

# New paradigms for learning and teaching histology; changing focus from microscopy to 3D reconstructions and animations

Final Report 2015

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<histology-online.com>



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And

Peter Roberts (Team Member)

Lucy Webster (Team Member)

## List of acronyms used

ALTC	Australian Learning and Teaching Council
LMS	Learning Management System
MOOC	Massive Open Online Course
OLT	Office for Learning and Teaching
SURF	Student Unit Reflective Survey
UCLA	University of California at Los Angeles
UWA	The University of Western Australia
URL	Uniform Resource Locator (website address)

# Executive summary

Histology, pathology and haematology, are image-intensive disciplines. Most learning is completed examining histological sections of body cells, tissues and organs using a microscope. Providing these courses (particularly laboratory classes) is becoming increasingly expensive. The 2009 Fellowship Program of the Project Leader and the outcome and deliverables from this project, addressed this issue and more cost-effective solutions have now been achieved that have also improved student learning experiences and outcomes.

## General outcomes and deliverables

The original Fellowship resource content has been extended to acquiring and including histology content that was lacking in the original resources, and also includes pathology and haematology content. Pathology is the study and diagnosis of disease. Haematology is the study of blood, the blood-forming organs and blood diseases. Content for instruction in laboratory medicine, histological techniques and histology in veterinary medicine has also been created. These deliverables have positively impacted on the learning experiences of a much wider range of student cohorts.

Collections of serial sections of major tissues and organs taught in a normal histology curriculum have been assembled to be processed for 3D reconstruction of the relevant histological details using BioVis3D. Animations depicting functional correlates with histological structure will be created.

The project activities were “student focused” i.e. resources have been designed after continual consultation with the student users to ensure the development of sound student focused pedagogies that engage students and enhance learning outcomes.

## A real success story

The project asked the question: *Are these extensive resources, available via the current Learning Management System (LMS), sufficient to adequately offer a histology curriculum completely online – including completing laboratory practicals?* A formal study involving the 2012 and 2013 student cohorts studying histology at The University of Western Australia (UWA) answered this question. The project concluded that students could identify sections of organs if they had to use a microscope (e.g. in the workplace), after using virtual microscopy only as a learning tool, and therefore complete a histology course online. So, the student, having completed an histology course online, can attain work-ready skills required by employers.

Formal evaluations carried out at UWA provided clear evidence that students enjoyed this online histology course. A Student Unit Reflective Survey (SURF) was completed by UWA. For all parameters/questions presented, scores were higher for this online histology unit than the average scores for our School of Anatomy, Physiology and Human Biology, the Faculty and UWA overall.

## Another success story

The histology resources, accessed via the internet, have had a very positive consequence. At the time of completing this report over 16,000 students were accessing the resources. Many of these students were attending universities in Australia, but an increasing number were from overseas institutions. This has enabled a unique situation whereby the project has dramatically changed the way in which students learn histology. Students worldwide can now access reliable and updated academic content on a unique, innovative, online learning platform.

This has been a most exciting outcome as the project team can in the future extend this concept of “online delivery of histology” to cater for increased demand for online education and achieve the goal of : global delivery of a premier histology course to students anywhere in the world, monitored by an established, collaborative network of histology professors. However, during the course of the project the team realised that the LMS was limited in adapting to recent technological advances in online learning. So the dilemma, or limiting factor, in achieving the final milestone of a global histology course was the need to use a learning platform more suitable to presenting the course completely online. This required the content be formatted in such a way to permit students to access the resources via any browser and on new digital ‘toys’ and so function on any mobile smart phone device, iPhone, iPad, Samsung Galaxy phones and tablets and all other Android and Blackberry devices.

Therefore another three deliverables were initiated using technologies now available that will render a new LMS sustainable over the long-term.

The project team is reformatting the text content (Topic chapters – Descriptive Texts and Online Laboratory Guides) into HTML5 formats. When reformatting is completed, content will be migrated from the current “Moodle” learning platform onto a “UWAClass2Go” edX platform.

The Online Interactive Histology Atlas is now upgraded to include additional innovative functionalities. The virtual microscopy platform includes specific educational attributes and delivers each scanned histological section of a tissue/organ via a unique URL. In a similar way to using the Online Interactive Atlas, users can select annotations from a list or within embedded text descriptions. When an annotation is selected the image viewer moves to the region of the image containing the annotation allowing interactive/guided learning content.

The URL (<http://histology-online.com>) will be used as the website address, for the first point of contact, as this URL is most familiar with users. When subsequent websites and learning platforms are renewed or recreated they will be re-directed from this website.

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# Chapter 1

## Preamble

Histology is an image intensive discipline. “Visual learning” is the predominant teaching and learning style of histology as it incorporates concepts and other descriptive information associated with images and histo-techniques. For this reason, this report will include a number of images to help disseminate the activities, outcomes and deliverables of this project.

This project’s outcomes and deliverables are best put in perspective if the “Introduction” that follows provides some historical account of what had initiated the project activities.

## Introduction

Histology (the microscopic study of cells, tissues and organs) is a course of study delivered to medical, dental, and various other cohorts of health and biological science students in universities and colleges worldwide. It is an image-intensive discipline as most learning is completed viewing high-resolution images of histological sections of body cells, tissues and organs and examining the histological sections using a microscope.

Traditional histology instruction is an expensive commitment by a university. Students attend lectures to listen to a descriptive account of each of 25 topics in a typical histology curriculum. They attend formal laboratory classes, supervised/assisted by academic staff, and view histological sections of tissues/organs using a microscope. With increasing numbers of student enrolments in courses requiring histology instruction, multiple laboratory classes need to be provided since most university’s schools or departments may only have 50-80 microscopes and class slide collections.

This increases the teaching hours of academic and other professional/support staff. Students are also often required to purchase a histology textbook and a histology laboratory manual.

Prior to taking up an Australian Learning and Teaching Council (ALTC) Fellowship, the Project Leader (Professor Geoffrey Meyer) already successfully addressed these issues at his institution, The University of Western Australia (UWA). His “computer-based” histology resource, originally called *“The human body – under the microscope”* but later renamed “Meyer’s Histology” was an award-winning, interactive atlas which solved some of the problems mentioned above and enhanced teaching and learning in histology (Figure 1). These were compelling features of why histology educators at other Australian and some overseas institutions requested access to this resource for their students. They acknowledged the resource would contribute significantly to achieving better quality of student learning – and it would be cost effective.



Figure 1: “Meyer’s Histology” is a cost-effective histology resource providing improved students’ experiences and learning outcomes

To meet the requests from these histology educators, Professor Meyer's Fellowship assembled additional learning contents/materials (Figure 2) on an online Learning Management System (LMS) that enabled secure access for histology students in Australian universities and some overseas universities and colleges.



Figure 2: An example of topic 5 providing extensive learning resources for learning the histology of "Skin"

The learning platform contains all topics in a traditional histology curriculum. Each topic (Figure 2) has "links" that enable students to understand learning outcomes expected, to download lecture text handouts, power-point presentations of lectures and audio-visual recordings of lectures. They also access the award-winning, online interactive histology atlas (Meyer's Histology), an online laboratory manual and access to a virtual histology slide database, as well as a "chat" channel and extensive quizzes that improve performances of students' in final examinations.

Opportunities were available to reconsider and reconceptualise traditional teaching approaches such as reduced staff requirements in traditional laboratory practicals due to the interactive resources students used on their own practical sessions when viewing histological sections using the microscopes. Increasing numbers of histology teachers became collaborative partners and their students accessed the resources.

As a consequence of the Fellowship activities, students shifted to a more computer-aided learning environment using quality resources delivered via an LMS with reduced need to use a microscope (Figure 3).



Figure 3: The new paradigm shift in learning histology - from microscope to computer.

A number of new desired outcomes, requiring new directions of innovation and development, were recognised during Professor Meyer's Fellowship activities and these were the focus of this Project's activities.

Two histology teachers, Dr Peter Roberts (Edith Cowan University) and Dr Lucy Webster (Charles Sturt University) had enthusiastically collaborated on the Fellowship activities and as Team Members on this OLT Innovation and Development Grant they assembled additional histology content to include on the learning platform. Content for other disciplines such as pathology, haematology and histological techniques was also created.

The learning content/resources created were delivered via <http://meyershistology.moodle.com.au>. Recently, as part of the Project activities, the resources have been presented as "ANHB01 Microscopic Anatomy" and relocated to a new learning platform: <http://online.class2go.uwa.edu.au>

"Microscopic Anatomy" is synonymous with "Histology" and the term is used frequently in other countries.

NOTE: The website quoted on the cover page (<http://histology-online.com>) is recommended for readers as it will redirect to any new URL that will deliver the LMS if, and when, these URL's change over time and further development.

## Chapter 2

### Project activities

#### Specific outcome 1

##### Aim

To extend the histology resource content and applications to a wider range of student cohorts using the resource template as a basis for learning pathology. Pathology is the study and diagnosis of disease.

##### Outcome

A wide variety of histological sections of pathological tissues (Figure 4) have been sorted for quality and scanned at the highest resolution for viewing via virtual microscopy, thus enabling students to study each pathological process (visible on the sections) without the need to attend laboratory practical classes and/or access only a limited numbers of slides and microscopes. All pathologies presented in a normal pathology curriculum have been included.

