An Interactive Anatomy Dissection DVD.

Submitted for MSc to the Royal College of Surgeons in Ireland

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Dedication

For Marie, Scarlett & Sa'diah
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The overall project and this thesis would not have been achieved were it not for so much input from people too numerous to list, but I shall make an attempt to briefly mention the major players.

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If I have forgot to mention anybody by name, please forgive me and consider my appreciation and thanks as a given.

Most importantly to my students, past, present and future for making me a better clinician and a better teacher.
Declaration

I declare that this thesis, which I submit to RCSI for examination in consideration of the award of a higher degree - Master of Science (MSc) - is my own personal effort. Where any of the content presented is the result of input or data from a related collaborative research programme this is duly acknowledged in the text such that it is possible to ascertain how much of the work is my own. I have not already obtained a degree in RCSI or elsewhere on the basis of this work. Furthermore, I took reasonable care to ensure that the work is original, and, to the best of my knowledge, does not breach copyright law, and has not been taken from other sources except where such work has been cited and acknowledged within the text.

Signed

Student Number 4236483

Date 16/03/2013
Abstract

Anatomy remains the cornerstone of medical education. Human anatomy has not changed, yet our understanding of the topic and the methods by which we teach anatomy continue to evolve. At present lectures, tutorials and human cadaveric dissection in the anatomy room remain central to anatomical education in the Republic of Ireland and throughout many parts of the world. With the emergence of new technologies, new teaching methods can be explored.

In-house and on-line teaching of Radiology and Histology are already used at the Royal College of Surgeons and we believed it apt to create an "Interactive Anatomy Dissection DVD" to complement the teaching of topographical anatomy.

We took an already successful and established anatomy course, ostensibly based off “Cunningham’s Manual of Practical Anatomy” (currently in its 15th edition), and filmed sessions of cadaveric anatomical dissection which correspond to the sessions, or practicals of the dissection room teaching time at the RCSI and with the collaboration of our colleagues from the Department of Electronic & Electrical Engineering of Trinity College Dublin, were able to use computer-assisted digital content analysis to auto-edit the footage, producing a 5-minute short, and highlighted and labeled the relevant structures that the student need be familiar with in a given anatomical area, we then interfaced this with images from “Cunningham’s Manual of Practical Anatomy (15th edition)” which Oxford University Press has kindly given permission to be used.

The anatomical dissection DVD is not intended to replace the lectures, tutorials, dissection room practicals and textbooks. Our intention is to create a user friendly simple interactive DVD that corresponds to the anatomy curriculum for the 1st Medical year of the Royal College of Surgeons.
Chapter 1: Introduction

1.1 Overview

Anatomy remains a cornerstone of medical teaching. In recent times our overall knowledge of the subject has not changed but the methods of how we teach the subject have, and will by all likelihood continue to evolve.

Technological advances alter education. Other resources can either be abundant or rare over time and can influence educational practices. Education is also prone to follow different fashions over time, which can have an effect on the dogma of educational institutions and their practices.

At the Royal College of Surgeons in Ireland (RCSI) cadaveric dissection is a central component of the Anatomy course for the medical student. This is supplemented with lectures, tutorials and examinations. This is not unique to the RCSI, many universities around the world employ cadaveric dissection as a core element to the education of anatomy as it is known to work and there are added benefits to cadaveric dissection.

When the medical student is introduced to the cadaver many seeds of education and skill sets are being sown, well before a dissection implement is utilized. This is usually often the first patient the student meets, and one they often rarely forget.
For some it could be the first real encounter with the dead. This process cannot be simulated in the lecture theatre, in textbooks or with audio-visual aids. The doctor will encounter the dead and the dying throughout their career. The encounter in the anatomy rooms is a good controlled start to these concepts. To some it is an education in desensitisation.

