Am J Physiol Gastrointest Liver Physiol 307: G1145–G1146, 2014;
doi:10.1152/ajpgi.00384.2014.

Young Investigator Perspectives. Blogging for electronic record keeping and collaborative research

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Submitted 20 October 2014; accepted in final form 22 October 2014

Dr. Sandefur is a postdoctoral scholar using computational and systems biology to study epithelial biology in cystic fibrosis and other diseases. His perspectives article provides useful information about the strengths of blogging in record keeping, team science, collaboration and student mentoring.

—P. Kay Lund

RECORD KEEPING IN RESEARCH is critically important and more challenging and complex given the multifaceted, interdisciplinary, and collaborative nature of the projects we embark on today. The format of research records has quickly expanded from inked entries annotating gel scans in a carbon copy laboratory notebook to high-throughput data spread across terabytes, complex computational models, and predictive three-dimensional images of biological structures. As a computational biologist investigating epithelial cell function in physiology and diseases, I use blogging software to store research records, collaborate with colleagues, mentor students, and interface with the public.

Blogs (World Wide Web logs) provide a tool to recreate traditional laboratory notebooks and integrate centralized data storage (5). At a basic level, blogs can be broken down into Posts and Pages (Table 1). Posts to a blog generally appear in reverse chronological order, making them quite useful for electronic record keeping (i.e., as "e-lab notebooks"). Text, images, and hyperlinks can be included in each time-stamped post. Edits to a post can be tracked through a revision history, an important component for ethical electronic record keeping. Posts can also be "tagged" (labeled with keywords) for quick access and grouping related e-lab notebook entries. The blogging software will "remember" these tags for future Posts, making it relatively straightforward to consistently annotate records.

Research team members can collaborate efficiently by posting to a project blog. Posts can be commented on, which provides a way for geographically distant collaborating project members to discuss results, new literature, and future ideas. Additionally, using blogs in electronic record keeping provides a convenient way to mentor individuals new to research and (electronic) record keeping. Regularity of blog posts by team members is easy to ascertain and can be used as an indicator of orderly record keeping. Individual lab member research records are accessible through a project team blog and commenting allows mentors to provide constructive criticism on the record keeping process.

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The other major component of blogs, Pages, is generally used for infrequently changing content. A classic example is an About Page, which describes the purpose of the blog. From a research point of view, Pages can be used for variety of purposes. I use Pages for project outlines, which range from mind map images to more formal Specific Aims. A Page of student-annotated references allows organization of scientific literature pertinent to a project while challenging students to critically analyze research articles. Pages are also useful to record files (and locations of files) associated with a project. For research projects using publically available data, tracking and linking to source databases is convenient by using a blog. And all files associated with a project — from journal articles to protocols, e.g., — can be linked to file-sharing services (i.e., the "cloud") through blog Pages (2, 3).

Blogging also provides an easy and relatively painless way to share your science with the public. By nature, the blogs we read online are public. Blog access, however, can be restricted by using blog software privacy settings. The available blogging software WordPress allows Post- and Page-based privacy settings so that each Post or Page has a distinct accessibility setting (6). Restricted access blogs allow one to keep research notes private but still share with the world a static Page of information about your lab or a tagged group of related, relatively recent Posts. Comments to public Pages and Posts can be "silenced" (turned off) to restrict unsolicited comments from visitors. This type of low-cost setup is relatively straightforward to implement and relatively secure for those not dealing with protected data.

It is, however, important to address data security and protection before implementing any type of electronic data storage or posting. There is a range of security systems available when using research blogs. Security levels range from very basic (e.g., using a free blogging service), to highly secure limited-access blogs running on university or lab-based servers. Access to a university or lab server typically requires prior establishment of a virtual private network connection, which creates a virtual extension of a secure private physical network (1). Two-factor authoriza-

Table 1. *Posts and pages provide different functionalities for a research blog*

	Post	Page
Characteristic	Time stamped Displayed in reverse chronological order Labeled with keywords	Not time stamped Displayed independent of date Unlabeled
Examples	Laboratory notebook entries, collaborative discussion topics, lab announcements	Protocols, hyperlinks to data, reference lists, public "About me" and other static content

tion adds another level of security; e.g., requiring *1*) a password-protected university login and *2*) a physical device, carried on your person, that generates a new digitized numeric code at a set time interval. An even more secure setup is blogging software running on an internal lab server wired to an internal network of computers. To access this type of blog, an individual needs to be physically present at a computer connected to the blog server.

Addressing copying/backup frequency and format of data copies is another important step in protecting data and maintaining scientific integrity when using electronic record keeping systems such as blogging software. Best practice for electronic data protection is the 3-2-1 rule (4). To abide by the 3-2-1 rule, you must have at least three copies of your data in three physically distinct locations, in two different formats (e.g., hard drive and DVD), and one of the copies must be off site (e.g., in a cloud) (2, 3).

A major benefit of using blogs is that all project-related records and correspondence are centrally located. These records can be highly organized by keyword annotation and, depending on the security level, accessible at anytime from anywhere in the world. Storing research data, analyses, and results electronically requires intentional decision-making focused on ensuring high standards of research ethics, integrity, and data security. By addressing data security and protection needs up front, high ethical research standards are met, while research gains and collaborations benefit from the convenience of quick access to secure organized electronic records.

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