

Leveraging Technology for Remote Learning in the Era of COVID-19 and Social Distancing

Tips and Resources for Pathology Educators and Trainees

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• The ongoing global pandemic of coronavirus disease 2019 (COVID-19) has rapidly disrupted traditional modes of operation in health care and education. In March 2020, institutions in the United States began to implement a range of policies to discourage direct contact and encourage social distancing. These measures have placed us in an unprecedented position where education can no longer occur at close quarters—most notably, around a multiheaded microscope—but must instead continue at a distance. This guide is intended to be a resource for pathologists and pathologists-in-training who wish to leverage technology to continue collaboration, teaching, and education in this era. The article is focused mainly on anatomic pathology; however, the technologies easily lend themselves to clinical pathology education as well. Our aim is to provide curated lists of various online resources that can be used for virtual learning in pathology, provide tips and tricks, and share our personal experience with these technologies. The lists include videoconferencing platforms; pathology Web sites; free online educational

resources, including social media; and whole slide imaging collections. We are currently living through a unique situation without a precedent or guidebook, and we hope that this guide will enable the community of pathology educators worldwide to embrace the opportunities that 21st century technology provides.

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The global pandemic of coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) has placed unprecedented demands on pathologists in practice and training by necessitating social distancing, which threatens to disrupt collaborations between pathologists, and between pathologists and clinicians. These interactions traditionally occur in conference rooms or lecture halls, or at multiheaded microscopes. With social distancing, in-person conferences, meetings, and microscope sessions have appropriately been cancelled. Residents are facing the prospect of learning pathology independently from their desks, or from home. Consensus conferences and tumor boards stand to lose value without pathologist input—real-time review of pathology findings with clinical colleagues. In short, the greater-than-6-foot distance between people threatens to turn into a chasm of lost opportunities for learning and teamwork. These circumstances create an urgent need for resources to help bridge the chasm. In this article, we have assembled a guide for those attempting to navigate a new and perhaps unfamiliar digital landscape. We will review available tools for remote sharing and pathology education, and discuss other settings in which virtual technologies enable pathologists to perform collaborative tasks without contravening the principles of social distancing. Of note, this list is not exhaustive. Additional useful platforms and resources exist; however, listing all of them in an article would be impossible—the authors' goal is to provide a starting point. Although many of these resources and technologies are not new and were used at various institutions before this pandemic, social distancing has necessitated rapid innovation and exploitation of these resources to maintain clinical care and education while ensuring personal safety.

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TOOLS

Remote Sharing

A variety of tools and mobile applications (known as “apps”) harness the power of technology and online platforms to share slides, images, PowerPoint presentations, and other materials remotely. Many of these have been used at various institutions previously for various activities, but in this era of social distancing, innovations in utilization of these tools are rapidly evolving. Numerous videoconferencing and screen-sharing applications and software exist. While this list is not exhaustive, these are the systems that are currently widely used, and with which the authors have the most personal experience.

Regardless of platform, users should always ensure that protected health information (PHI), including pathology case numbers, is not being shared inappropriately. Many educational activities can be performed without sharing PHI, but for activities (ie, tumor board) that use PHI, it is important for users to ensure the platform is Health Insurance Portability and Accountability Act (HIPAA) compliant. As always, follow your institutional guidance and policies in these respects.

Zoom.—Zoom (Zoom Video Communications, Inc, San Jose, California) is a videoconferencing service that has experienced a rapid increase in users during the COVID-19 pandemic.¹ It is currently a free app available for download on desktop, laptop, or mobile devices. Zoom can be used for one-on-one or group videoconferencing and uses 2-way audio and video capacity. An account is required to create and host a meeting, but participants can join without creating an account. Basic functions include the ability to invite participants to a session; to share one’s screen for slide, image, or lecture presentations; and to chat with the entire group or with individual participants. Zoom also has a built-in high-resolution screen recording function that can easily record the entire lecture/meeting for archiving, internal sharing, or public sharing later on YouTube or other social media platforms. Various subscription versions are available, with more advanced features available in versions that charge a fee. Some institutions have agreements with Zoom as well. Zoom has also created educational and support resources to facilitate rapid training.²

Multiple authors of this article practice in institutions that had a preexisting Zoom subscription. Before the pandemic, these subscriptions were used for tumor boards, rapid on-site evaluations in cytology, and/or meetings across campuses. The user interface is intuitive, and most users find it easy to use. In response to social distancing, there has been a significant increase in the use of Zoom, including use for consensus conferences, internal consultations, and trainee-faculty sign-out. Zoom can be used to provide educational lectures as well, both internally as well as open-access conferences to a worldwide audience. These conferences may be enhanced with polling, audience participation, and recording, for future viewing.

The pros of Zoom as a videoconferencing platform include ease of accessibility and use, the availability of a free version, continued reliability in the face of enormous increase in demand, the ability to share screens, and compatibility with a variety of devices, including mobile options.

On the flip side, advanced features require a fee. For example, at the time of this writing, usage of the app for more than 40 minutes requires a fee to continue, although

a new session can be initiated without a fee. The platform has a built-in polling feature, but this feature has not always worked reliably in the authors’ experience. An unpleasant phenomenon known as “zoombombing” has also emerged recently, whereby anonymous persons with access to a Zoom link enter the conference with malicious intent.³ Options such as having meeting passwords, or not posting Zoom links in public, can help curtail this phenomenon.