Anatomical education is not the sole reason for cadaveric dissection. There are a multitude of skills and experiences that it brings to the student. It is a hands-on, tactile, interactive manner in which to experience and learn anatomy. It is often performed under supervision in teams so not only does the student learn the regional anatomy they also learn how to take senior instruction while working with colleagues. The anatomical structures are both viewed and felt, so enhancing the learning process. Handling of surgical instruments is learned in an environment where damaging important structures has no adverse outcome on the patient.

Medical schools have to keep their curricula up to date in order to produce graduates who are familiar with current knowledge and practice. Accordingly, new topics and subjects are continuously being added into the curriculum. This means that pre-existing topics have less time dedicated to them.
At RCSI there are also other specific factors that are pertinent. Student enrollment increased and new schools were either opened, expanded or had more anatomy incorporated into the teaching programme. Primarily there were more students taken on, a Graduate Entry Programme was introduced and a sister college was opened in Bahrain. The Schools of Physiotherapy and Pharmacy had more exposure to anatomy.

Essentially there were more people drinking at the well. This obviously stretches resources. Seeing as the resources are multifactorial it poses many challenges. If you have more students, you need more space, either more teachers or teaching time and arguably more cadavers. More space often requires more building. More teachers require more salaries, or teaching time is increased so the academic staff spends less time on their duties. More cadavers can be a complicated issue. In the case of the Medical University of Bahrain, supply, cultural sensitivities, and a hostile environment for the embalming process are significant factors. Bahrain is a hot country, but energy rich. Air conditioning is readily and cheaply available and so anatomy dissection rooms can be kept cold. The air circulation evaporates the embalming fluid, so more is added. The net effect is that cadavers becomes dehydrated, making them less than optimum specimens.

These changes pose challenges to those who teach applied anatomy to medical students for their clinical careers. New technologies offer possible solutions and cadaver dissection and technological advances should combine to overcome this challenge (Inwood and Ahmed, 2005).
What needs be done is to take well-established, respected and successful teaching methods and to marry them to either unutilized pre-existing or cutting edge technology. A marriage of necessity or convenience perhaps, but it poses a solution to the problem without resorting to major capital expenditure. Theoretically: as the technology continues to advance, so to can the amalgamation of the technology with the already established teaching. While holding fast to the best traditional teaching methods, we can embrace the best of computer-aided learning (Lee, 2006)

At the RCSI there is a well-established and celebrated anatomy teaching method. The undergraduate medical student follows an integrated curriculum, of which anatomy is part. It is spread over three semesters and involves: lectures, anatomy room dissection, tutorials and frequent continuous assessment sessions.

Twice a week the students attend a fifty-minute lecture pertaining to a particular region of the human body. Clinical anatomy is being taught to the students, as the assumption is that you will be producing a clinician, so the clinical significance of the regional anatomy is always emphasized. After a short break the student then enters the dissection room. Here a ninety-minute teaching session begins. The students have already been assigned to groups and a cadaver, under the tutorship and direction of a Surgical Prosector (either a retired surgeon or an active clinician).
The Surgical Prosector explains and demonstrates the surface anatomy, aids and guides the student in their dissection of the relevant region and correlates this with radiological images. A clinical case scenario is discussed and explained. Most importantly they impart to the student the knowledge that comes from a wealth of experience from their clinical practice.

Every fortnight the student's knowledge is assessed in a structured tutorial or "Card Signing". The students gather round the dissection table and the Surgical Prosector quizzes them on the material that has been covered to date. The questions relate to: surface anatomy, identifying structures on the cadaver, questions pertaining to the radiological images, or clinical case scenarios.

The student is allocated a grade depending on how well or poorly they have done. The grades are as follows A (good), B (satisfactory), C (unsatisfactory). The prosector may add a minus (-) or plus (+) to the grade, it does not change the actual mark but can drive a point home to the student that they are either doing well or not. These grades make up part of the continuous assessment mark of the student.

