Editorial: “Set My Scientists Free” - Scientific Phone Apps and DIY equipment during lockdowns.
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INTRODUCTION
The SARS-CoV2 pandemic of year 2020 caused unprecedented disruptions globally. With lockdowns implemented in many countries, scientific research such as biomedical sciences, experienced major disruptions in the access and supply of research materials and equipment.

With these disruptions, the dependence of research on centralized infrastructure had become apparent. Without the scientific equipment and the associated infrastructure, many aspects of research grinded to a halt. Yet, this highlights the need for adaptations to build our own devices, particularly how scientific apps and mobile devices including the “Internet of Things” can help. In this, a phrase that I previously used to describe the early work of scientific phone apps – “Set My Scientists Free” seems apt to describe a much-needed change.

“STRUCTURES BECOME SHACKLES”
Rehashing from a previous review on biomedical science mobile apps (Gan & Poon, 2016), many scientific discoveries took place in the private living spaces of the scientists. From Antonie van Leeuwenhoek’s “Animacules” (Dunea, 2018), Edward Jenner’s now-unethical smallpox vaccine (Riedel, 2005), Gregor Mendel’s peas (Miko, 2008), to Alexander Flemming’s accidental Penicillin (Tan & Tatsumura, 2015), many of these discoveries would have been impossible with today’s scientific structural restrictions and bureaucracy. The re-quoting of “structures become shackles” from Christopher Nolan’s 2012 Batman movie is now uncannily fitting in how the experimental scientists of today are shackled to the specialized equipment and associated infrastructure.

The dependence on infrastructure, while improving efficiency, may also be departing from the spirit to how the very first scientific equipment, along with many scientific discoveries were made. And it is in this spirit that scientific phone apps, such as those that could displace equipment e.g. APD Colony Counter (Wong, Yeo, & Gan, 2019), GelApp (Sim, Nguyen, Lee, & Gan, 2019) were made. With these examples, there is certainly space for an increase in the variety of such apps to eventually allow entire research processes to be performed in setting scientists free.

Coupled with 3D printers and microcontroller kits, more devices that leverage on sensors beyond the repertoire within smartphones could be made (e.g. APD SpectBT in Ng et al., 2019). Just as was proposed for psychological research (Gan & Yeo, 2020), the same could be made for other research disciplines, including improving accessibility of scientific research to the general public in citizen science.

UNSHACKLING
There are certainly challenges to making a “home-made” high precision and high accuracy equipment. No one would argue that equipment like a Synchrotron or an electron microscope would best be centralized given the infeasibility of having one in personal living spaces. Research requiring high biosafety containments are also best kept centralized. Yet, let us not forget that scientific progresses were made by intelligent individuals using their scientific acumen and powers of observation. None of the “fathers” of the scientific fields mentioned earlier relied on the structures that we are so dependent on today, even though some may argue that those discoveries were quite crude.

A short digression to counteract the objection, the great scientists of old utilized whatever was
available to them, including Leeuwenhoek’s building of the first microscope, a clear example of a technological breakthrough ahead of Leeuwenhoek’s time.

Apart from microcontroller kits and 3D printed equipment e.g. a cell incubation system (Vera, Schwan, Fatsis-Kavalopoulos, & Kreuger, 2016), “Do It Yourself” or DIY lab equipment or research consumables (such as bacteria agar using household materials, links provided in “Additional Resources”) are now widely available. These developments have moved into the molecular realm with the increased availability of open source projects and economical molecular biology reagents (such as those provided by the ODIN). It is almost certain that in time, more DIY devices will make available to complete the various research processes without expensive commercial devices, albeit at some compromises.

PROBLEMS

With DIY, microcontroller kits and apps to decentralize research, scientific research can be made more resilient to disruptions, and also a boon to those setting up a new lab. The advancing of humanity’s ability to discover new paradigms to improve lives and seed technologies can be made with less geological and financial constraints. Nonetheless, there is a caveat in potential risks of bioterrorism or even unreliable findings that result from uncalibrated equipment or weak scientific rigor. Naturally to control these unwanted effects, there has been an increase in bureaucracy and downright outlawing of certain activities e.g. conducting dangerous research in one’s own backyard. It is certainly hard to strike a balance between completely constraining research activities to be within regulated structures and allowing the natural growth from deregulated research.

It is perhaps timely to consider if the true shackles are the scientific structures or the dependence on them. Did we shackle ourselves with convenience and dependencies?

ADDITIONAL RESOURCES:

To unshackle, there is much the scientist can do in times of not being able to access our labs, or when starting a new one. Keeping the scientific spirit alive is in some sense, the purpose and aim of the work published in this journal, is to disseminate information on new apps and devices.

Including the possibilities beyond apps, below are some resources that the scientist, especially biomedical scientist, may benefit from.

HOME MADE SCIENTIFIC EQUIPMENT

Thingiverse – “lab equipment”
https://www.thingiverse.com/tag:lab_equipment

“DIY Lab equipment”
https://www.instructables.com/id/Laboratory-Equipment-1/

https://www.instructables.com/id/Homemade-Nutrient-Agar/

Resource guide to making generic lab equipment
https://hackteria.org/wiki/Generic_Lab_Equipment

Forum and Helpful DIY bio community:
https://groups.google.com/forum/#!forum/diybio

Protocols and economically priced reagents for DIY-Biohacking - The Odin

GaudiLabs – “Open Source Hardware Projects”:
http://www.gaudi.ch/GaudiLabs/?page_id=19

Biohack Academy:
https://github.com/BioHackAcademy

CitiSci:
http://citsci.blogspot.com/

SCIENTIFIC PHONE APPS AND OTHER DEVICES

Review on biomedical science apps:
Review on clinical apps:
https://scientificphoneapps.springeropen.com/articles/10.1186/s41070-016-0009-2

Editorial on 3D printing, microcontrollers and apps for psychology:
https://scientificarticles.apdskeg.com/Articles2020/promisesOfMicrocontrollerKitsAndSmartphoneAppsForPsychologicalResearch.html

Review of using apps to make apps:
https://scientificarticles.apdskeg.com/Articles2018/ProgrammingApp.html

Also check out the other articles in the journal “Scientific Phone Apps and Mobile Devices” at https://scientificphoneapps.springeropen.com/ArticlesList and its archived previous home at https://scientificphoneapps.springeropen.com/articles

CONCLUSION

On the back of enabling technologies like smartphone apps, microcontrollers kits, DIY instructions, and 3D printing, the scientist or even citizen scientist can do a lot to improve research resilience. It is a satisfying endeavor, enabling the expression of pure curiosity driven research with minimal bureaucratic and financial constraints. Most importantly, it is a form of reawakening the scientific acumen and observation, that is in the regaining of the scientific spirit fueled by curiosity and problem-solving that the scientific forefathers had.

In science, “where there is a will, there is a way”.

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