Cisco Webex and Jabber.—Cisco (Cisco Systems, Inc, San Jose, California) has 2 products, Webex and Jabber, which allow for videoconferencing and screen-sharing capabilities. Webex has individual account access or may be part of other Cisco communication and security applications within an institution. Webex offers video and audio connection, screen sharing, and joining of multiple users. A Webex app is available for iOS and Android smartphones. Webex is offering free individual accounts during the pandemic, which allows screen sharing and multiple participants. Some of the authors have found this system less easy to navigate and less streamlined than Zoom. Specifically, in multiple user settings, participants have experienced variable success in connecting to the conference call-in number and/or have been ejected from the meeting unexpectedly. Features are labeled with icons rather than words—for example, assigning speaker/presenter status to another participant is handled by passing a “ball” icon—which may be confusing to the uninitiated.

Some institutions may have access to Cisco Jabber, which combines instant messaging, video, voice, voice messaging, screen sharing, and conferencing capabilities securely into 1 client on your desktop. This is an institutional account-based software system and we are not aware of individual access. Jabber has some similar capabilities to Zoom and Webex; however, it is primarily designed to facilitate conversations and collaborations between a smaller group of people at the same institution, rather than share content with a large external group.

Digital Pathology Tools

A variety of tools are available to digitize pathology slides; while some institutions or groups have access to costly systems, the ability to do digital pathology is open to anyone with even a smartphone-based camera.

Whole Slide Imaging.—The first whole slide imaging (WSI) platform was approved by the US Food and Drug Administration on April 12, 2017.⁴ While only a few institutions are actively pursuing complete transition to a digital workflow, many institutions have WSI technology capabilities. For groups with WSI capabilities, until recently, digital slide review could be performed remotely, although the actual sign-out of the case still needed to be performed at a Clinical Laboratory Improvement Amendments–certified physical location. As of March 26, 2020, the United States Centers for Medicare & Medicaid Services (CMS) has stated that it will not enforce the requirement to have a separate certificate for laboratories that are located at a temporary testing site. Per the CMS document, “such a temporary testing site may be the pathologist’s home.”⁵ Even given this provision, certain states will require an additional level of permission before remote/at-home sign-out is possible. It is important for laboratories to use appropriate validation if using this technology for primary diagnosis; in 2013, the College of American Pathologists

(CAP) developed validation guidelines for WSI.⁶ One author's institution was in the process of converting to an all-digital workflow before the COVID-19 pandemic. As social distancing requirements evolved, the department quickly converted to an entirely digital workflow, inclusive of autopsy slides, cytology cell blocks, immunohistochemical stains, and consultation cases. This rapid implementation allows for increased social distancing and flexibility of previewing and sign-out workflows to accommodate the challenges of sheltering in place. Added benefits include ease of reviewing concurrent or recent cases for the same patient, and easily identifying areas of concern to obtain consultations from colleagues. The ease of accessibility of whole slide images enables joining consensus conferences from any location and the ability to show cases to colleagues without having to be physically present with glass slides. It has been our experience that faculty find this helpful, even when they do not prefer to use digital slides to perform routine case sign-out in their practice. In addition, at least 1 institution is readying an application with validation data collected from multiple digital pathology/WSI initiatives and pilot projects to present to a state medical board, which would frame digital pathology/WSI as a laboratory-developed test.

There is a great deal of variability in how practices have incorporated digital pathology into their workflow. Using a digital workflow does not have to be an all-or-nothing approach; digital images may be used just for select applications, for instance, internal consultation between pathologists, tumor board presentation, immunohistochemical stains, frozen section interpretation for hospitals with multiple sites, rush slide review if histology is off-site, among others. An additional benefit that had not previously been considered is the reduction in physical handling of glass slides and slide flats. Although the risk of infectious spread in handling such materials is uncertain, decreasing interaction with them may alleviate anxieties associated with the uncertainty.

Remote/Robotic Microscopes.—Some institutions may already have access to remote/robotic microscope technologies, especially institutions that are using telecytology. There are commercial systems available that allow for slides to be loaded into the instrument and “driven” by a remotely located user (eg, <https://www.mikroskan.com/>; accessed April 23, 2020; Mikroskan Technologies, Inc, Carlsbad, California). Alternatively, systems have been developed that digitize the slide as the slide is “driven” by a user, combining elements of both slide scanning and remote viewing simultaneously.⁷

Smartphones.—Simple smartphone adapters can be purchased online to mount the smartphone camera to the eyepiece of a microscope. Numerous video call applications exist and most people already have access to at least one of these systems (eg, FaceTime [Apple, Inc, Cupertino, California], WhatsApp [Facebook, Inc, Menlo Park, California], Skype [Microsoft Corporation, Redmond, Washington]), which can be used to facilitate a consultation between pathologists. Anecdotally, we have seen more than one occasion when a desktop-based videoconferencing platform has failed and FaceTime (widely available on cell phones) has been used to successfully continue a virtual conference. Static images for educational or collaborative applications can also be taken with a smartphone even without using an adaptor⁸; thus, most pathologists already have a solution for digital pathology

right in their pocket. Various other low-cost solutions have been reported largely in the cytology literature for rapid on-site assessments.^{9–11}

Virtual Tumor Board, Consensus Conference, and Other Meetings

Tumor Boards.—Pathologists play a key role at multidisciplinary tumor boards, discussing pathology cases and showing pertinent features. Both of these roles are easily shifted to virtual collaborative conference spaces (“virtual tumor boards”) such as the ones listed above.¹² As of March 2020, the authors of the article are already using various videoconferencing platforms for tumor boards and other multidisciplinary conferences, eliminating the need for an in-person tumor board in a meeting room. The platforms we have used include Skype, Webex, and Zoom. An unanticipated benefit of the mandated use of these platforms in the COVID-19 era is that participants are becoming increasingly familiar with the benefits of using virtual technologies, raising the possibility that these technologies may be used to optimize efficiency even after social distancing mandates are lifted.