The Card Signing session has a few more benefits for staff and students. To the staff it can identify that a student is struggling with the material. To the student it also reveals to them an honest reflection of how they are coping with the subject matter; some maybe surprised and feel the need to enter the library more frequently. The testing is also a group session tutorial, the students learn
much from listening to others being quizzed. It is also true that nobody wants to look foolish in front of their peers. It is not designed as education via humiliation, but does actually have that benefit. Finally there is the added benefit of preparing students for viva voce and clinical exams, which are for most a stressful experience. Being exposed to a stress while having to think clearly and recall information is beneficial for a future doctor.

Each session in the dissection room is called a “practical” and they are numbered and titled according to the region studied. Each practical has a corresponding lecture associated with it. The practical dissection instructions are collected, along with questions and descriptions of what should be achieved and viewed in each session, in a manual. This dissection guide is a companion to the teaching course. It is part DIY instructions, part textbook, and part curriculum synopsis.

The structure of the course at present reveals the pressures placed on the resources. Having graduated from the RCSI myself (not too long ago and not too recently) one can see how the student numbers have caused the teaching time to change. When I was a student the dissection room time allocation was two hours rather than the current one-hour and a half. The student numbers are now greater; the class has been split in two. One group is in the dissection room for ninety minutes, then they leave and the following group is then sent in.
This project is intended to act as a further adjuvant to this well-established teaching programme. It is not intended to replace any part of the components, in fact it is intended to complement the programme and reinforce it.

Our intention is that the students will watch the related dissection on the DVD, go to the lecture, attend the dissection room practical and then later re-review the material with the ability to self-test themselves on the covered material. The process of re-reviewing the material and self-testing can be carried out any number of times. It can be done remotely from the college facilities.

Prior to end of semester exams, it was routine for students to enter the dissection room to review material. With a strain on demand for resources and limited office hours, the students now have the material available to them at the click of a button.

This DVD is intended as a bespoke adjuvant to the RCSI anatomy course. However if successful this can also be exported to the Post Graduate Entry Programme at the RCSI and its sister Medical University in Bahrain, as their anatomy courses are based on the same successful teaching programme. Furthermore the RCSI is involved in Post Graduate Surgical Training; the DVD can be also used as an aid to surgical training.
1.2 Aims

To modify an existing anatomy dissection plan, film it and produce an interactive DVD so that students can identify structures in three dimensions, test themselves and relate them to images from Cunningham’s Manual of Practical Anatomy (15th Edition).

This project will provide a bespoke, computer aided learning package that will be used by students of the 1st Medical Year in the Royal College of Surgeons in Ireland to preview and review practical classes.

- To create Dissection Instructions for each Anatomy Practical Class.
- To choose and assign relevant and appropriate images from Cunningham's Manual of Practical Anatomy 15th edition (Romanes, 1986) to each practical class.
- To perform and film the cadaveric dissection for each practical.
- To edit each filmed practical with computer assisted content analysis to provide a concise short video of 5-10 minutes duration.
- To identify and label important anatomical structures.
- To create a quiz for the students to test themselves.
- The quiz has to be interactive to allow for the students to score their performance.
- To provide all of the above on a DVD.
# Chapter 2: History of Anatomy

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2.1 Introduction

In this chapter we will review the history of anatomy. It is a story of humanity and civilization, how they rose and fell and with them the knowledge that they achieved and often lost.

The fact that history writers always seem wiser than the subjects on which they write is proof that history is rich in lessons. The history of anatomy is no exception. It is full of imperative lessons in the Art and Science of the discipline of anatomy, from which following generations should learn (Malomo, 2006).

The word anatomy is derived from the Greek word "anatom" meaning to cut up or to cut repeatedly (‘ana’-up; ‘tome’-cut) (Anson, 1908). The Greeks, however, cannot take credit for discovering anatomy simply because they coined the phrase that is now used to describe the science in modern English usage.