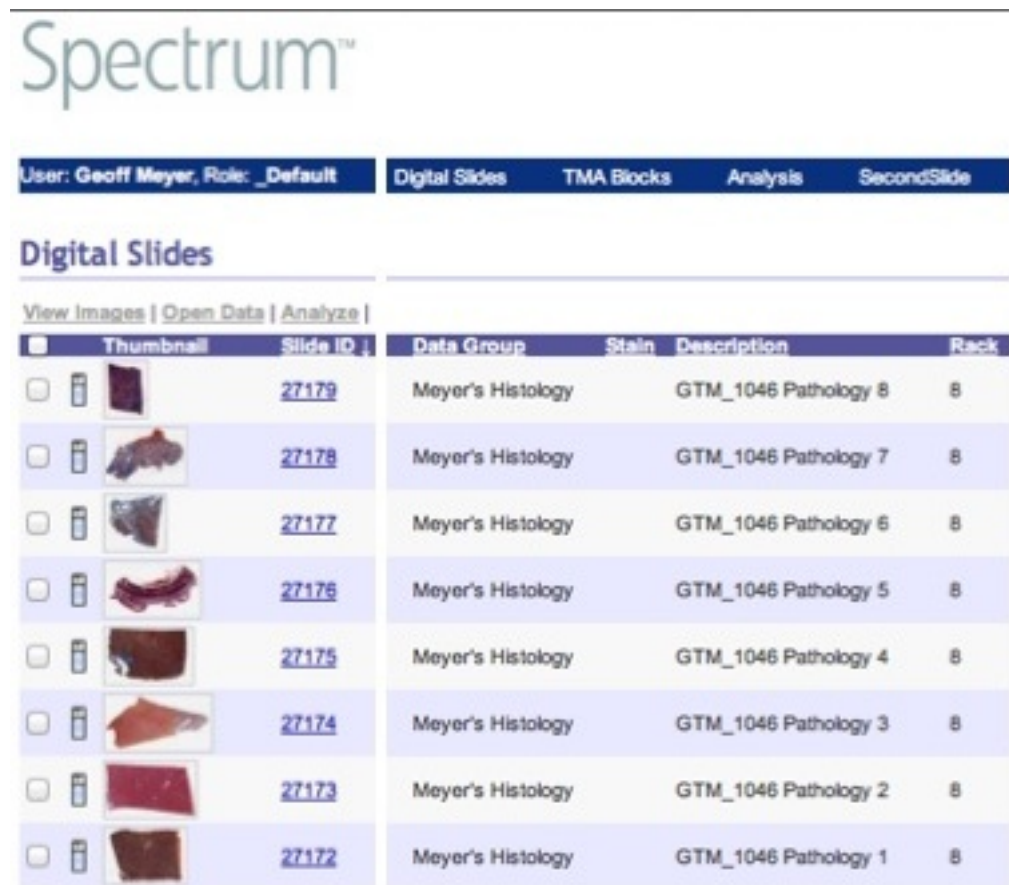
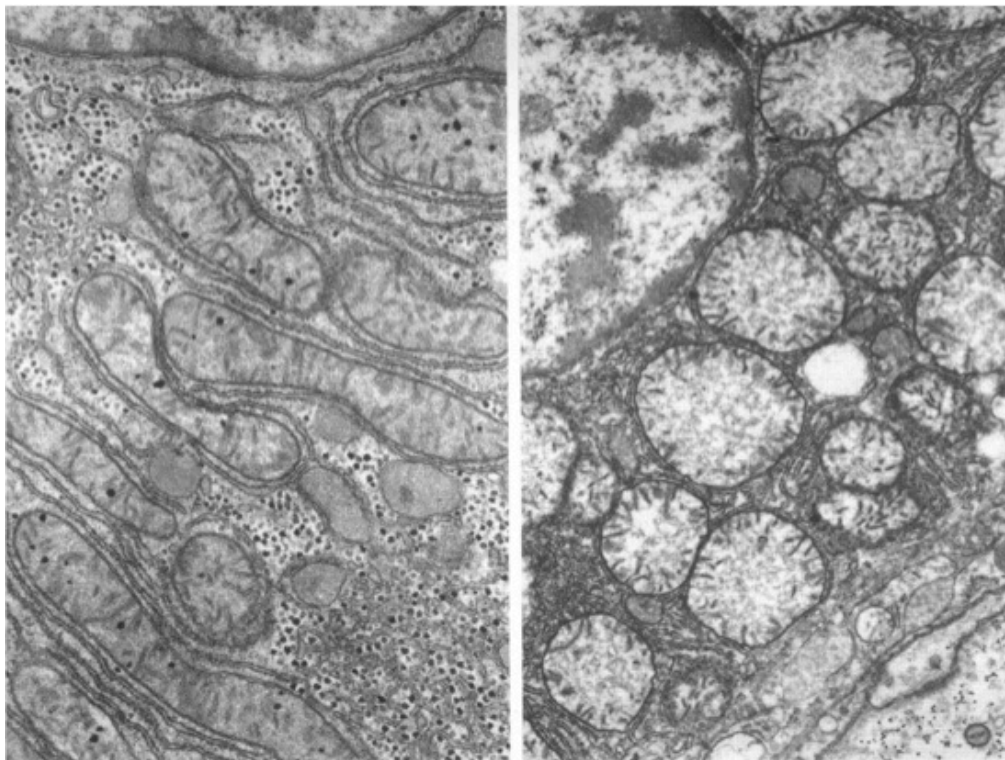


Figure 4: Scanned pathology sections as they appear in the database of 80 sections

Dr Peter Roberts provided detailed descriptions of the pathological processes visible on these scanned sections of pathological tissues/organs – at light microscopic and electron microscopic (Figure 5) magnifications and resolutions.





### Ischaemia 2.

Image 3. To the left are normal mitochondria with the edge of a nucleus visible at top. Following ischaemic injury the mitochondria are swollen (shown at right) by an influx of intracellular fluid. If the ischaemia is reversed, so too is the injury and the cell will return to normal function.

Figure 5: Description of a pathological process (Ischaemia) at the electron microscope level

Associate Professor Kimberley Roehrig, School of Pathology and Laboratory Medicine, UWA has recently made available additional pathology and also haematology resources to add. Haematology is the study of blood, the blood-forming organs and blood diseases. The project team has also started to assemble other resources for learning Laboratory medicine, Neuro-histology and Dental Histology.

### Specific outcome 2

#### Aim

To further the histology resource content and applications to a wider range of student cohorts using the resource template as a basis for learning histo-techniques.

#### Outcome

Dr Lucy Webster supervised colleagues to assemble content and a number of histology teachers that have recommended the resources for their students have contributed content on histological techniques and microscopy.

Dr Rebecca Donkin, Lecturer in Medical Laboratory Sciences, School of Health and Sport Sciences, Faculty of Science, Health, Education and Engineering, University of the Sunshine Coast has assembled relevant materials. Ms Mary Lee from the School of Anatomy, Physiology and Human Biology, UWA has assembled resources on histological techniques and microscopy.

Links have been created to the “Myscope” training resource for learning advanced

instrumentation and techniques in microscopy (<http://www.ammrf.org.au/myscope/>).

The project team also selected a number of electron micrographs from the extensive collection at the School of Anatomy, Physiology and Human Biology, UWA to be scanned and added to the resources. The micrographs are very high magnifications and high resolution images of cell/tissues/organ structure at the level of the electron microscope rather than the light microscope. These micrographs were added to the online, interactive atlas.

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### Specific outcome 3

#### Aim

In addition, the project set out to assemble a series of histological sections from animal tissues/organs to suit the histology curricula for students studying veterinary science/medicine.

#### Outcome

Colleagues at the Schools of Anatomy at the Universities of Capetown and Witswatersrand (Johannesburg), South Africa, have assembled this content.

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### Summary of specific outcomes 1-3

The project has gone well beyond the project's deliverables as proposed in the original grant application. The project team not only assembled high quality content for learning pathology, histo-techniques and histology specific for veterinary students, but also assembled content for presenting instruction in haematology and laboratory medicine.

The resource content and applications are now available to a much wider range of student cohorts than initially anticipated.

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### Specific outcome 4

#### Aim

Students find studying histology difficult – 3D interpretation from 2D representations of cell, tissue and organ structure is very difficult for many students and when they have difficulties they can lose interest and fail to gain sufficient knowledge and learning outcomes when completing histology courses and subsequent pathology instruction.

The popularity of using animations and 3D reconstructions to help learners understand and remember information has greatly increased since the advent of powerful graphics-oriented computers. One project activity was to create up to 24, 3-dimensional visualisation of structures, and integrate explanatory content onto the visualisation (via sound) to provide a much more valuable learning tool.

#### Outcome

An enormous amount of work has been undertaken viewing all the extensive collections of histological sections of cells, tissues and organs, sorting them, and creating a sequence of serial sections of each organ for the 3D reconstruction of the relevant histological details. This has been a very time-consuming activity and could only be completed by experienced histology teachers assisting in this project's activities. In some cases, new serial sections were cut from tissue blocks and stained. This is now a collection of 100 - 150 effective serial sections, five microns thick, (Figure 6) of each of the 56 major tissues and organs taught in a normal histology curriculum. This collection is a far greater number than was originally conceived. The project team agreed that assembling serial sections of all organs was a

priority as the process of 3D reconstruction using BioVis3D (see below) is less time consuming and will be an ongoing academic activity of the Project Leader.