Histologic findings can be livestreamed from a microscope-mounted camera, or static gross images or photomicrographs may be shown by using the “share screen” functionality. The “share screen” functionality also allows pathologists to highlight key portions of their report and easily show pertinent articles or other resources for clinical colleagues. Virtual tumor boards allow participants who might not otherwise be able to participate (because of physical location or time constraints) to attend virtually. These conferences save time by eliminating travel time to and from the conference location, which is beneficial to all. They allow pathologists increased flexibility because they have multiple resources at their fingertips, including gross images and photomicrographs, whole slide imaging platforms, and pathology databases. Another potential benefit is time savings for those pathologists currently spending time using their office-based scope camera to take photomicrographs in preparation for tumor boards held in conference rooms without a microscope; livestreaming images directly from a microscope to a virtual tumor board eliminates the step of taking photos ahead of time. Whole slide images may, of course, be used to show images remotely as well. High satisfaction rates for virtual tumor boards have been previously published.¹³

Consensus Conferences (Within Pathology Departments).—Consensus conferences are a useful tool for quality assurance as well as collaborative learning for pathologists. One model for reaching consensus is that of one person “driving” a multiheaded microscope while others view and render their opinions—this format is easily ported to a virtual conference call by using livestreaming technology (Figure 1). For groups where not every individual has a microscope camera in their office, only 1 microscope-mounted camera is necessary; the “driver” can sit at this scope to show cases. For instances where cases are traditionally physically passed from office to office for consensus review, this virtual setup has 2 benefits: (1) allowing real-time group review, particularly useful if there are specific questions or features/cells of interest for discussion; and (2) eliminating the need for multiple hands to physically touch the slides; this consideration is of particular interest to minimize exposures.

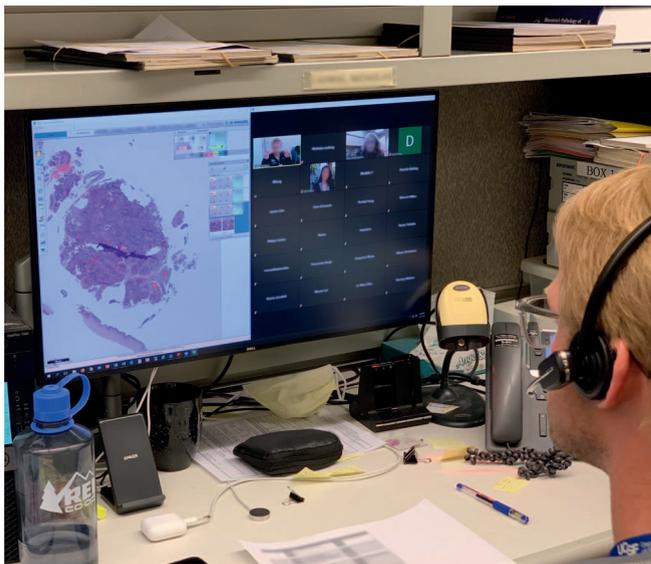


Figure 1. Sample Zoom virtual consensus conference.

For consensus conferences in which multiple pathologists present cases, this may be accomplished through allowing multiple participants to share their screen in Zoom, passing the “ball” icon to a colleague logged into Webex or similar mechanisms. The pathologist “driving” for any given case simply needs to share their screen at the appropriate time.

Education of Pathology Residents and Fellows.—In addition to clinical duties, a significant portion of a pathologist’s time is spent educating those in training. This may take place in the form of scheduled didactics, unknown slide sessions, or sign-outs at a multiheaded microscope. Many training programs quickly made use of online virtual videoconferencing platforms to accommodate the loss of in-person didactics. Virtual slide sessions for both unknown conferences and clinical sign-out require either a microscope with a camera, previously scanned slides, or access to a scanner. Once these systems are in place, previously described videoconferencing platforms may be used. A unique and valuable benefit of virtual teaching is the option to reach learners far beyond one’s home institution by a shareable link via email or social media post. There is undoubtedly a loss of the personal-social dynamic in sitting at a scope with an attending pathologist, but this is perhaps somewhat counterbalanced by the sense that “we are all experiencing this together,” as well as the flexibility and ease of accessing a sign-out session from a remote location. Virtual sign-outs may also offer some unique insights into the attending pathologist’s sign-out style that may not necessarily be evident in a traditional sign-out session around a multiheaded microscope. For example, since the attending pathologist typically shares their computer screen with the residents and fellows via virtual videoconferencing platforms, trainees can view the actual sign-out process in real-time. In addition, multiheaded microscopes are limited by the number of microscope heads, whereas Web-based platforms can accommodate many more viewers.

Other Meetings.—Most in-person conferences and meetings have been canceled (appropriately so). An unintended consequence for academic pathologists, particularly those who are relatively junior, is the loss of invited speaking opportunities, which has the potential to nega-

tively impact their career. Fortunately, institutions and groups have been working to coordinate virtual Grand Rounds.^{14,15} These efforts, using conferencing platforms like those mentioned above, allow for continued cross-institutional educational events and teaching.

