Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Science & Society

Synthesis and Assembly of Virtual Collaborations

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The interplay between academics and society within the environment of the COVID-19 pandemic has impacted on scientists across the world, prompting reevaluation of how virtual toolboxes can be used to support responsible collaborative research practices. We provide awareness of virtual resources and activities that enable scientific discovery using safe and efficient practices.

The COVID-19 pandemic is causing a global reevaluation of collective human behaviors and is significantly remodeling the scientific research landscape [1,2]. The pandemic is limiting in-person laboratory activities and constraining research operations, but scientists are adapting to this new model of research and are safely continuing what remains of their research programs. Although these changes are necessary to protect the safety of researchers and the general public, new policies may impact on the maintenance of research endeavors, decrease productivity, and in some cases terminate existing projects. The many projects that depend upon collaborations between research institutions further complicate this situation. To thrive under normal circumstances, collaborations require careful coordination and trust between scientists as well as open lines of communication. We argue that these features take on new meaning during a worldwide pandemic. In this article we discuss how the pandemic has impacted on the collaborative research landscape as it relates to project management, trainee education, and dissemination of results. We offer our perspective on how scientists may take advantage of their virtual toolbox to support scientific discovery in a safe and responsible manner, thereby generating a digitized collaborative network, as summarized in Figure 1.

Maintaining and Generating Open Lines of Communication

Before the COVID-19 pandemic caused global restructuring of research practices, open lines of communication underscored the success of intra-laboratory relationships and institutional collaborations. We argue that open communication is paramount to all scientific progress. Regardless of career stage, location, or expertise, in the time of second waves, shutdowns, volatile reintegration strategies, and social distancing regulations, technology helps scientists to maintain existing projects and pursue new research endeavors in their home offices and virtual laboratories. Communication applications and social media outlets support open lines of communication between colleagues, collaborators, and institutions in lieu of in-person meetings. Multinational collaborations benefit from virtual tools such as time-zone matchers (e.g., timeanddate.com) that identify convenient meeting times across combined time zones. Group productivity platforms (e.g., Slack, RocketChat, Microsoft Teams) simplify and streamline resource sharing, and support open communication between collaborators. Because these virtual collaboration tools are free, they provide an accessible platform for scientists to use, and enable collaborators to effortlessly stay current with research projects. In addition, this virtual toolbox provides mechanisms to support the genesis of collaborations by providing scientists with transparency as well as with documentation regarding the status of the project at hand.

One of the most important collaborations that has been remodeled during the pandemic is between mentor and mentee, particularly for trainees such as graduate students and postdoctoral fellows. Regularly scheduled meetings between mentor and mentee can be supported by digital platforms to monitor progress and offer feedback and guidance as needed to promote productivity. Another means by which a mentor can support a mentee in their training is by sharing online resources that may be used to extend their skillsets (e.g., TED Talks and TED-Ed, NEUBIAS, freeCodeCamp). Virtual lecture seminars (e.g., iCANX Lectures, Max Planck School MtL Lecture Series, Columbia University BME Breaks, Cell Migration Seminars, Blood and Bone Seminar Series) also provide trainees with an opportunity to connect with scientists internationally to extend their discipline-specific knowledge base and foster open lines of communication for future collaborations [3]. Finally, we recommend scientists use time away from the laboratory to digitize, organize, and store data using cloud-based programs (e.g., Box, Dropbox, Google Drive, etc.) to provide a simple and transparent mechanism for sharing information.

Beyond formal meetings between collaborators, several scientific conferences have moved to virtual platforms, supporting the creation of an inclusive environment for researchers to share their findings with the international community while adhering to travel and social distancing restrictions. For example, Zoom, Cisco Webex, and other webinar platforms have reduced the price of admission for attending scientific symposia (e.g., SynBio, APS, Syncell2020, CytoVitrual 2020). Virtual meetings support the development of connections that may previously have been impossible to create because of economic, personal, or physical barriers that prevent conference attendees from participating. For example, in the recent virtual Syncell2020, 1.3 million USD in travel and accommodations was saved, conference registration increased by 650% on the first day, and 1.9 kilotons of CO_2