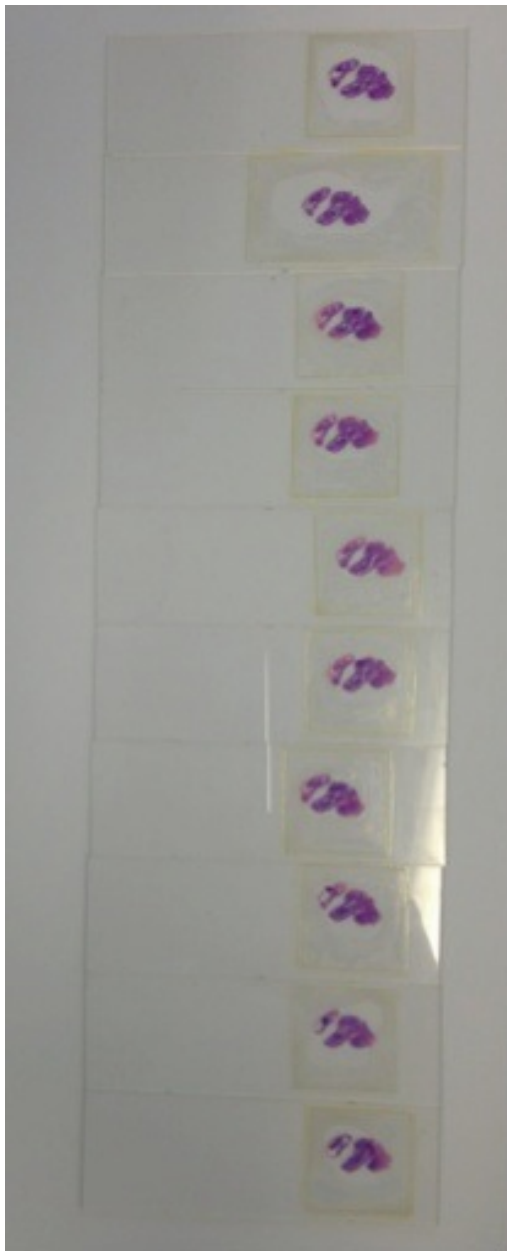


Figure 6: Serial sections of the uterine tube ready for BioVisD visualization

The project is also very fortunate to have been donated a wonderful series of neurological and dental sections from the University of California at Los Angeles (UCLA) and veterinary sections from the Universities of Capetown and Witswatersrand. The team intends to similarly assemble these tissue/organs into adequate serial sections of histological structures of interest. Over time, sections for 3D reconstructions from the pathology and hematology collections will be assembled.

During 2012/13 the team became aware of emerging technologies and the availability of these technologies (from late 2013) to create 3D reconstructions from serial histological sections. After completing trials with three different technologies it was decided to use

**“BioVis3D”**. This is a software application for three-dimensional visualization and analysis, specifically designed for scientists who work with serial sections, and suited the project’s need as an innovative learning tool for histology.

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## Specific outcome 5

### Aim

An additional outcome of this project was the creation of up to 24 animations.

### Outcome

Work is continuing on the development of the animations, which proved to be more costly than originally projected. The Project Leader has commenced a collaboration with Professor Rajasekharan; Focus Medica – Health Animation; <http://www.focusmedica.com> to create the required animations using the technical/animation skills within the Focus Medica group.

Specific outcomes 4 and 5 will continue to progress as an ongoing academic activity of the Project leader and the collaborators mentioned above.

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# Chapter 3

## The real success story

A success story of both the Fellowship activities (of the Project Leader) and, more significantly, the activities completed in this Project (with Drs Roberts and Webster) has been the direct impact on student learning and their learning experiences. The project activities have always been “student focussed” – ie. what is best for the students’ learning experiences.

This project has extended far beyond achieving the specific outcomes discussed above, to:

- (a) create resources and a facility for students to view quality resources via the internet and so,
- (b) reduce the need for formal practicals and therefore,
- (c) reduce costs to institutions, without compromising (but in fact improving) student learning experiences

The facility can now offer a histology course completely online. This is the first known occasion in the world that an online course in histology has been achieved.

## Could students learn histology completely online?

Even though all resources are available through the internet, the project team questioned whether all the resources are sufficient to adequately instruct a histology curriculum completely online – including completing laboratory practicals. If not, then what changes would need to be made.

## The approach/methodology

The **2012 cohort of 286 students** at UWA were divided into two groups:

**Group A** accessed all the resources but were also able to attend formal laboratory practicals and view histological sections using microscopes i.e., complete traditional laboratory classes.

**Group B** could NOT attend the traditional laboratory classes and only accessed the histological sections using virtual microscopy.

At the end of the course the assessment format, in relation to their practical class format/requirement, was reversed, so;

**Group B** students were required to identify histological sections of 35 organs by moving through a series of 35 microscopes set up.

**Group A** viewed computers for virtual microscopic examination of the same 35 organs. There were several sections that were very challenging.

## Results

The mean score for **Group A** was **31/35** and for **Group B** it was **29/35** (well within the normal range students had achieved in the past 5 years studying histology the traditional way).

## Conclusions

Students could identify sections of organs if they had to use a microscope (e.g. in the workplace) using virtual microscopy only as a learning tool, and therefore complete a histology course completely online.

To further confirm the team's conclusions, the complete 2013 cohort of 246 students at UWA studied the whole histology course online – they did not attend any lectures or laboratory classes and accessed all the learning resources at

<http://meyershistology.moodle.com.au>

Formal evaluations from all these 2013 students (Figure 7) provided clear evidence they enjoyed this as an online course. For all parameters/questions, scores were higher for the histology unit (Human Organs and Systems; ANHB2214) than the average scores for the School of Anatomy, Physiology and Human Biology, the Faculty and UWA overall.

Student evaluation of units for 2013 Second half								
Unit title: <b>Human Organs and Systems</b> Unit code: <b>ANHB2214</b> Campus: <b>Crawley</b> Teaching period: <b>SEM-2 2013</b> Start Date: <b>29/07/2013</b> End Date: <b>23/11/2013</b>								
Number of unit enrolments: <b>234</b> Number of Surf evaluations: <b>144***</b> Response rate: <b>61.5%**</b>								
Question	Percentage of Responses				Unit	School	Faculty	UWA
	Strongly Disagree	Disagree	Agree	Strongly Agree				
Q1. It was clear what I was expected to learn in this unit	1	10	41	49	3.4	3.1	3.1	3.1
Q2. The assessment requirements were clearly stated	1	6	38	55	3.5	3.2	3.2	3.2
Q3. The assessment tasks were closely linked to the unit objectives	1	1	41	56	3.5	3.2	3.2	3.2
Q4. The unit was well organised	2	12	36	50	3.3	3.1	3.1	3.1
Q5. The learning resources (handouts, text, web resources, etc) were adequate for my study in the unit	3	9	35	53	3.4	3.1	3.1	3.1
Q6. Overall, this unit was a good educational experience	4	6	38	52	3.4	3.2	3.2	3.2

\* The average of responses after quantifying them as follows: Strongly Disagree=1, Disagree=2, Agree=3 and Strongly Agree=4. The mid-point of this scale is a rating of 2.5.  
\*\* If the number of evaluations is greater than the number of enrolments, there was an anomaly in the administration of SURF and the results may not be reliable.  
\*\*\* To protect student anonymity, where there are fewer than 6 evaluations, results for the unit are not shown.

Figure 7: UWA SURF (Student Unit Reflective Survey)

A formal evaluation survey completed by all students was also very positive (Appendix A) and respondents presented a range of suggestions to improve their learning experiences. But, this achievement also identified a dilemma the project team needed to solve (see below).

## Another success story

At the time of completing this report there were over 16,000 students (Figure 8) accessing the resources on the "Moodle" site. At the time the final report of Professor Meyer's ALTC Fellowship was submitted in 2011 there were 5436 users.

Meyer's Histology		You are logged in as Geoff Meyer (logout)
Available Course		
Home > Site administration > Users > Accounts > Browse list of users		Blocks editing on
Admin bookmarks		16229 Users
bookmark this page		Page: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 ...541 (Next)
New filter		Show advanced
User full name contains		Add filter

Figure 8: Current users of Meyer's Histology

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Many of these students are attending universities in Australia but an increasing number of users are from overseas institutions. This has enabled a rather unique situation whereby the project has dramatically changed the way in which students learn histology.

The ultimate goal of the collaborative network of histology teachers can now be realised – ie. global delivery of a premier histology course to students anywhere in the world, monitored by an established, collaborative network of histology professors. In February 2014 a Massive Open Online Course (MOOC) commenced in histology (ANHB01: Microscopic Anatomy, Figure 9) that was facilitated by Professor Geoffrey Meyer and colleagues from the University of California at Los Angeles but monitored by an extensive network of histology teachers both within Australia and at three overseas universities.

<http://online.class2go.uwa.edu.au/courses/UWAClass2Go/ANHB01/2014/about>

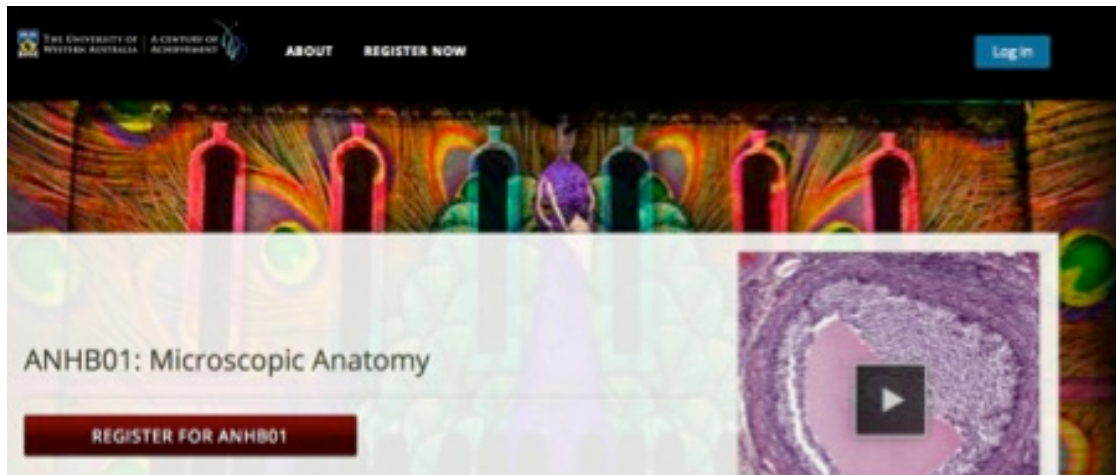


Figure 9: UWAClass2Go edX template and frontpage for the migration of content

## The dilemma

During the course of the project, the team realised that although the resources were excellent and presented in a very user-friendly platform, the learning management system was limited in adapting to recent technological advances in online learning.

