

## Histology Study in Undergraduate Medical Education

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Histology is an essential field in the education of medical students, and competent knowledge in histology is very important when studying pathology. Current teaching methods for histology in medical schools involve using a conventional light microscope (CM) with or without a virtual microscope (VM). This review aims to present advantages and disadvantages of using CM and VM in terms of teaching and learning histology in the context of undergraduate medical education. One major advantage of the traditional CM histology learning method in laboratory practice is that this allows students to practice using a light microscope; however, study flexibility is limited as the students cannot take the microscope back home for self-study after the histology class has finished. Costly repairs and maintenance must also be considered when using CM. By contrast, VM technology can provide flexibility and convenience for both students and staffs. This method allows students to both self-study and group-study almost anywhere at any time. This review emphasizes that histology learning in undergraduate medical education using VM is no longer confined to the classroom. However, the basic skill of how to operate a conventional light microscope is still important for medical students because CM is commonly used in the hospital laboratories and some hospitals may not be equipped with VM technology.

**Keywords:** Histology, Conventional light microscope, Virtual microscope, Medical education

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## Introduction

Human histology (also called microanatomy) is a basic morphologic science that plays an essential role in undergraduate medical education. Histology can be described as the study of normal cells, tissues, and organs structure of humans, by using glass slides and conventional light microscope (CM). A detailed understanding of histology is also required for studying pathology.<sup>1-3</sup> During the 1990s, computer technology improved and the virtual microscope (VM) was developed. Nowadays, VM has become more convenient and is widely used in medical education and for research.<sup>4</sup>

In the Faculty of Medicine Ramathibodi Hospital (RA), Mahidol University curriculum, the main topics in histology laboratory practice for medical students are basic tissues (epithelial, connective, muscular and nervous tissue) and organ systems (Table 1).

In the past, RA medical students studied sets of histological glass slides in the lab by CM, read histology textbooks and lab handouts, and attended histology lectures and other traditional resources. Nowadays, the histology course consists of a mixture of CM and VM in practical classes (Figure 1). So, what are the advantages and disadvantages of the conventional light microscope and a virtual microscope for undergraduate medical students to learn histology?

### 1) Conventional Light Microscope

A conventional light microscope (CM) (also called an optical microscope) uses visible light and lenses to magnify images. Thin sample glass sections can be directly observed by the eye.<sup>5</sup> CM practical sessions have been a basic teaching-learning tool in medical education for a long time. One advantage of the learning method by CM is that this allows students to become familiar and competent with the manual operation of a light microscope and slides. However, images cannot be recreated and viewed by the students after the histology class has finished. Other disadvantages include the high costs

of histology equipment and supplies procurement, maintenance of the microscopes and replacement of expensive slide sets.<sup>6-8</sup>

### 2) Virtual Microscope

Virtual microscopes (VM) utilize computer technology to store hundreds of histological images that can be viewed on a computer screen or via a mobile application on a smartphone. A VM allows the user to observe, select an image, zoom in or out, and add annotations on virtual slides. A virtual stained-tissue section is created by a robust slide scanner machine using specific software, and the pictures are converted into high-resolution digital images that are stored as electronic files on fast, high capacity computer servers.<sup>8-10</sup> Students can study or practice in a virtual histology laboratory in their own time using software applications on smartphones as a web-based virtual microscope.

