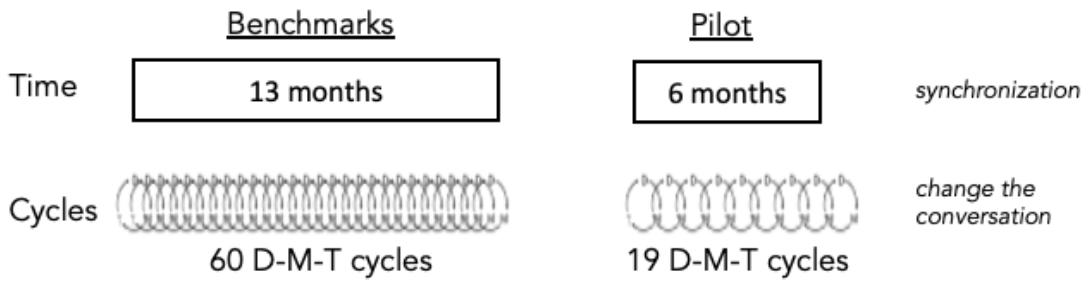
To protect against such a risk, the lead chemist changed how she assigned work. Rather than fully loading chemist's schedules, the assigned work load was tuned to 85%, with the remainder left as 'slack time' for extemporaneous activity. If someone needed more time for their own efforts, to confer with a fellow chemist or to consult with a biologist, they'd have it. If they needed less time, they could cover an ancillary topic or lend help to someone in need. These mechanisms where stabilizing, keeping local problems from persisting where they were first experienced and keeping them from spreading systematically.

Results of EXPANDING and Enriching the Conversations to Tap Collective Intelligence

There were positive consequences from structuring processes so workflows were more clearly defined, with better synchronization across priorities, with collaboration over exchanges, and with slack and support to provide stability.

In previous benchmark programs, start to finish (hit to lead) was about a year. This program completed its hit to lead journey in six months. Not only that, the benchmark programs required some 60 Design-Make-Test cycles. This program required on 19.

Figure 12: Impact



Not only had the team of chemists, biologists, and technicians worked less hard and a lot faster, they had better results. Chemistry had been handed more hits to consider (i.e., their start point was more ambiguous, less certain as to where to begin), yet they delivered more promising compounds to the lead-optimization group, each with better metrics than typically was the case.

These are non-trivial results. Imagine the societal benefit if this six-month acceleration could be preserved and even multiplied through lead-development and the several stages of clinical trials. It'd mean getting treatments to patients, months if not years faster than currently the case. And the benefits to the companies able to do this would be enormous too. With any therapeutic, the benefits of being first to market rather than second third or fourth are enormous in terms of percentage of potential revenue. Every extra *day* under patent protection is worth millions.

FROM SPECIFIC TO GENERAL

This transition from hard work and low yield for conceptual efforts to conceptual work that requires less work but has higher yields faster is not just the experience of these scientists. Pratt and Whitney took a similar discipline of making explicit the flows of work required to design a jet engine. After the company had a series of costly loses in contests, the pilot program of 'engineering standard work' won the F-35 program, with revenue at $10M per engine for an expected 3,500 aircraft, plus service parts and maintenance.[4]

The US military's Joint Special Operations Command found itself unable to maintain an operational tempo adequate for fighting al Qaeda in Iraq effectively. The root cause of the problem were different specialists (i.e., Army Rangers, Navy Seals, CIA analysts, etc.) working within their silos, but without a shared sense of prioritization and appreciation of the (informational) needs fore and aft. Making clear the flow of work—from data being gathered in a raid, through that data being converted into meaningful intelligence in analysis, ending up in planning of timely missions—led to a multifold improvement in operational tempo, efficacy in finding the targets and conducting successful missions, all without adding people or materiel.[5]. These exact themes are what has led to disastrous software projects, often involving thousands of software engineers; and the same types of techniques described in this paper also are what

[4] See chapter 5, *The High Velocity Edge*, for details.

[5] Based on *Team of Teams* plus conversation with the authors.

has led to orders of magnitude increase in productivity, often described as Agile and/or DevOps, pioneered by the tech giants in the 2000s (e.g., Facebook, Amazon, Netflix, Google, Microsoft) [6][7]

In fact, if one goes back to Taiichi Ohno's 1978 explanation of Just in Time, one might think that his advocacy for linear flows versus job shops, and cleaner direct connection between adjacent steps versus centralized production control was out of concern for equipment utilization and material flows. After all, he'd evolved his management thinking in an engine plant and he was the architect of a system for managing the manufacture of automobiles. Yet, Ohno's primary concern was returning time to people so rather than mindlessly managing inanimate objects, they could devote their creativity to understanding the products and processes for which they were individually and collectively (collaboratively) responsible.[8]

Common across these several examples and others is people spending too much time figuring where they fit in to the larger whole, tracking down the information they need to do their work, and having to be accommodating of inputs they receive (e.g., data scrubbing), the arrival of which seems arbitrary. The solution in each of those situations was to give clarity as to what was the necessary flow of work (who had a mutually dependent relationship with whom, making more linear those flows were possible, with leaders facilitating the conversations about common priorities, roles and responsibilities, and relationships within shared dependencies, all to increase the productivity and ease of integrating the contributions of many into a well-functioning collaborative whole.

In these and other instances, the liberation and application of people's creative energy to do things of great value was amplified magnificently.[9]

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[6] *Microsoft's Secrets: How the World's Most Powerful Software Company Creates Technology, Shapes Markets, and Manages People*, 1995 and "How Microsoft Makes Large Teams Work Like Small Teams," *Sloan Management Review*, Fall 1997.

[7] *Accelerate: The Science of Lean Software and DevOps: Building and Scaling High Performing Technology Organizations*, Dr. Nicole Forsgren, Jez Humble, Gene Kim

[8] Ohno, Taiichi, *The Toyota Production System: Beyond large scale production*, (English) Productivity Press 1988.

[9] Development of covid vaccines: While waiting for a covid-19 vaccine was painful socially, economically, and medically, that we've several in wide distribution only but a year after the pandemic was recognized as such is remarkable. That speed is consistent with the model we're developing about simplification of workflows to make for more

productive collaboration. Operation Ward Speed changed the business model for pharma companies. Rather than having to weigh the high cost and slim chances of R&D against the potential rewards of inventing medicine, companies could commit resources to vaccine development because the government paid them for the bench time. That accomplished two things. First, it made it easier for more companies to commit to the inquiry. Even if the odds for each were still slim, society's odds went up—like Bingo, the more cards you're playing the more likely you'll score. The second effect that those trying to develop a vaccine could put their other work aside and focus monomaniacally on covid. Yes, this meant they could shift talent from other programs to this one. More importantly, it meant that everyone in myriad specialties and disciplines were working to common goals—systemic priorities translated to local priorities cleanly.

That does beg a question. Having had such speed to a solution relative to what might have been reasonably expected had a cost (that of the funding behind Operation Ward Speed), but the benefit of being able to ensure health while reopening the economy has to be a fabulous ROI. So, going forward, does the public sector eat the R&D costs associated with other pressing ailments in exchange for having more teams chasing solutions, each accelerating their innovation by using similar focusing approaches?