The bulk of the work in this project has been assembling appropriate content/resources to deliver to increasing numbers of students, but, there is also now the need for employing the most modern and up-to-date technologies to deliver this content online. A platform is needed that can accept unlimited numbers of students and will last indefinitely. The goal is to meet the requirement of creating and engaging sophisticated online teaching strategies to effectively teach histology in the technology enhanced higher education environments and to prepare the student for the technologies used in the workforce they will enter. A new proposed learning system has been designed after continual consultation with the student users to ensure the development of sound student focused pedagogies which engage students and enhance student learning outcomes.

So, the key factor in achieving the final goal and opening this online histology course was the need to recreate the learning platform so as to be more suitable to present the course completely online. Whilst the team persisted with the original content that had been migrated from the “Moodle” Learning platform (ie. <http://meyershistology.moodle.com.au>) onto the UWAClass2Go platform, the focus then turned to three further objectives that are essential for this online delivery of histology content to be highly successful and sustainable in the future.

# Chapter 4

## Three New Objectives

### 1. Reformat the text content for long-lasting sustainability of online delivery

The content must be formatted in such a way to function on any mobile smart phone device, iPhone, iPad, Samsung Galaxy phones and tablets and all other Android and Blackberry devices.

There is a need to reformat the text content (Topic chapters – Descriptive Texts and Online Laboratory Guides) into HTML5 formats and use other technologies now available which would be sustainable and permit students to access the resources via any browser and on new digital ‘toys’ such as mobile devices, ipads etc.

A new learning platform “template” has been created in edX (Figure 10) using HTML5 to deliver all the resources. This new platform is “state of the art”, has many more functionalities, and was created specifically for delivering courses online.



Figure 10: The edX platform delivers the UWAClass2Go course in “Microscopic Anatomy”

### 2. The Online Interactive Atlas

The award-winning, online interactive atlas template (Figure 11) that has served as the most useful learning resource and the major resource component of the histology learning and teaching LMS had to be completely redesigned to suit modern browsers. This was unexpected and has caused delays in adding the content (created from this project’s activities/deliverables) to the resource. However, the value of this is the creation of a much more impressive resource (Figure 12) with more integrated, user-friendly, and sustainable functionalities. This new version is now fully functional and accessible via the project website.

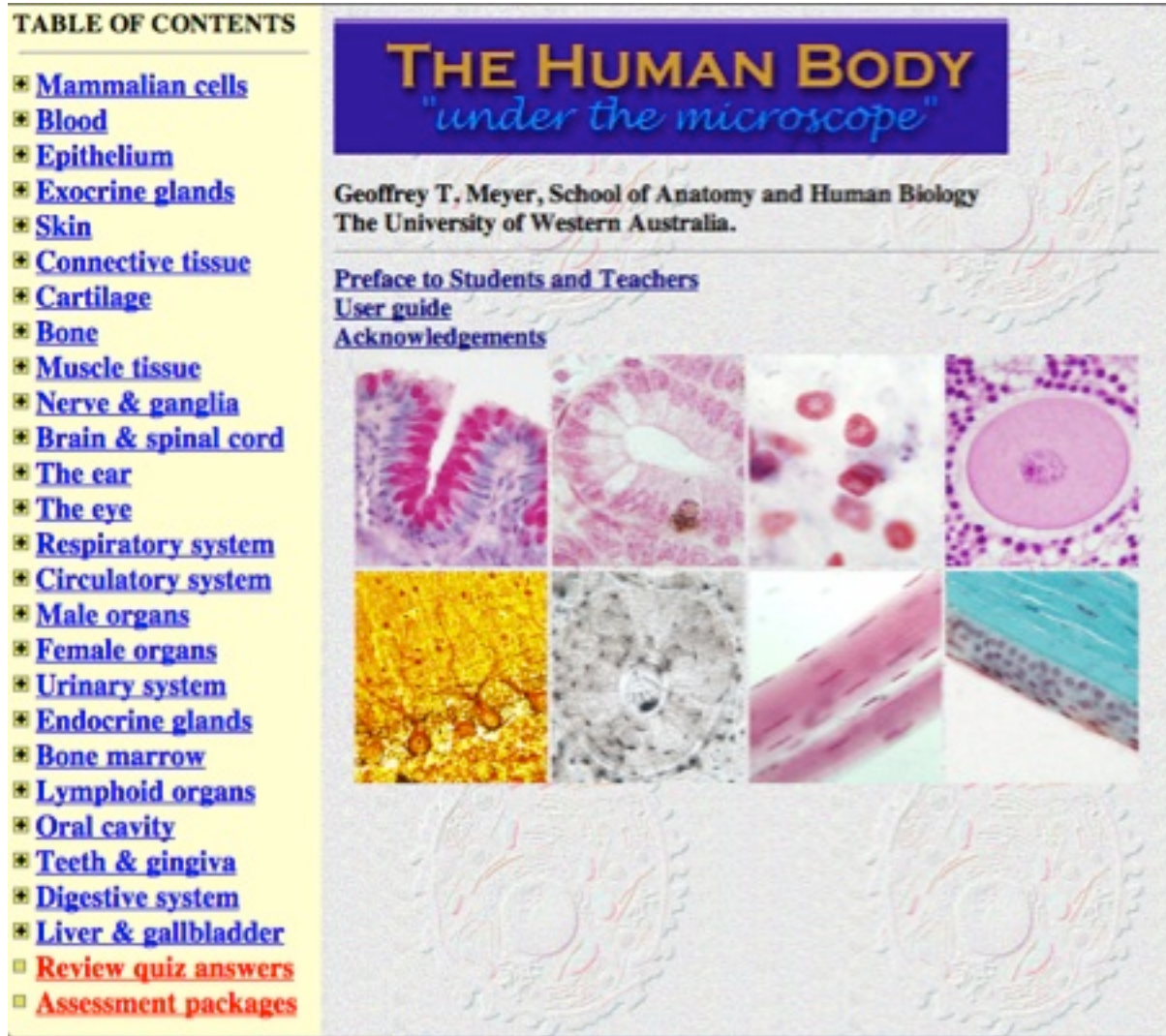


Figure 11: Old version (created in 1996) of the Online Interactive atlas



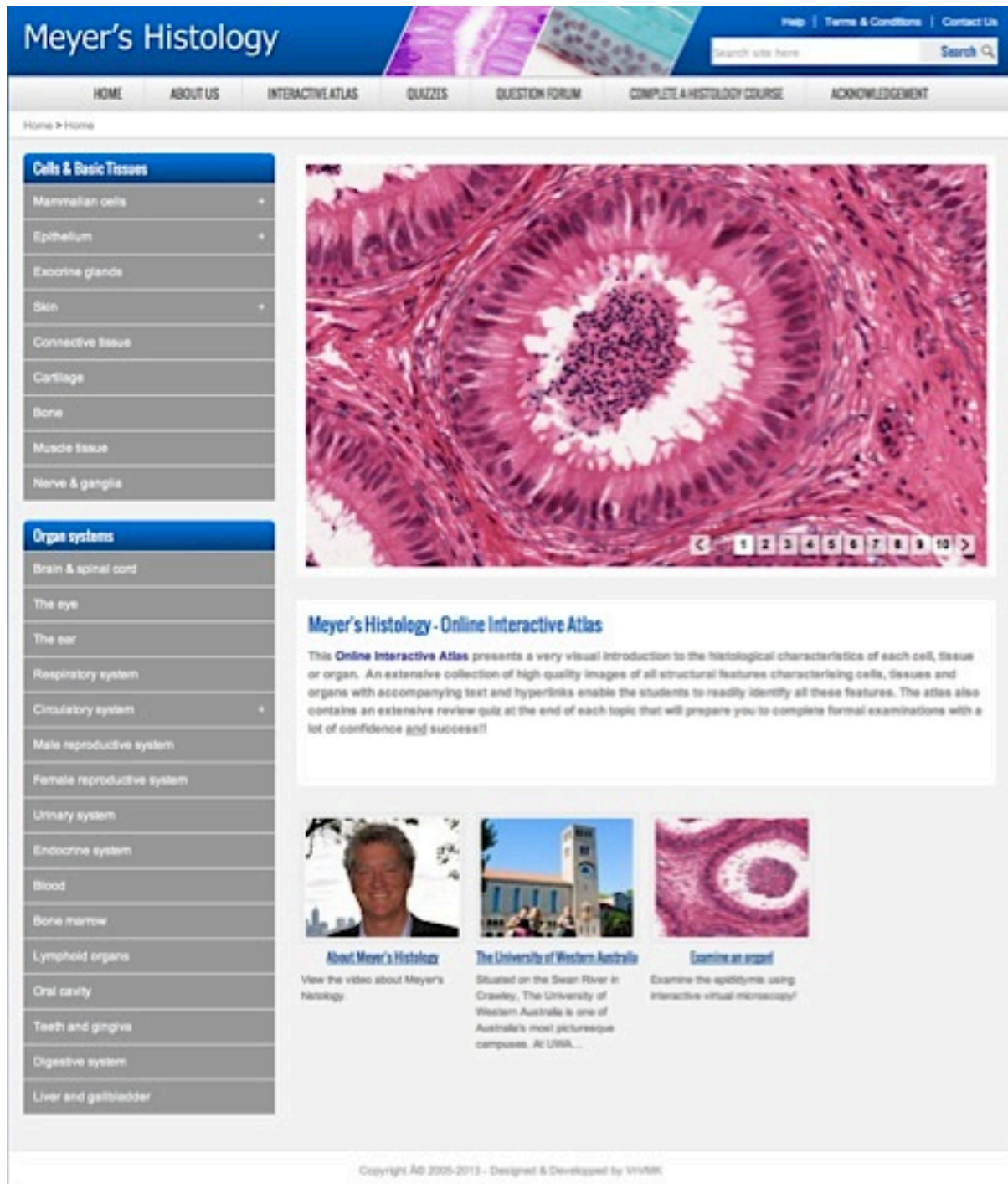


Figure 12: New template (created January, 2014) for the Online interactive Atlas

### 3. The virtual slide box

There is now new, state-of-the-art software which complements the virtual histology slide database and provides a more flexible use of the digitised images. This software was integrated into the virtual histology slide database for the start of semester 2 at UWA (July, 2014) and it is available for the network of histology teachers throughout Australia, and at specified universities in other parts of the world, to create a “shared repository” of histological sections.