The ability of a pathologist to function remotely may have other distinct advantages to traditional in-person sign-out sessions, conferences, and meetings. Firstly, the problem of “lost slides” may be reduced, as slides will not physically travel to the sign-out rooms or conference rooms. Second, pathologists and trainees with physical limitations may be able to function more efficiently in their own workspace.

Pathology Resources Online: Social Media Platforms

Twitter.—This microblogging social networking service was extensively used for “socially distanced” pathology education well before the onset of COVID-19.¹⁶ During the era of social distancing, however, Twitter (Twitter, Inc, San Francisco, California) is seeing a burst of activity by numerous medical educators answering the need of the time. The platform is free; easy to use on handheld devices (smartphones and tablets), desktops, and laptops; and widely available. Experienced users have created useful step-by-step guides for newcomers to the platform.¹⁷ Although functionality is best on the Twitter app, most posts on Twitter are open to the public and can be read in a Web browser without downloading the app or signing in. As a trial of this concept, pathologists who have not signed up for Twitter are encouraged to read an example in their Web browser simply by clicking this link: <https://twitter.com/RaulSGonzalezMD/status/1072861483632132096> (accessed April 23, 2020).¹⁸ This post is a “tweetorial,” a tutorial composed of several tweets threaded into a linked sequence. The entire tutorial can be read by scrolling down the thread. The number of tweets in a thread varies, but is theoretically unlimited. The longest pathology tweetorial currently contains 134 tweets.¹⁹ Individual photomicrographs within tweets can be clicked on and viewed with greater clarity, and links to outside sites such as PubMed provide expanded content. While individual tweets are restricted to 280 characters, educators who use Twitter make use of various tools that Twitter offers (such as the ability to post images, links to other tweets, links to the published literature, and polls). Educational material on Twitter can take the form of stand-alone tweets, pathology quizzes in the form of polls, or the above-mentioned “tweetorials.” A sample list of educational tweetorials is provided in Table 1; additional educational materials are being posted continually.

A widely used tool on Twitter is the “hashtag.” A hashtag is a word or phrase preceded by a hash (pound) sign (eg, #pathology). Hashtags serve to index tweets with a similar theme so they can be conveniently retrieved and reviewed at a later date. Pathologists worldwide perform this indexing function by adding hashtags to their tweets. Pathology residents navigating the ocean of pathology posts available on Twitter are encouraged to try the hashtags #Pathboards and #PathTweetAward, which serve to index tweets of value for pathology board exams and tweets of educational value, respectively.²⁰

Several new resources have emerged in the COVID-19 era on Twitter, all of which have been linked together with the hashtag #VirtualPath (ie, virtual pathology).²¹ Twitter users were made aware of this hashtag soon after shelter-in-place

Table 1. Selected Twitter-Based Pathology Tutorials (Tweeterials)

Author	Topic	Link to Tweeterial ^a
Rola Ali, MD	HER2 in breast carcinoma	https://twitter.com/DrRolaAli/status/1112051822661906438
Rola Ali, MD	Giant cell rich tumors of bone	https://twitter.com/DrRolaAli/status/1217839247916523520
Luis Humberto Cruz, MD	Ganglioglioma	https://twitter.com/luishcruz/status/1230867921603198976
Samson W. Fine, MD	Prostate anatomy	https://twitter.com/rovingatuscap/status/1156317771246002177
Valerie A. Fitzhugh, MD	Synovial sarcoma	https://twitter.com/DrFNA/status/1032086422327570432
Raul Gonzalez, MD	Hepatic masses	https://twitter.com/RaulSGonzalezMD/status/1237785642148302849
Daniela Hermelin, MD	Kell blood group	https://twitter.com/HermelinMD/status/1190014347193573376
Sanjay Mukhopadhyay, MD	Aspiration pneumonia (particulate matter aspiration)	https://twitter.com/smlungpathguy/status/1058922823857696768
Sanjay Mukhopadhyay, MD	Immunotherapy	https://twitter.com/smlungpathguy/status/1236376706845421568
Karen Pinto, DNB	Testicular masses	https://twitter.com/TheKarenPinto/status/1223188799695532032

^a All Web sites were accessed on April 23, 2020.

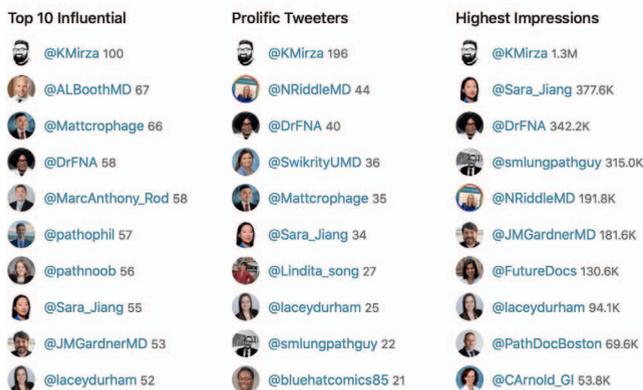
restrictions became common, creating a crowdsourced mechanism to teach pathology to medical students, residents, and fellows. Several faculty volunteered their time to give #VirtualPath lectures, using platforms such as Zoom or others as discussed above, and some institutions opened up their internal lecture schedules to Zoom participants. One of the authors was able to collect attendance data for Zoom-based lectures thanks to the in-built registration function. As of the date of this article, the initial lectures given under the aegis of this initiative all had more than 100 attendees. For lectures where evaluations were completed, the data suggest that users benefited significantly from these sessions. As an example, the first #VirtualPath lecture (“Introduction to Blood and Bone Marrow Cell Morphology”) garnered 131 registered attendees, including medical students, pathology residents, fellows, medical laboratory scientists, and educators. Most attendees were medical students and pathology residents from the United States. When asked to compare traditional in-person live lectures with the #VirtualPath talk, attendees responded that the virtual experience was as good as an in-person talk, if not better. Within the month of March 2020, data collected by the social media analytics platform Symplur revealed that #VirtualPath had received greater than 1 million impressions (the number of times a tweet appears in a user’s timeline) and more than 500 tweets. #VirtualPath builds on the previous success of group pathology experiences such as #TwitterHomework where medical students doing their pathology elective participate in formulating a pathology-related tweet during their elective time. The #TwitterHomework hashtag allows