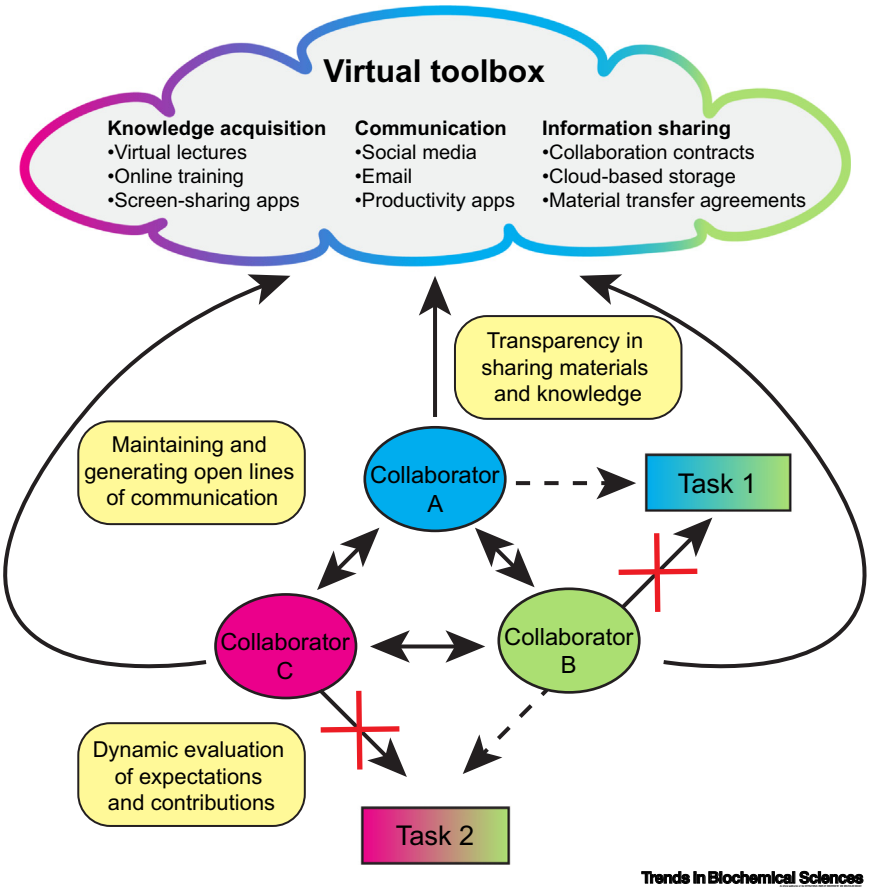

Figure 1. Model of Virtual Collaborations. Interactions between collaborators supported by the virtual toolbox are illustrated, demonstrating the dynamic flow of information between agents within the virtual collaborative network. The concept of maintaining and generating open lines of communication is bidirectionally depicted by double-headed arrows between collaborators. Transparency in sharing materials and knowledge is conceptually represented by dashed arrows, indicating unidirectional transfer of information that is supported by materials transfer and collaboration agreements. Red crosses illustrate the idea that, especially in the context of a pandemic, initial collaboration conditions may be disrupted. In this case, dynamically evaluating expectations and contributions will enable the completion of research tasks and ensure productivity. Finally, because physical barriers may present obstacles to collaborations, all pathways in this new model lead to the virtual toolbox where collaborators may learn, communicate, and exchange their contributions to the project.

emissions were prevented. These statistics demonstrate the wide-reaching interest of the scientific community in engaging in virtual scientific symposia. Virtual conferences redefine how scientists engage in their respective collaborative communities. It follows that scientific gatherings may evolve into inclusive hybrid approaches that enable individuals from different fields to cross-pollinate, leading to the generation of ideas that would not have otherwise been conceived.

One important benefit of virtual exchanges is that scientists are given the opportunity to communicate thoughtful questions and comments using the chat/Q&A function included in webinar platforms. Because scientists are identified with their name as they ask questions using these platforms, a name-based relationship and potential future collaboration may be established. These digital interactions can be followed up using social media such as Twitter or LinkedIn to begin open lines of communication between individuals, which has been shown to support scientific community [4]. Although in-person meetings may satisfy a deeper desire for human connection, virtual conferences nevertheless create the ideal conditions for establishing truly multidisciplinary and multinational collaborations with complete inclusion; that in our opinion will lead to impactful discoveries.

Transparency in Sharing Materials and Knowledge

Because strict border regulations are in place that prevent the physical presence of collaborators in the laboratory and the exchange of materials between scientists, collaborative transparency is of utmost importance. Nuances may arise that prevent sharing of intellectual property (e.g., highly developed protocols, sequences, codes). However, the use of documentation such as materials transfer agreements and collaboration conditions/agreements will enable researchers to engage in responsible resource-sharing that protects all parties involved [5]. By generating a collaborative contract that is shared between investigators using virtual platforms (e.g., email, cloud-based programs), transparency between collaborators is ensured. We specifically suggest that collaborative contracts should include project timelines, deliverables, funding contributions, personnel, dissemination strategies, and authorship expectations, as well as confidentiality agreements if proprietary information is to be exchanged.