The technology utilised is delivered by “pixcelldata” utilising “Collibio”. Pathologists and Histotechnologists now share images/data using Collibio software” (<http://www.pixcelldata.com>); Figure 13.

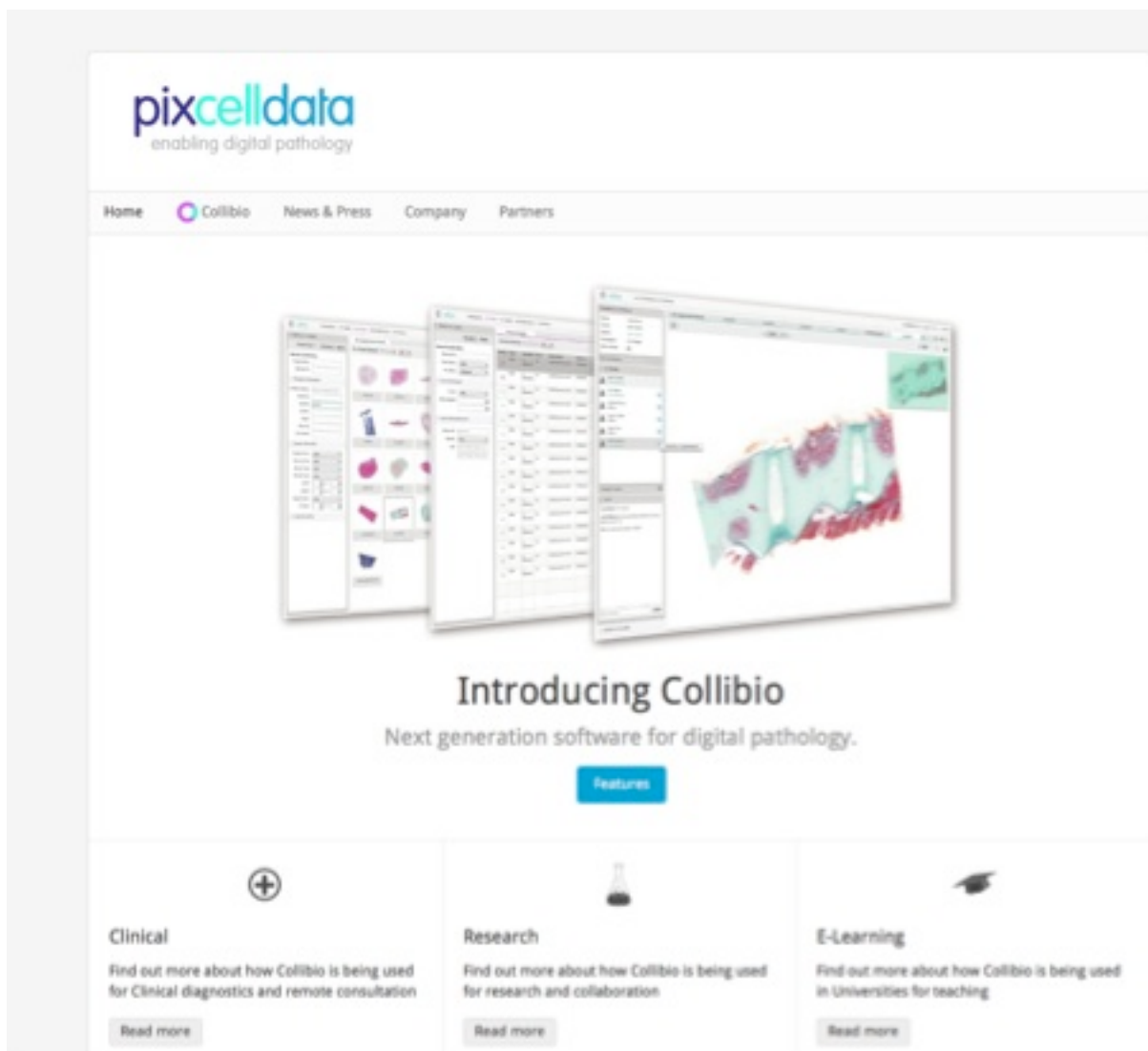


Figure 13: pixcelldata – enabling digital pathology

## Key features using the “Collibio” system:

One of the key features is the interactive components. Until now databases of scanned images to view with virtual microscopy were essentially a convenient means to project sections of tissues and organs to students during formal practical classes and/or to allow independent viewing of images by large numbers of students – often in diverse locations. However, students still relied on reading descriptive text and/or listening to formal explanations of the tissue sections from their professors.

The Project Leader has actively consulted with the creators of “Collibio” (Figure 13) and how they would develop and support the interactivity and functionality required in an educational scenario. Now, as an outcome of that collaboration, interactive functionalities are being incorporated to make viewing virtual slides independent of any other learning tool in a similar way to the award-winning online interactive atlas. Any online learning environment is only engaging when being immersed, interactively, with the slide image.

## The specific and detailed features of Collibio as an educational platform

The “workspace” is a collaborative environment which brings together user groups for the purposes of educational studies of histological sections. Users access images, interactive annotation layers, and other information.

A time period can be set when giving access to images to revoke access when the time period has passed.

Multimedia files can be uploaded and associated with images. This included instructional audio or video to enhance interactivity.

Collibio can generate a URL for any image to be displayed by any internet user. The URL opens the image in an image viewer and displays image information, annotation layers and interactive documents next to the image. The image viewer (Figures 14 and 15) is the key histology interface to each image, rich in functionality and interactivity. This URL can be emailed to collaborators or embedded in websites or third party applications. The URL can also be active only for a specified number of days, and can be deactivated at any time offering complete flexibility to creating online course content.

In a similar way to using the Online Interactive Atlas, users can select annotations from a list or within embedded text descriptions. When an annotation is selected the viewer moves to the region of the image containing the annotation allowing interactive/guided learning content.

Since Skype User Names can be stored in Collibio user profiles, the instructor can communicate audibly via a Skype conference call to any online users. So, the instructor can interact with students via an online chat for Q&A, and transfer control of the image viewer to students and have them lead the conference demonstrating their knowledge or raising a question about the image presented.





Figure 14: New viewer (created September, 2013) for virtual microscopy

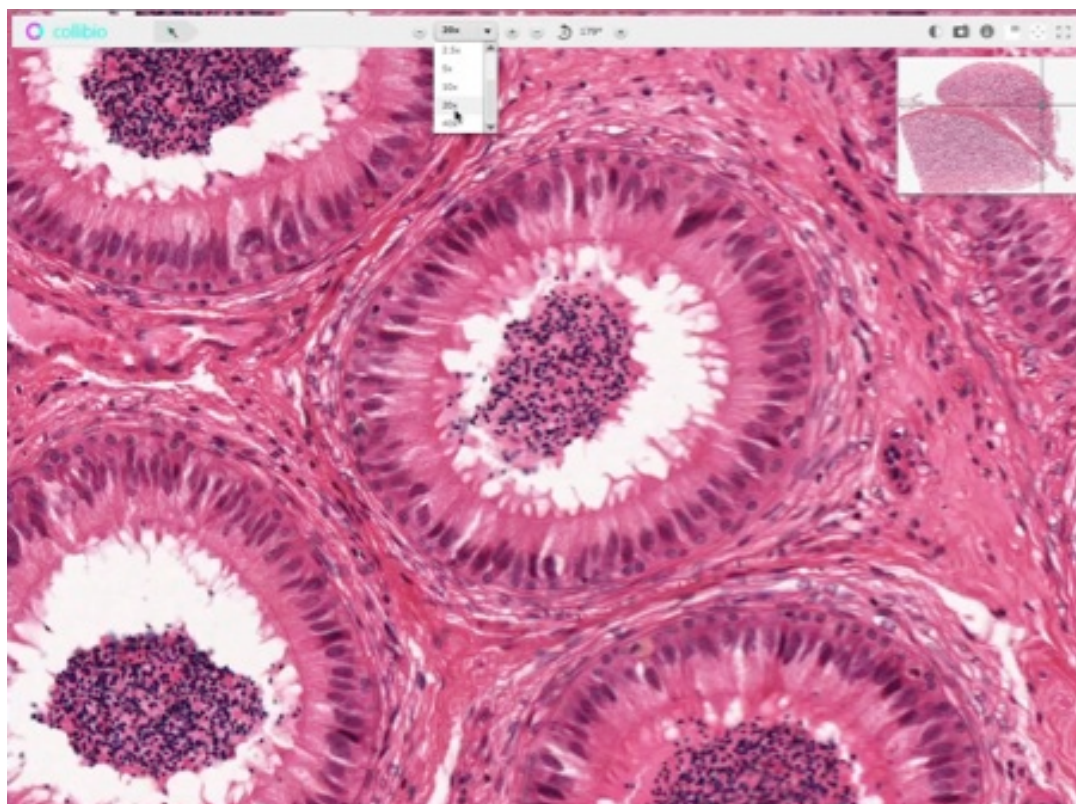


Figure 15: Histological structures examined of the section in Figure 14 using virtual microscopy

Try it!