indexing of these tweets, leading to dissemination of pathology knowledge and serving to shine a spotlight on the active engagement of medical students in self-directed learning. As this manuscript is being prepared, the #VirtualPath story is continuing with the evolution of #VirtualPathGR (virtual pathology grand rounds, @Virtual-PathGR), which will serve as a platform for pathology faculty to deliver high-impact grand rounds to large audiences across the globe. The first 2 speakers have been announced, and hundreds have already registered for these talks through Twitter announcements. Although the concept of virtual pathology education is not new and has been advocated by some of the authors of this article for some time, the COVID-19 era has pushed online education to the forefront. As more medical students, residents, and faculty become accustomed to virtual pathology education, it may revolutionize traditional teaching and become a go-to gold standard of learning, given the ease and convenience of accessing lectures, and the ability to learn from a diverse group of pathologists from around the world that one would not ordinarily be able to access from one’s home institution.

Twitter has also served to bridge the void created by cancellation of pathology candidates’ match ceremonies due to social distancing. To remedy this situation, the hashtag #VirtualPathMatch was rapidly created before Match week 2020, and in 1 week alone the “virtual” Twitter-based celebration of successful pathology residency candidates had already surpassed 4 million impressions (Figure 2).²²

YouTube.—YouTube (Google LLC, Mountain View, California) is a well-known platform used by more than a billion people worldwide for sharing and viewing videos.

The #VirtualPathMatch Influencers



The Numbers

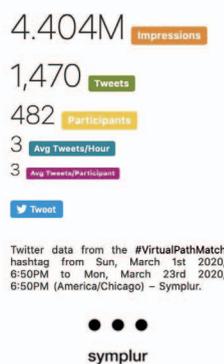


Figure 2. Symplur impressions (number of potential individual views of tagged tweets) from the #VirtualPathMatch hashtag.

Table 2. Selected Pathology Channels on YouTube

Name of Channel	No. of Videos	Types of Content	Link to Channel/Representative Video ^a
Jerad Gardner, MD	148	Topics: Dermatopathology, soft tissue pathology	Link to channel: https://www.youtube.com/user/JeradMGardnerMD Representative video: Dertmpath board review: 100 classic cases https://www.youtube.com/watch?v=Q88yDU-Pyis&t=13758s
Sanjay Mukhopadhyay, MD	42	Topics: Pulmonary pathology, anatomic pathology quizzes	Link to channel: https://www.youtube.com/user/smurf3073 Representative video: COVID-19 can kill: a lung pathologist explains what ARDS means and why it's important https://www.youtube.com/watch?v=vPtH42Lnt_Y&t=411s
Michael Arnold, MD, PhD	4	Topics: Grossing, pediatric pathology	Link to channel: https://www.youtube.com/channel/UC1NPPcBRHqTwFPIHvNR-A Representative video: Grossing a placenta in 90 seconds https://www.youtube.com/watch?v=9pv1Z_uU9VQ
Rajal B. Shah, MD	6	Topics: Genitourinary pathology	Link to channel: https://www.youtube.com/channel/UC15OjboCni2ywhX9JGMg8iw Representative video: Common pitfalls of Gleason pattern 3 https://www.youtube.com/watch?v=VfL1KLFxDpA&t=175s
Matthew Cecchini, MD, PhD	5	Topics: Pulmonary pathology	Link to channel: https://www.youtube.com/channel/UCG39jXxaKiNCgLM_2a1IXZQ Representative video: High yield pulmonary pathology review cases: non-neoplastic pulmonary disease https://www.youtube.com/watch?v=U6Xd7HfDLJM
pathCast	72	Topics: Various anatomic pathology topics	Link to channel: https://www.youtube.com/channel/UCVxosS9hPP3ikMQXAE9Pamw Representative video: #cytopath: the atypical thyroid FNA - Dr. Cibas (BWH) https://www.youtube.com/watch?v=YabBxxDgZBc&t=705s
Cleveland Clinic Laboratories	16	Topics: Various anatomic pathology topics	Link to channel: https://www.youtube.com/channel/UCWZvQOfSwgbqpW7BWJdtR8A/videos Representative video: Pathology insights - soft tissue pathology with John Goldblum, MD https://www.youtube.com/watch?v=kMKZdlyS0b8
Phillip McKee, MD, FRCPath	45	Topics: Dermatopathology	Link to channel: https://www.youtube.com/channel/UCDMtR-TYs9ZkHU6x41YuMUw Representative video: Phaeohyphomycosis https://www.youtube.com/watch?v=ZY7n8ApS8tk&t=40s
Mount Sinai Department of Pathology	56	Topics: Various anatomic pathology topics	Link to channel: https://www.youtube.com/channel/UCck4UW9jf7V97Khc1AQu1nA/videos Representative video: High yield GI pathology for the boards with Dr Meredith Pittman https://www.youtube.com/watch?v=aLZCGwZH8TU&t=108s
Weill Cornell Medicine - Department of Pathology	25	Topics: Various anatomic pathology topics	Link to channel: https://www.youtube.com/results?search_query=weill+cornell+pathology Representative video: Grossing colon pathology specimens https://www.youtube.com/watch?v=1-E4NPLLDnl&t=57s
Alexander Damron, MD	6	Topics: Breast pathology	Link to channel: https://www.youtube.com/channel/UCVHNTIQZsMLX1q53IsB_tQ/ Representative video: Anatomic Pathology Board Review: Breast Pathology https://youtu.be/rCdaaTDesPQ