Furthermore, generating alternative strategies to provide technical knowhow will also allow collaborative research to continue despite travel restrictions. For example, by generating standard operating procedures (SOPs), laboratories can document in detail the methods used in research practices that are specific to their laboratory. However, the synthesis of such SOPs does not necessarily lead to the assembly

of the subsequent product intended by the SOP, especially when laboratory productivity is challenged by prolonged inaccessibility. Therefore, connection in real time via virtual platforms provides researchers the remarkably valuable asset of troubleshooting or clarifying uncertainties. Screensharing and video applications offer a safe alternative to in-person collaborations, ensuring the sharing of ideas and techniques while abiding by social distancing measures. As such, virtual tools can be leveraged to support an efficient and productive research mechanism (i.e., the 'tele-bench') to facilitate transparent sharing of technical knowhow while engaging in new collaborative plans.

Dynamic Evaluation of Expectations and Contributions

The availability of resources and facilities is subject to dynamic regulations, but these can actually be leveraged to enable a productive collaboration. For example, time-sensitive experiments may have originally been slated to be completed in a laboratory at a research center that has now been closed until further notice. However, a different laboratory that is a part of the collaboration may have a safe mechanism to complete the outlined assays. Because institutions across the world have implemented different levels of research restrictions, it is essential that researchers are open to reevaluating their contributions to a given collaboration to enable creative solutions while safely continuing expensive and time-sensitive research. We recommend that researchers revisit their collaboration contracts (see previous text) to clarify and modify their respective contributions. By engaging in this proactive and flexible approach to collaboration, mutual research goals can be achieved.

Another necessary variable to consider concerns how the scientists involved in the research collaboration have been personally affected by the pandemic. For example, a scientist may have been obliged to take on more family responsibilities owing to lack of childcare, whereas others may experience changes in their own physical or mental health that may limit their ability to undertake research. Because daily life has been drastically disrupted (e.g., public transportation restrictions, curfews, grocery shifts, etc.), it is unrealistic to expect researchers to perform as was previously possible. Taking on this challenge of restructuring scientific expectations through the lens of optimism will support creativity, discovery, and innovation by the research community. Having an open mind and empathetic attitude during these difficult times is necessary to sustain collaborations even when the plan has changed.

Concluding Remarks and Outlook for the Future

If the COVID-19 pandemic is considered as a *bona fide* disruption that forces researchers to deeply reflect on their purpose and methods in collaborations, the research community will be given a rare opportunity to implement improved alternative mechanisms for science. To support continued scientific discovery throughout the pandemic and beyond, we suggest that researchers should carefully consider how collaborative efforts are created or continued using the alternative mechanisms described here that aim to permanently replace inefficiencies and extraneous research practices.

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References

1. Kupferschmidt, K. (2020) A completely new culture of doing research: coronavirus outbreak changes how scientists communicate. *Science* Published online February 26, 2020. https://doi.org/10.1126/science.abb4761
2. Gibson, E.M. *et al.* (2020) How support of early career researchers can reset science in the post-COVID19 world. *Cell* 181, 1145–1149
3. Ebner, M. *et al.* (2009) Social networking in scientific conferences – Twitter as tool for strengthen a scientific community. In *Proceedings of the 1st International Workshop on Science* (Vol. 2), pp. 1–8
4. Taylor, K.A. *et al.* (2020) Blood and bone: the quarantine chronicles. *Res. Pract. Thromb. Haemost.* 4, 727–730
5. Fusi, F. *et al.* (2018) Barriers and facilitators of access to biological material for international research: the role of institutions and networks. *Sci. Public Policy* 46, 275–289

Spotlight

Alternative Protein Topology-Mediated Evolution of a Catalytic Ribonucleoprotein

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The high-resolution structures of yeast RNase for mitochondrial RNA processing (MRP), a catalytic ribonucleoprotein (RNP), recently reported by Lan *et al.* and Perederina *et al.* illustrate how RNA-mediated selection of alternative protein conformations, sampled during stochastic excursions by polymorphic/metamorphic proteins, enabled RNAs and proteins to mutually influence their functional repertoires and shape RNP evolution.