View this section of the human testis and epididymis by opening the link below. No need to access a database etc.

<http://collibiouwa.perfekt.net.au/collibio/CollibioViewer.html?sharelinkid=a517927dd8501221e58904e62cf561de>

## Project achievements

Key achievements of the project are:

- The online histology course has opened new possibilities for technology-enabled learning.
- The project has created sophisticated online teaching strategies to effectively teach histology in the technology enhanced higher education environments and prepared students for the technologies used in the workforce they will enter.
- Students who cannot access quality histological section now can use the virtual microscopy facility on the learning platform.
- Exhaustive numbers of review questions provide opportunities for students' to review their own performances in achieving the desired learning outcomes. Immediate extensive feedback on their responses has enhanced a highly personal experience, particularly for those students in remote areas or "off campus".
- The learning platform gathers international students on the same learning platform so a very worthwhile outcome is students' engagement with other students from different universities worldwide in a way that fosters cross-cultural communication. On the "Open forum" of the website students (worldwide) are interacting academically and also socially but also selected students from previous years (2012 and 2013) remain active on the "Open forum" and have "mentored" the present student cohorts.
- The platform is not a static database of resources but interactive learning environments online, enabling students to use "virtual microscopy" and so augmented reality become possible. The focus has always been on learning design and the use of authentic learning to engage students.
- The histology resource LMS has had a very positive consequence in being able to cater for increased demand for online education.

## Summary

A learning platform more suitable for presenting courses in histology, pathology and haematology completely online has been created and content for these courses assembled. Learning content is formatted so access is via any browser and also functions on any mobile smart phone device, iPhone, iPad, Samsung Galaxy phones and tablets, and all other Android and Blackberry devices.

A formal study completed at UWA concluded that students could successfully study a histology course online and successfully achieve expected learning outcomes. Formal evaluations provided clear evidence that students enjoyed this online histology course.

The online resources (<http://histology-online.com>) include an interactive histology atlas with innovative functionalities. The virtual microscopy platform delivered each scanned histological section of a tissue/organ via a unique URL. In a similar way to using the histology atlas, users can select annotations from a list or within embedded text descriptions. When an annotation is selected the image viewer moves to the region of the image containing the annotation allowing interactive/guided learning content.

Collections of serial sections of major tissues and organs taught in a normal histology curriculum are being processed for 3D reconstruction of the relevant histological details. Animations will then be embedded.

## References or Bibliography

- (1) Building a network of academics who use, contribute to and disseminate, an online, cost-effective histology learning and teaching resource for students in Australia and overseas.

Geoffrey T. Meyer (2009 ALTC Teaching Fellow)

# Appendix A

## Formative evaluation

In the UWA 2<sup>nd</sup> semester over 350 students completed their histology course completely online and provided continual formal evaluation feedback.

A sample question is imaged below

**Meyer's Histology - "Online Interactive Atlas" is a useful resource**

Select one:

- ☐ Strongly disagree
- ☐ Somewhat disagree
- ☐ Neither agree nor disagree
- ☐ Somewhat agree
- ☒ Strongly agree ✓

Scores are "out of 4.35"

Strongly disagree	= 0
Somewhat disagree	= 1.09
Neither agree nor disagree	= 2.17
Somewhat agree	= 3.26
Strongly agree	= 4.35

---

Questions asked are presented below but the significant scores relative to the deliverables of this project are highlighted in "bold".

1. This course would be better with a regular lecture format rather than the "online" format.  
1.99
2. **John Campbell's "Laboratory practical guide" is a useful resource**  
**3.67**
3. **Meyer's Histology - "Online Interactive Atlas" is a useful resource**  
**3.83**
4. **I find the Meyer's Histology website easy to navigate**  
**3.57**

5. This course would be better with a regular (scheduled) laboratory practical session to examine scanned histological sections on the computer ie. virtual microscopy  
2.14
6. This course would be better with a regular (scheduled) laboratory practical session to examine real histological sections on glass slides using a microscope.  
2.2
7. **The "Descriptive text handouts" were a useful resource**  
3.92
8. I regularly checked all conversations posted on the "Open forum" link  
2.65
9. **The "Review quizzes" and "Assessment packages" on Meyer's Histology - "Online Interactive Atlas" are a useful resource**  
3.78
10. The goals, expectations and organization of this course were adequately described at the beginning of the course  
3.42
11. I have enjoyed this histology course  
3.18
12. **By using virtual microscopy I was able to understand the structure of each tissue/organ.**  
3.62
13. **I enjoyed examining tissue/organ structure using virtual microscopy**  
3.72
14. Tests 1, 2, 3 and 4 were a fair assessment of the required learning outcomes  
3.24
15. In our planning for later cohorts of students, we are wanting to offer this histology course "all year round" ie. you can complete the course at anytime of the year (eg. semester 1, semester 2, even over summer) and complete the assessment when you are ready. This would be a useful offering for future students?  
3.76
16. **Given all the other resources available on "Meyer's Histology", I did not need assistance from academic staff to examine and understand the histological structure of tissues/organs.**  
3.62
17. **I enjoyed having the freedom to choose when and where I could examine each tissue/organ using virtual microscopy.**  
3.81
18. **Overall, this unit was a good educational experience**  
3.60
19. I regularly used a histology textbook to aid my understanding of tissue/organ structure.  
0.73

20. Would you like to have audiovisual lecture recordings provided for all of the lectures? Such as the one for the "Respiratory System" this year?  
3.07
21. I would like to have a weekly 1 hour face-to-face review session at a regularly scheduled time  
2.46
22. Questions posted on the "Open Forum" should be left for 24 hours to be answered by my fellow students. After this time, the teaching faculty could answer the questions, or correct posted answers. This would encourage participation and interaction by students.  
2.19

## **STUDENT COMMENTS**

So far only students at UWA have provided evaluations

"Wonderful resources, wonderful histology course. Thank you Professors Meyer, Hall and Campbell - you guys were awesome!"

UWA Biomedical Science student.

"As a first year I had my doubts when I first enrolled in this unit as I was unsure if I was going to be out of my depth, but with the ongoing support and encouragement of the unit coordinators I soon came to enjoy Histology ANHB2214 more than any of my other units, and to my surprise, I am doing well. Online study has been fantastic for me, as I prefer to work independently and feel I get better results this way. It's also very time effective and I love the freedom to work through the unit at my own pace. All in all, this unit has reassured me that studying anatomy and histology is exactly where I want to be, and I'm so glad I chose to enrol."

UWA ANHB2214 student

"Having all the resources you need online is great because you can complete the work anywhere and any time. Being able to choose when and where I completed the required work each week was fantastic as I have a variable schedule week to week. It's great to have everything you need to know for the unit delivered in well-structured resources. I was apprehensive about doing an all-online unit at the start of the semester but after my experience with this unit I would like to see more units in the university adopt this structure. The resources are easy to follow and the unit coordinators are very attentive to the discussion forum so any queries you have can be resolved quickly."

UWA Medical student

"Thank you so much for the nice welcome message & the precious opportunity you gave to access such enriched Histology resources. I hope & am sure it will be a wonderful learning experience not only for students but also for both of us including my respected professors & colleagues at the Histology department of Kasr Alainy Faculty of Medicine. FYI, kindly find below the link to our department & faculty that is considered the largest & oldest medical school in Africa & Middle East."

<http://histology.kasralainy.edu.eg/>

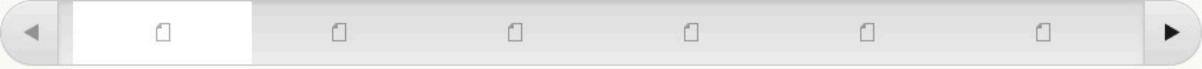
"The resources are fantastic, really concise and to the point. Any chance of uploading the muscle descriptive text? Have histochallenge coming up in a couple of weeks."



## Appendix B

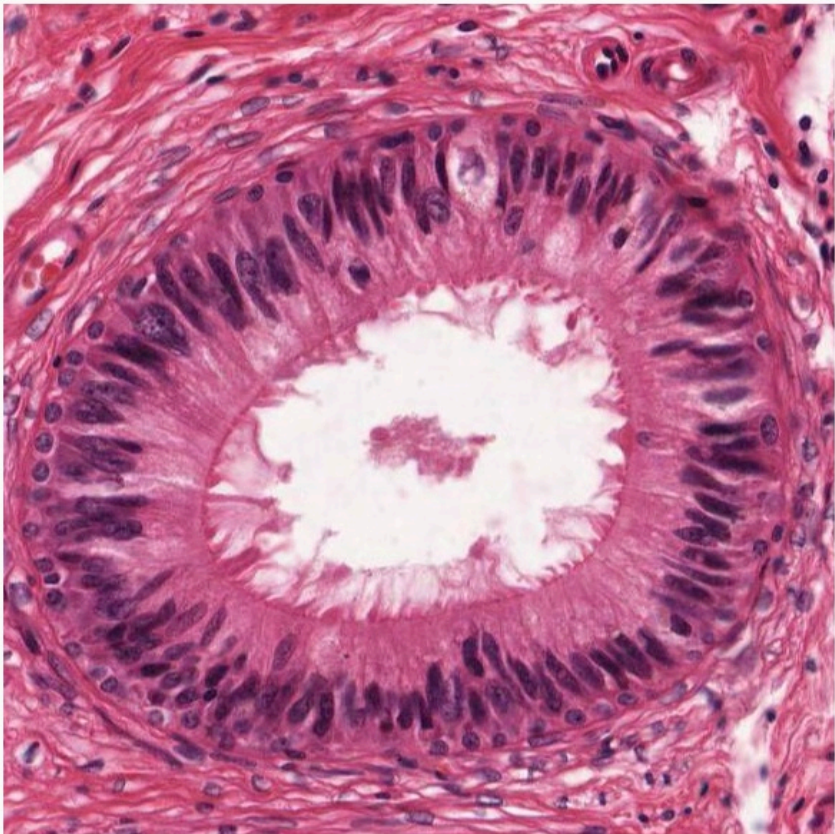
A series of “screenshots” follow of a “User’s Guide” to showcase some of the features of the new edX delivery platform and related link to the “Online Interactive Atlas” and the database of histological sections for viewing using virtual microscopy.