^a All Web sites were accessed on April 23, 2020.

Videos posted on YouTube are easily and freely accessible to anyone with an Internet connection in the United States and all but a handful of countries worldwide. Viewers can watch YouTube videos free of charge from a place of their choosing (including from home) on a variety of devices. The YouTube app is available for download, but neither an account nor a sign-in is necessary for viewing videos. Viewers who create an account and sign in can respond to the video in the form of likes and comments, but real-time interaction does not occur unless the live feature is used. Although YouTube videos have been used for medical student teaching for many years, relatively few YouTube channels cater to the educational needs of pathology residents. Several of the authors have created YouTube lecture series, as have other pathologists. The pathCast series of videos, created by Rifat

Mannan, MD, and Emilio Madrigal, DO, also contains quality content taught by well-regarded pathology faculty.²³ These sessions are broadcast live on Facebook and YouTube and subsequently archived on those platforms. A list of these high-quality YouTube channels with further details is provided in Table 2.

The worldwide reach of YouTube videos is staggering and the value associated with “anywhere, anytime” learning is high. From the point of view of educators, YouTube videos require more effort to make and upload, but the return on effort and time invested is high. It may take a few hours to create a pathology teaching video for YouTube, but viewers around the world can then watch it for free round-the-clock. YouTube videos allow an educator to teach even while they are sleeping, and a single lecture may amass tens of

Table 3. Additional Free Pathology Lectures

Organization	URL ^a	Examples of Video Topics
United States and Canadian Academy of Pathology (USCAP)	https://www.facebook.com/pg/TheUSCAP/videos/	Sharon Weiss' Soft Tissue Pathology Wendy Frankel's Gastrointestinal and Liver Pathology Jason Hornick's Deep Soft Tissue Tumors, Spindle Cell Tumors Steven Billings' Dermatopathology in the Desert
College of American Pathologists (CAP)	https://www.cap.org/calendar/virtual-lecture-series-for-pathology-residents https://www.cap.org/calendar/webinars/listing	Tik Tox, A 3-Part Toxicology Primer, Barbarajeon Magnani Survival Guide to Pediatric Tumors, Michael Arnold Differentiating the Undifferentiated: An Immunohistochemical Approach, Andrew M. Bellizzi Molecular Pathology of Colorectal Cancer, Raul S. Gonzalez Recorded Webinars on a variety of topics
Associated Regional and University Pathologists (ARUP)	https://arup.utah.edu/education/videoIndex.php	Extreme Molecular Diagnostics by Carl T. Wittwer What's New in Inflammatory and Fibrotic Lung Disease? by Henry D. Tazelaar Updates in Mastocytosis by Tracy I. George
American Society of Cytopathology (ASC)	https://cytopathology.org/page/liveonlineseries2020	Stefan E. Pambuccian, COVID-19 and the Cytology Lab (Do's and Don'ts) Liron Pantanowitz, Soft Tissue Cytopathology Güliz A. Barkan, UR-ine Wonderland

^a All Web sites were accessed on April 23, 2020.

thousands of views. The time invested upfront can also result in time saved later, as videos covering frequently asked questions and common points of confusion can be shared with multiple trainees year after year rather than spending time repeatedly covering the same issues. The pros and cons of YouTube as a tool in pathology as compared to traditional teaching tools and the livestreaming app Periscope have been previously described by Fuller et al.²⁴ Jerad Gardner, MD, has created a step-by-step video tutorial on how to record, edit, and upload pathology YouTube videos.²⁵

Facebook.—A large advantage of Facebook (Facebook, Inc) is the massive number of people worldwide who use this platform on a daily basis. In addition, pages and groups allow for open sharing of knowledge and robust discussion. The utility of Facebook discussion groups as a robust platform for free pathology education has been previously described.²⁶ The discussion groups listed by Gonzalez and colleagues²⁶ facilitate discussion of cases from around the world and are a particularly useful resource for pathologists in settings where high-quality consultation is limited or nonexistent. In addition, these groups provide a mechanism to share practice patterns, discuss common challenges in management, and provide peer-to-peer advice and support.

As with other social media platforms, material posted on Facebook can be viewed at a time and place of the viewer's choosing with a cellphone, laptop, desktop, or iPad. For livestreamed content, viewers can respond and interact with speakers in real-time.