A web-based virtual microscope is an online tool for histology study. Students can access data through the internet and visualize images using a computer or on their own mobile phones. Using web-based virtual microscope allows students to self-study and group-study almost anywhere at any time.<sup>9</sup> Some examples of free access web-based VM include Histology Guide-Virtual Histology Laboratory (University of Minnesota, USA)<sup>11</sup> and Michigan Histology-Virtual Microscopy (University of Michigan, USA).<sup>12</sup>

**Table 1. Major Topics of Practical Sessions in the Histology Course of Second Year Medical Students at Faculty of Medicine Ramathibodi Hospital, Mahidol University**

Epithelial tissue	Digestive System
Connective tissue	Urinary system
Muscular tissue	Female reproductive system
Nervous tissue	Male reproductive system
Integumentary system	Endocrine system
Eye and ear	Lymphoid system
Heart and blood vessels	Blood cells & Hematopoiesis
Respiratory system	

**Figure 1. Comparison Between the Use of Conventional Light Microscope and Virtual Microscope in Practical Classes**



A, Tablets or iPad are a great tool for studying histological images. B - C, The virtual microscope software (OlyVIA, Olympus, USA) that is installed on the computers and available for histology study; D - E, linked to web-based virtual microscope, publicly-distributed by Michigan Histology - Virtual Microscopy. F, The conventional light microscope and slide box for histology practice. Practical sessions of the histology course are taught at the Multidisciplinary Laboratory (MDL) of Faculty of Science, Mahidol University.

## 2.1) Histology Guide-Virtual Histology

Histology Guide website was developed by T. Clark Brelje and Robert L. Sorenson, Department of Genetics, Cell Biology and Development, University of Minnesota, USA.<sup>11</sup> It contains more than 250 virtual microscope slides. Students can zoom in and out to find specific regions of interest or shift to other areas (Figure 2). Moreover, electron micrographs (EM) and other specialized staining virtual slides are provided on the website.

## 2.2) Michigan Histology-Virtual Microscopy

Michigan Histology-Virtual Microscopy website provides medical students with histological glass slide

images viewed on a computer display. This virtual histology database was compiled by Kent Christensen, J. Matthew Velkey, Lloyd M. Stoolman, Laura Hessler, and Diedra Mosley-Brower, Department of Cell & Developmental Biology, University of Michigan Medical School, USA.<sup>12</sup> There are various types of virtual slides (H&E, special stains and EM) on the website similar to the Histology Guide website. The Michigan Histology-Virtual Microscopy mobile application is available for iOS users at the iTunes Store and for Android users at the Google Play Store, making it widely available for use in histology study.



**Figure 2. Comparison Between a Virtual Slide From the Histology Guide and Michigan Histology-Virtual Microscopy**



A, A screen capture of a virtual slide from the Histology Guide collection that represents a histological section of the eye (MHS 229 Eye), 0.4x magnification. B, A screenshot of the Michigan Histology - Virtual Microscopy that represents a histological section of the trachea (040\_HISTO\_40X.svs), 4x magnification.

Similarities and differences between Histology Guide and Michigan Histology-Virtual Microscopy in term of function are as follows:

- 1) Both are free web-based virtual microscopy sites available to users who have access to the internet.
- 2) Adobe Flash Player software is required to load the virtual slides from Michigan Histology-Virtual Microscopy, but not required for the Histology Guide.
- 3) Users can access histology information from

the virtual slide tab display of Histology Guide, but this is not provided on the virtual tab display of Michigan Histology-Virtual Microscopy.

- 4) The Michigan Histology-Virtual Microscopy mobile application is available for both iOS and Android-based computer tablets or smartphones. Mobile application is not available in the Histology Guide website.
- 5) Review questions are available in both Virtual Microscopy websites.

In 2013, Michael Hortsch found that although most students preferred to study histology at their own place and in their own time through scheduled resources such as lectures and lab sessions, there was a strong and growing preference to use a variety of electronic resources.<sup>9</sup> VM provides flexibility and convenience for both students and staff,<sup>2, 8, 10</sup> and the VM concept has been received positively by medical students. VM creates a better understanding and assists students to achieve better results in examinations than conventional light microscope techniques.<sup>7, 13, 14</sup>

However, the basic skill of how to operate a conventional light microscope is still important for medical students because viewing real tissue under CM assists long-term memorization by creating a positive

psychological effect, improving microscopy practice skills, and creating positive student-teacher interactions and relationships, and some hospitals may not be equipped with VM technology.<sup>6, 15</sup>

## Conclusions

Computer technology and the internet are available in all universities and hospitals in Thailand. The use of VM in medical schools can completely replace CM in histology practice and learning for medical students. Nevertheless, practical skill training in the use of a light microscope is still a useful skill for medical students studying histology. Further study is needed to determine the exam score results between the VM and CM study groups.