Only the module on the “Male Reproductive System” has content reformatted added so it can be used for demonstration purposes..



### User's Guide (pg 1)

The image below is of a section through the highly coiled "**ductus epididymis**" – an organ in the male reproductive system. You will study the microanatomy of this duct in your histology curriculum. So how do you do this on Meyer's Histology?





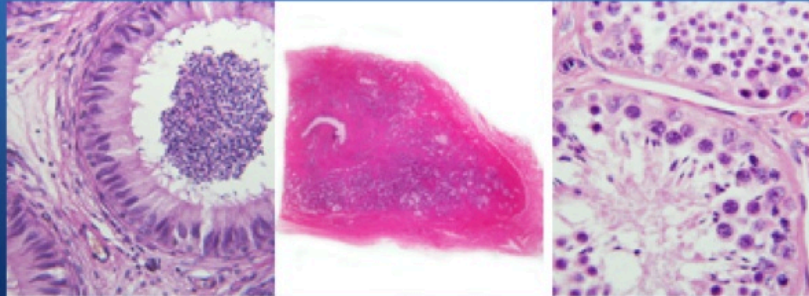


## User's Guide (pg 2)

Open the "**Male Reproductive System - descriptive text**" (as indicated in the image below) and read about the "**ductus epididymis**" in that document (*it is on page 6*). What knowledge do you now have of the "**ductus epididymis**"?

The screenshot displays a courseware interface with a top navigation bar containing links: Courseware, Course Info, Discussion, Wiki, Progress, and Empty. On the left is a vertical navigation menu with categories: Meyer's Histology - General Information, Descriptive Texts - Basic Tissues, Descriptive Texts - Human Organs and Systems, Organ Organisation - Histology Terminology And Ideas, Brain And Spinal Cord, The Eye And Orbital Anatomy, The Ear, Cardiovascular System, Respiratory System, Endocrine System, Female Reproductive System, Male Reproductive System (highlighted), Urinary System, Blood, Thymus And Lymphoid Tissues, Lymph Node And Spleen, Digestive System, Oral Cavity And Tooth (Including Gingiva), Salivary Glands, Liver, Gallbladder And Pancreas, Online Interactive Atlas, and Histology Slide Box (for Major Organ Systems). The main area shows a document viewer with a list of links: Male Reproductive System - Descriptive text, Meyer's Histology - Online Interactive Atlas, John Campbell's histology practical guide for the "Male reproductive system", and Practical Guide. A red arrow points from the 'Male Reproductive System' link to a thought bubble containing the text 'From page 6'. Below the list is a preview of the selected document, titled 'Meyer's Histology', which contains text about the ductus epididymis. The preview window has a toolbar with Zoom, Tool, Annotate, View, and Search... buttons.

## Male Reproductive System



### Learning Outcomes

Your knowledge of the Male Reproductive System should include the following:

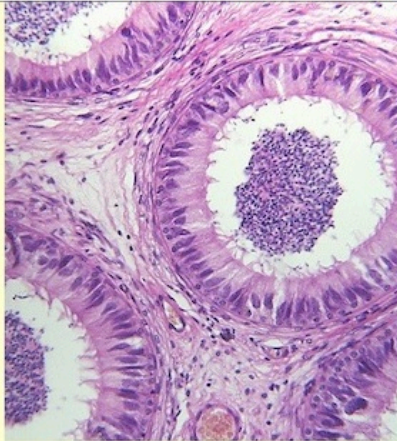
- Recognise and name the structures of the male reproductive system
- Understand the gross structure of the **testis**
- Identify all of the cells of the **seminiferous epithelium**
- Distinguish between **spermatogenesis** and **spermiogenesis** and describe the progression of sperm through the complete process of spermatogenesis
- Identify **Sertoli cells** and describe their main functions.
- Identify **Leydig cells** and describe their main functions
- Understand the **hormonal control** of spermatogenesis
- Identify the **ducts** involved in the passage of sperm from the testes to the penis, and describe what role each plays in the maturation of sperm
- Identify the **accessory sex glands** and know their role in nourishing and protecting the sperm after ejaculation
- Understand the structure of the **penis** and how **blood flow** causes erection
- Understand the mechanism of action of Viagra (if you understand this, then you will have answered the previous question).
- Understand the role of the **sympathetic** and **parasympathetic nervous systems** in erection and ejaculation.
- Distinguish between **sperm** and **semen**, and know the components of semen

## User's Guide (pg 3)

Now access "**Meyer's Histology - Online Interactive Atlas**" and open the topic "**Male organs**" (click on the + icon to open the content/"tree"). Then open the link "**head of epididymis**" (arrowed in the image below).

### TABLE OF CONTENTS

- \* Mammalian cells
- \* Blood
- \* Epithelium
- \* Exocrine glands
- \* Skin
- \* Connective tissue
- \* Cartilage
- \* Bone
- \* Muscle tissue
- \* Nerve & ganglia
- \* Brain & spinal cord
- \* The ear
- \* The eye
- \* Respiratory system
- \* Circulatory system
- \* Male organs
  - male organs (diagram)
  - male genitalia
  - anatomical dissection
  - adult testis (diagram)
  - \* adult testis (H&E)
  - immature testis
  - epididymis (diagram)
    - efferent duct
    - head of epididymis
    - ductus epididymis (VG)
    - tail region
    - spermatozoon (diagram)
    - sperm (H&E)
  - spermatic cord
  - ductus (vas) deferens
  - seminal vesicle
  - \* prostate gland (diagram)
  - bulbourethral gland
  - \* penis (diagram)
  - Review quiz
- \* Female organs
- \* Urinary system



### Epididymis head

In this image there are numerous profiles of the sectioned, highly coiled, head region of the ductus epididymis. These profiles appear as many shapes depending on how the coiled duct is sectioned.

Maturing spermatozoa are visible in the lumens of these profiles.

The next image provides you with details of the histological structure of the wall, and epithelium lining the lumen, of the ductus epididymis.

In the right hand frame, accompanying text and hyperlinks enable you to readily identify histological features. Often an additional feature at the bottom of the right hand frame is the computerized microscope (**tutor**). An image of the histological slide in the class slide box is loaded. By engaging the objective lenses, superimposed "target regions" direct you where to locate the "**ductus epididymis**" within the histological section. Simultaneously, descriptive text is loaded and relevant structural detail can be identified using the interactive hyperlinks. ***So if you were now to view this histological section using a microscope you should know where to locate the "ductus epididymis" and view its histological detail.***