A minor drawback of Facebook is that accessing most content requires the user to sign into Facebook, and accessing group discussions requires being allowed access into these often-moderated groups. Nonetheless, many pathologists already have Facebook accounts for personal purposes and can use these same accounts to access professional content. For pathologists who wish to use Facebook to create educational materials, the authors recommend creating a public professional Facebook *page*. A page is created and managed via the user's regular personal Facebook account, but the content on the page can

be seen by anyone on Facebook (even those who are not Facebook friends with the user) or even by those who do not have a Facebook account while the content on the user's personal Facebook account remains private. Detailed discussion of education using Facebook has been discussed previously in the literature.^{16,27}

Periscope.—Periscope (Twitter, Inc) is a primarily smartphone-based app that enables livestreaming of videos to a global audience free of charge, using only a cellphone, with educational potential.²⁴ With the advent of livestreaming on Facebook and YouTube, the formerly unique position of Periscope as a livestreaming platform has been diminished. Videos posted on this platform are automatically archived and freely accessible, but accessibility is mainly cellphone based. Archived Periscope videos can be watched free of charge from anywhere in the world, including on a desktop browser. Viewers who download the app and sign in can express their appreciation, type comments, and type in questions during live broadcasts. The following are some live lectures that were broadcast on Periscope on topics such as lung pathology,²⁸ protothecosis,²⁹ and social media.³⁰

Other Free Online Pathology Resources

In addition to the links below, many pathology societies offer free educational content, including unknowns in a Case of the Month format. Examples of such resources are summarized in Tables 3 and 4.

While the content listed below is free to access, some sites may require installation of particular software (usually free Web browser plugins such as Flash) to view the content, particularly for whole slide images.

Pathology Wiki Web Sites.—Libre Pathology is a wiki Web site focused on pathology content (https://librepathology.org/wiki/Main_Page; accessed April 23, 2020). The Pathology Resident Wiki is another pathology-related wiki, which was created primarily as a directory of all pathology residency and fellowship programs in the United States and Canada; it also has a "Pathology Links" page with a long list of links to various pathology educational Web sites divided by subspecialty (<https://pathinfo.fandom.com>).

Table 4. Open-Access Educational Cases in Anatomic Pathology Offered by Pathology Societies and Organizations

Posted by	Type of Content	Link to Case Page ^a
Association of Indian Pathologists in North America (AIPNA)	General surgical pathology	Case of the Month https://www.aipna.org/Educational.html
College of American Pathologists (CAP)	General surgical pathology	Case of the Month http://www.cap.org/member-resources/case-of-the-month
Genitourinary Pathology Society (GUPS)	Genitourinary pathology	Case of the Week https://gupathsociety.org/COW-2020-13
Hans Popper Hepatopathology Society (HPS)	Hepatopathology	Interesting Case http://hanspopperhepatopathologysociety.org/category/interesting-case/
International Society of Urological Pathology (ISUP)	Genitourinary pathology	Case of the Month https://isupweb.org/blog/cotm/
Pancreatobiliary Pathology Society	Pancreatic pathology	Case of the Quarter http://pbpath.org/category/case-of-the-quarter/
Papanicolaou Society of Cytopathology	Cytopathology	Case of the Month http://www.papsociety.org/case-of-the-month/
Pulmonary Pathology Society (PPS)	Pulmonary pathology	Case of the Month https://www.pulmonarypath.org/cotm/cotm_current.html#
The American Society of Dermatopathology (ASDP)	Dermatopathology	Case Study of the Month https://www.asdp.org/education/case-study-of-the-month/

^a All Web sites were accessed on April 23, 2020.

com/wiki/Pathology_Links; accessed April 23, 2020). Wiki Web sites can be freely edited by anyone so content can be updated and added to over time.

Departmental Web Sites With Free Open Access Resources.—Many pathology department Web sites offer free, easy-to-access educational content for learners, often in the form of case presentations with accompanying multiple-choice questions. A few examples include Johns Hopkins Surgical Pathology Unknown Conference (<http://apps.pathology.jhu.edu/sp/>; accessed April 23, 2020), which offers thousands of unknowns cases where learners can review a brief history and several photomicrographs, offer their diagnosis, and read a write up of each case/entity. The cases are searchable by diagnosis and organ. Visitors must provide an email address to access the site, which is otherwise freely available.

The University of Pittsburgh also offers a large volume of Case Studies and Case of the Month material, as well as extensive educational material regarding transplant pathology (<https://path.upmc.edu/>; accessed April 23, 2020).

Massachusetts General Hospital (<https://learn.mghpathology.org/>; accessed April 23, 2020) provides several hundred digital slides with diagnosis, as well as a wide variety of gross images in both anatomic and clinical pathology, accompanied by a multiple-choice opportunity to guess the diagnosis.

Stanford Medicine Surgical Pathology Criteria (<http://surgpathcriteria.stanford.edu/>; accessed April 23, 2020) offers free grading and staging criteria and differential diagnostic considerations for a wide variety of pathology lesions, though images are not included.

University of Michigan (<https://www.pathology.med.umich.edu/apps/slides/>; accessed April 23, 2020) offers a virtual slide collection of more than 16,000 digitally scanned slides, organized by topic. Users may choose to view slides with or without the diagnosis visible, or generate a “test set” of slides to review.

University of Utah WebPath (<https://webpath.med.utah.edu/>; accessed April 23, 2020) offers comprehensive educational material across all fields of anatomic, clinical, and basic pathology. Most educational tidbits center around

a photograph with a thorough caption. The site also offers virtual examinations and a few virtual patients.

