



## Special Section on Telepathology

# Overview of telepathology, virtual microscopy, and whole slide imaging: prospects for the future<sup>☆</sup>

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**Summary** Telepathology, the practice of pathology at a long distance, has advanced continuously since 1986. Today, fourth-generation telepathology systems, so-called virtual slide telepathology systems, are being used for education applications. Both conventional and innovative surgical pathology diagnostic services are being designed and implemented as well. The technology has been commercialized by more than 30 companies in Asia, the United States, and Europe. Early adopters of telepathology have been laboratories with special challenges in providing anatomic pathology services, ranging from the need to provide anatomic pathology services at great distances to the use of the technology to increase efficiency of services between hospitals less than a mile apart. As to what often happens in medicine, early adopters of new technologies are professionals who create model programs that are successful and then stimulate the creation of infrastructure (ie, reimbursement, telecommunications, information technologies, and so on) that forms the platforms for entry of later, mainstream, adopters. The trend at medical schools, in the United States, is to go entirely digital for their pathology courses, discarding their student light microscopes, and building virtual slide laboratories. This may create a generation of pathology trainees who prefer digital pathology imaging over the traditional hands-on light microscopy. The creation of standards for virtual slide telepathology is early in its development but accelerating. The field of telepathology has now reached a tipping point at which major corporations now investing in the technology will insist that standards be created for pathology digital imaging as a value added business

<sup>☆</sup> Disclosures: Ronald S. Weinstein, MD, is a cofounder of DMetrix, Inc, and has equity in the company. Lynne C. Richter, M.T. (ASCP), has been a consultant to DMetrix and has equity. Doctor Weinstein was Scientific Director of Apollo, Inc, from 2001 to 2005. He also founded UltraClinics, Inc, and has equity in the company.

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proposition. A key to success in teleradiology, already a growth industry, has been the implementation of standards for digital radiology imaging. Telepathology is already the enabling technology for new, innovative laboratory services. Examples include STAT QA surgical pathology second opinions at a distance and a telehealth-enabled rapid breast care service. The innovative bundling of telemammography, telepathology, and teleoncology services may represent a new paradigm in breast care that helps address the serious issue of fragmentation of breast cancer care in the United States and elsewhere. Legal and regulatory issues in telepathology are being addressed and are regarded as a potential catalyst for the next wave of telepathology advances, applications, and implementations.

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## 1. Background

Two previous Telepathology Symposiums have been published in *Human Pathology*, in 1997 and 2001 [1,2]. Each of these symposiums included articles that have become “classics” in the field of telepathology and are among the most widely cited articles in the telepathology literature. The first Telepathology Symposium, in 1997, marked the 10th anniversary of the publication of the first articles in English, using the term “telepathology” [3,4]. The second Telepathology Symposium marked our entry into the 21st century, in which information technologies will play an ever increasing role in health care [5-10].

We now mark the 20th anniversary of the field of telepathology. Interest has increased as telepathology, and several of its enabling technologies, such as virtual microscopy and whole slide imaging, are being commercialized by a new wave of companies. Hundreds of virtual slide scanners have been sold by more than 30 commercial vendors.

The telepathology literature has shown steady growth as well. A PubMed search on the term telepathology, in December 2008, listed 628 telepathology articles in this National Library of Medicine database. There were 39 publications in medical journals in the year 2008 alone. These have originated from laboratories in many countries. Several monographs have been published on telepathology [9,10]. These provide detailed coverage of the telepathology field and its intellectual underpinnings, as well as overviews of areas ripe for both telepathology research and clinical implementations. The PubMed database lists only 3 articles on telepathology published before the year 1990, all from a single laboratory Ronald S. Weinstein in Chicago, IL [3,4,11]. A few other early publications from the same laboratory are in the computer science and engineering literature but not in the PubMed database [12-14]. This third *Human Pathology* Telepathology Symposium is expanded in scope and includes interrelated articles on telepathology, virtual microscopy, and whole slide digital imaging.

The original definition of telepathology was “the practice of pathology at a long distance” [3,4]. What was meant by “long distance” was a distance of many miles. Today “long” is taken to mean longer than any distance at which the light microscope system operator can control the microscope “hands-on.” For practical purposes, this means any distance bridged by some telecommunications system, ranging from a

few meters to a distance half-way around the world. The basic definition is essentially unchanged today. It is irrelevant whether telepathology is practiced using static images, virtual slides, whole slide images, or the images generated from a robotically controlled motorized light microscope [2]. Telepathology is about the practice of pathology at a distance by pathologists [9,15]. It encompasses all of the elements of a pathology histopathology consultation including the generation of a written report, quality control, and quality assurance (QA) of all of the processes of light microscopy, the gathering and interpretation of patient information, and, where needed, consultation with the patient’s other physicians [9,10].

“Whole slide imaging,” a relatively new term, is a technique with 2 components: the creation of digital images of the entire area of a glass histopathology or cytopathology slide, and the viewing of such a large digital image slide using a virtual slide viewer [10,16]. Whole slide imaging, taken alone, is not the practice of pathology or telepathology, although some authors have used the term as slang for the practice of telepathology. In the United States, this is to be discouraged for a very practical reason. A rapidly growing list of payors in the United States reimburse for telepathology services [15]. They correctly regard telepathology as being under the telemedicine umbrella, requiring the same hospital credentialing, the same medical licensure, and the same level of QA. Those agencies that reimburse for telepathology understand that physicians are providing a service comparable to that provided by more traditional methods [17]. They reimburse for pathology services at a distance, just as they reimburse for radiology services at a distance when they reimburse for teleradiology. At this late date, substituting term “whole slide imaging” for “telepathology” would unnecessarily complicate current efforts to make telepathology services universally reimbursable in the United States.

“Virtual microscopy” is the technology that attempts to emulate traditional light microscopy using digital image files (ie, virtual slides) manipulated on a computer screen using microscope emulator software. Typically, developers of virtual microscopy systems create a “presentation layer” for computers enabling the virtual microscope operator to perform the control functions ordinarily handled with a traditional light microscope, including positioning of the objective lens relative to a histopathology slide and

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