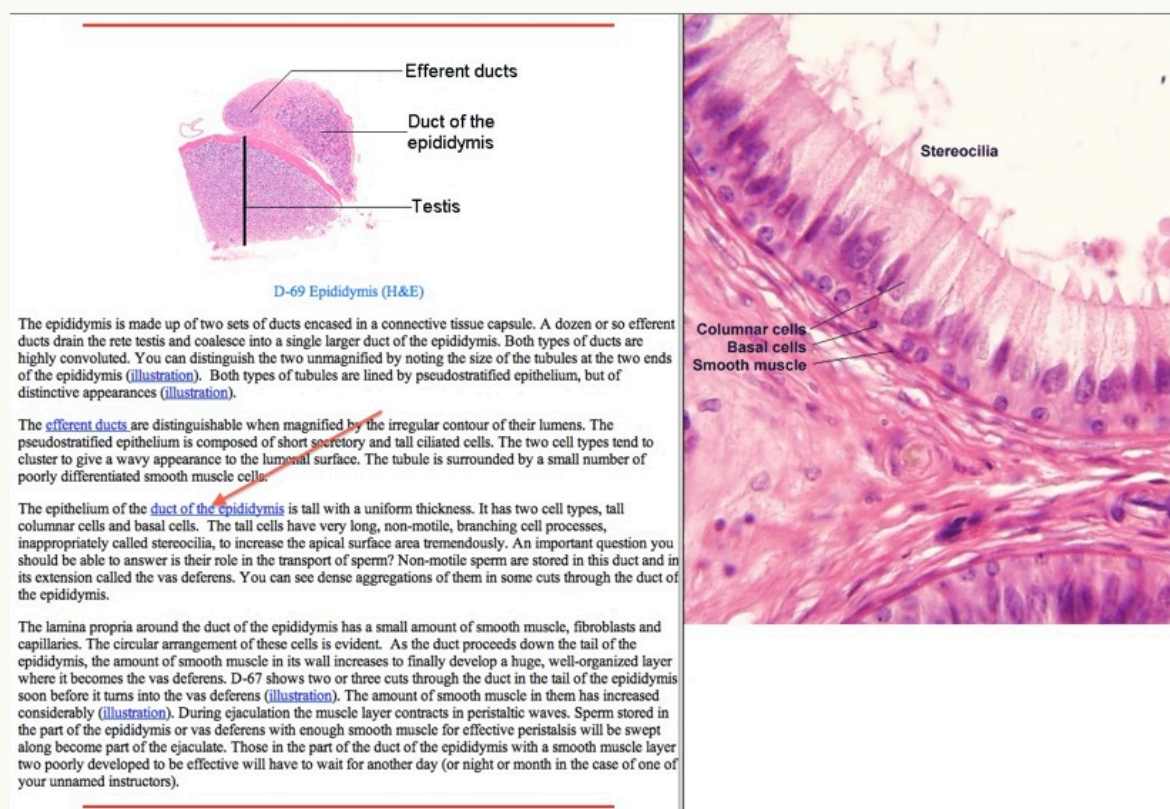




## User's Guide (pg 4)

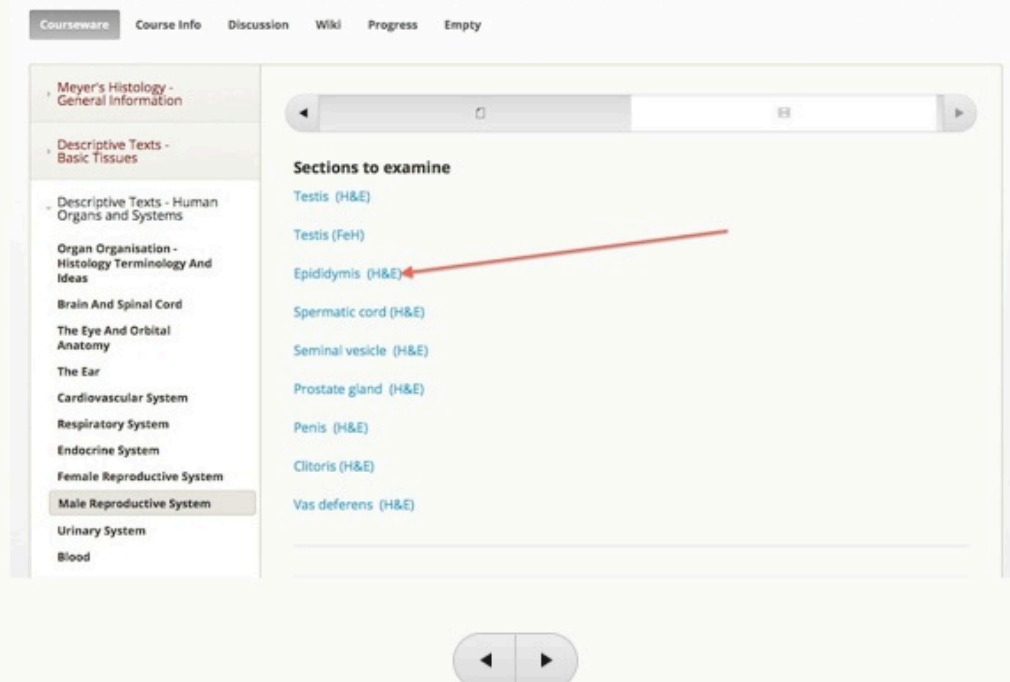
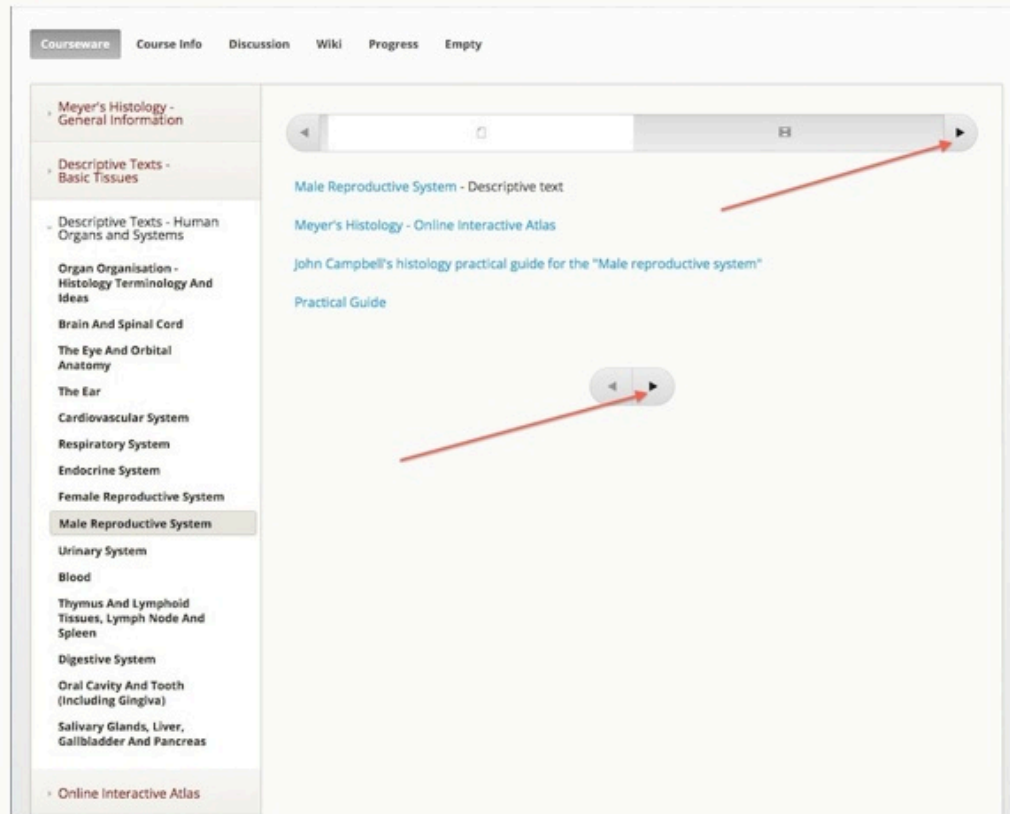
So after accessing knowledge of the “**ductus epididymis**” in the “**Male Reproductive System – Descriptive text**” and a visual interactive understanding from the **Online Atlas** you should then access **John Campbell's Histology Practical Guide**.

Learning outcomes to achieve when viewing the histological sections are listed. Scroll to the “**Epididymis**” and view a detailed description of that histological section. Hyperlinks, eg. “**duct of epididymis** (arrowed)” open labeled images of histological characteristics – **the columnar (principal cells), stereocilia, basal cells and smooth muscle**.



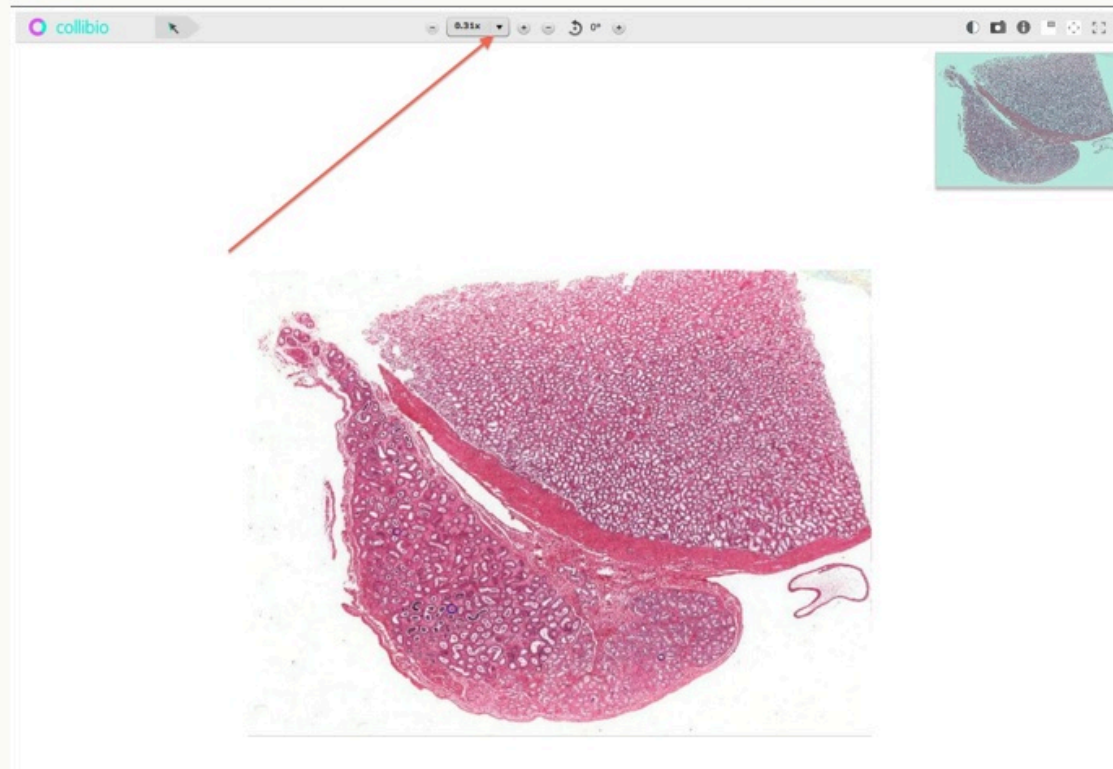
## Guide (pg 5)

You do not need to view this histological section in a formal laboratory practical class using a microscope, instead, open a direct link to the database of histological sections ) "**Histology Slide Box**" (see image below) on Meyer's Histology and view the section using innovative virtual microscopy technologies – *anywhere and at anytime*.



## Guide (pg 6)

View the section of the **epididymis** via a direct link to the database of histological sections.



Do you recognize this section from the images you viewed in the computerized microscope in the Atlas and the Histology Practical guide?

Choose an appropriate magnification (use the magnification scales (arrowed)).

Move the field of view frame on the thumbnail to view the ductus epididymis

You should recall where to focus the field of view from your use of the computerized microscope on the Online Interactive Atlas.

Move the structure of interest to a central position

Increase magnification and view structural details.

Again return to low magnification, this time, using the magnification scales to view the whole section, and you can continue to look at the microanatomy of other sectioned profiles of the coiled ductus epididymis, and also other organs in the section eg. the testis.