Web Sites Offering Image Collections.—Several independent Web sites have spent years curating educational content, based partly or entirely around gross and microscopic photographs of educational pathology material. A few examples follow.

WebPathology (<https://www.webpathology.com/>; accessed April 23, 2020) offers thousands of clinical, gross, and microscopic images, organized by subspecialty. Most entities have multiple images available, allowing for comprehensive review. All material is free.

Pathology Outlines (<http://www.pathologyoutlines.com/>; accessed April 23, 2020) is a virtual pathology textbook offering information about numerous common and rare pathologic diagnoses, primarily in anatomic pathology. Most are illustrated with histologic and cytologic images. Multiple-choice questions are also available for many topics, as well as Case of the Month and Image Quiz opportunities to test diagnostic acumen. All material is free.

Web Sites Offering Whole Slide Image Repositories.—PathPresenter (<https://pathpresenter.net/>; accessed April 23, 2020), in conjunction with the Digital Pathology Association, offers whole slide hematoxylin-eosin images of numerous entities across several anatomic pathology subspecialties. Most cases offer a diagnosis accompanied by clinical information, differential diagnoses, and key teaching points. The site also offers the ability to build a lecture presentation by using a combination of whole slide digital images and (if desired) PowerPoint slides to provide bullet point text. The Web site requires registration but otherwise is free to use. Presentations created on PathPresenter can easily be combined with Zoom or other screen-sharing software for live interactive virtual lectures and/or video recording for YouTube (eg, <https://youtu.be/rcVWaqz8pzs>; accessed April 23, 2020).

KiKo (<https://kikoxp.com/>; accessed April 23, 2020) is a social media platform for pathologists (and other physicians and researchers). It allows users to send glass slides in for scanning and hosting on the platform. The user can then share these digital slides by posting them on their feed on the KiKo platform and/or by sharing them to traditional

social media sites like Facebook or Twitter. Although there is a fee for sending glass slides to KiKo for digital scanning, anyone can sign up for KiKo for free to access the numerous digital slides and cases that have already been shared there by other users. KiKo works well on smartphones and can be accessed via Web browser or the KiKo app. Digital whole slides on KiKo (even those posted by others) can be easily saved into labeled “collections” (similar to file folders) for easy access later. Digital whole slides on KiKo can also be used as the basis for interactive virtual lectures and/or for creating videos (eg, <https://youtu.be/lk3-prHqiEI>; accessed April 23, 2020).

WYDX (<https://wydx.com/>; accessed April 23, 2020) similarly offers digitally scanned slides of numerous entities in anatomic pathology. All material is free.

The Rosai Collection (<https://www.rosaicollection.org/>; accessed April 23, 2020) offers thousands of virtual slides, with diagnoses, from the collection of Juan Rosai, MD. All material is free. A list of many individual slides from the Rosai Collection organized by disease name to enable easier searching can be found on the Pathology Resident Wiki (https://pathinfo.fandom.com/wiki/Digital_Slide_List_from_Juan_Rosai_Collection; accessed April 23, 2020).

Organizations Offering Pathology Lectures and Learning Modules.—The United States and Canadian Academy of Pathology offers archived videos of their interactive microscopy sessions (<https://www.uscap.org/upcoming-ic-courses/>; accessed April 23, 2020), where academic pathologists drive glass slides and discuss salient points and differential diagnoses. Most courses cost money, but select courses have been made available free via Facebook groups or for education during the pandemic. In addition, their Facebook page offers a number of videos on a variety of topics from leading experts.

The CAP has a number of educational offerings, ranging from courses with Continuing Medical Education (CME) and Self-Assessment Module (SAM) credit to proficiency testing. Many of their online offerings require a payment or subscription; however, there are free offerings as well. There are many free Webinars that have been recorded, on topics covering everything from anatomic pathology to practice management and advocacy (<https://www.cap.org/calendar/webinars/listing>; accessed April 23, 2020). The CAP has made many of their eLearning courses free of charge from April 1 to 30, to aid in education during the pandemic. In addition, a live lecture series aimed at pathologists-in-training has been organized to help continue resident education during this time.

The American Society for Clinical Pathology (ASCP) has many educational offerings online, many with CME credit. Most residency programs participate in the ASCP Resident In-Service Examination (RISE). If the program has subscribed to RISE Plus this includes enrollment in Resident Question Bank and Lab Management University. University of Pathology Informatics and the ASCP Leadership Institute can also be purchased. Depending on the subscription of the training program, these may be included or have a separate fee for trainees.

The American Society of Cytopathology (ASC) has created a series of free live Webinars given by an ASC Board Member to supplement teaching materials for the cytopathology fellows and cytotechnology programs during the quarantine. These Webinars are also archived and accessible to all.

Associated Regional and University Pathologists (ARUP) Laboratories offers online video lectures on a wide variety of anatomic and clinical pathology topics. Most of the lectures can be used for CME or SAM credit toward continuing medical education. All material is free.

SUMMARY

Technology has great potential to alleviate challenges such as disruptions to pathology education and practice caused by the COVID-19 pandemic. If the forced adoption of virtual technologies in this era spurs a wider embrace of these tools in the long-term, we would view this as an unanticipated but welcome consequence. The pathology community is doing its part to contribute to the greater social good by enforcing social distancing guidelines, while harnessing the power of available technology to continue education. There are a wide range of platforms and technologies available to educators, learners, and colleagues worldwide; the power of technology and online tools will keep us learning and collaborating successfully in these challenging times.

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