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## เนื้อเยื่อวิทยาสำหรับการศึกษาแพทยศาสตรระดับปริญญาตรี

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เนื้อเยื่อวิทยา (Histology) เป็นสาขาวิชาที่จำเป็นต่อการเรียนของนักศึกษาแพทยศาสตร์ ความรู้เชิงทฤษฎีในจุลกายวิภาคศาสตร์ของเนื้อเยื่อมีความสำคัญต่อการศึกษาศัลยวิทยา ปัจจุบันการสอนหัวข้อทางเนื้อเยื่อวิทยาในโรงเรียนแพทย์มักใช้กล้องจุลทรรศน์ใช้แสงแบบธรรมดา (Conventional light microscope) หรืออาจใช้ร่วมกับกล้องจุลทรรศน์แบบแสดงภาพเสมือน (Virtual microscope) บทความนี้นำเสนอข้อดีและข้อเสียของการใช้กล้องจุลทรรศน์ใช้แสงแบบธรรมดา และกล้องจุลทรรศน์แบบแสดงภาพเสมือนสำหรับการเรียนการสอนหัวข้อทางเนื้อเยื่อวิทยาในบริบทของการศึกษาหลักสูตรแพทยศาสตรบัณฑิต ข้อดีประการหนึ่งของการใช้กล้องจุลทรรศน์ใช้แสงแบบธรรมาคือ ช่วยให้นักศึกษาแพทย์สามารถฝึกการใช้กล้องจุลทรรศน์ได้อย่างถูกต้อง อย่างไรก็ตาม ความยืดหยุ่นในการเรียนนั้นมีจำกัด เนื่องจากนักศึกษาไม่สามารถนำกล้องจุลทรรศน์กลับบ้านเพื่อศึกษด้วยตนเองได้หลังจากชั่วโมงการเรียนเสร็จสิ้น ค่าบำรุงรักษาอุปกรณ์ที่ต้องใช้มีค่าใช้จ่ายสูงเป็นเรื่องที่ต้องพิจารณาเมื่อใช้กล้องจุลทรรศน์ใช้แสงแบบธรรมดา ในทางตรงกันข้ามการใช้ระบบกล้องจุลทรรศน์แบบแสดงภาพเสมือน ช่วยให้ผู้เรียนและผู้สอนมีความยืดหยุ่นและความสะดวกในการเรียนและการสอน วิธีนี้ยังช่วยให้นักศึกษาสามารถเรียนรู้ด้วยตนเองและเรียนแบบกลุ่มได้ทุกที่ทุกเวลา บทความนี้ชี้ให้เห็นว่าการเรียนรู้เนื้อเยื่อวิทยาโดยใช้ระบบกล้องจุลทรรศน์แบบแสดงภาพเสมือน จะช่วยให้การศึกษาของนักศึกษาแพทย์ไม่ถูกจำกัดอยู่ในห้องเรียนอีกต่อไป อย่างไรก็ตาม ความรู้เกี่ยวกับทักษะการปฏิบัติเพื่อการใช้งานกล้องจุลทรรศน์ใช้แสงแบบธรรมดายังมีความสำคัญต่อนักศึกษาแพทย์ เนื่องจากกล้องจุลทรรศน์ใช้แสงแบบธรรมดายังคงมีการใช้งานอย่างแพร่หลายในห้องปฏิบัติการของโรงพยาบาล และโรงพยาบาลหลายแห่งยังไม่มีติดตั้งระบบกล้องจุลทรรศน์แบบแสดงภาพเสมือน

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