This chapter will walk us through the history of anatomy from antiquity to present day. The history of anatomy is so closely intertwined with the history of medicine that it is often impossible to separate the two.

This chapter is divided into separate sections, based on time and the dogma and knowledge associated with them.
2.2 Anatomy in the ancient pre-classical world

It is debatable as to when the study of anatomy began. If we consider the naming of different parts of the human body as anatomy then it is fair to argue that anatomy as a topic is as old as language itself. If we consider any form of the human body depicted in art as anatomy then the earliest and simplest cave drawings represent the origins of the science.

Medicine in the Near and Middle East developed against a background of struggles between cities and empires. In the Zargos Mountains and the mountains of Armenia, the Mediterranean coast, the Sinai peninsula, the Arabian Desert and the valleys of the Tigris and the Euphrates that historians call, for want of a better name, Mesopotamia (literally, “between rivers”), there was a constant ebb and flow of people as dynasties rose and fell in dazzling succession (Sournia, 1992)

In Ancient Babylon where the code of Hammurabi includes legislation pertaining to the practice of medicine, dating back to the year 2200 B.C. It covered the topic of medical malpractice and set out for the first time the concept of civil and criminal liability for improper and negligent medical care (Wecht, 2005), so there was obviously some rudimentary knowledge of anatomy, but may not have been studied as well as it should have been if medical malpractice law was enshrined in the code. Topographical anatomy, is the geographical element of anatomy, the location and naming of features. This is essential information which can then be applied in clinical situations, but
without which many clinical mistakes are made and malpractice suits lost (Ellis, 2002). It appears that this is true today as it was in the ancient world.

Hummurabi wrote among his many laws standard rates that a surgeon should be paid. Among the various ailments and treatments was of eye surgery, the rate being higher if the surgeon could preserve the eye (Singer 1928).

The Babylonians believed in divination, prediction based on the study of the entrails of a freshly slaughtered animal, most often a lamb. A clay model of a sheep's liver was recovered from an archaeological dig, in what is now present day Iraq, dating back to 2000 B.C. It is presently housed in the British Museum. The model was used to teach divination in a Babylonian temple school (Singer 1928).

The different components of the liver had their Babylonian technical terms, which can be related to present day anatomical terms. It is unclear if the study of animal entrails leads to knowledge of human anatomy. Whether they had been able to make that intuitive leap of knowledge on this is purely speculative. If they had, it could represent the earliest form of comparative anatomy.

In Ancient Mesopotamia, there existed several types of healers, including seers, priests and physicians who performed surgery. The surviving evidence suggests that there was a significant corpus of medical knowledge and drug
treatments available to doctors but there is no evidence of systematic anatomy (Porter, 1997).

In Pre-classical times the medical profession did not exist as a discrete intellectual discipline (Porter, 1997). There is enough evidence to say that they had knowledge but they did not have anatomy as a defined topic of study, at least not in a way that we currently define it.

There is still much we do not know. It would doubtless be better to admit our relative ignorance. The most well informed Assyriologist cannot translate all the tablets at their disposal, and a bilingual anatomical dictionary does not exist (Sourina, 1992).
2.3 Ancient Egypt

The ancient Egyptians developed their medicine independently of the Mesopotamians (Porter, 1997). Egyptian medicine was practised for over three thousand years (Sourina, 1992).

About fifteen medical texts, drawn up at different dates are available to us, the best known being the Ebers papyrus (Sourina, 1992). In common with the Mesopotamian texts, religious and medical approaches are combined in the treatment of illness. It lists seven hundred drugs and numerous diseases and their treatment. Notable by its absence is any exploration of anatomy (Porter, 1997). While the Ebers papyrus is the most famous, having been the first to be translated, it should be emphasized that the Edwin Smith papyrus is of great interest, since it gives an idea of Egyptian medical thinking (Sourina, 1992).

The Edwin Smith Surgical Papyrus, dating from the seventeenth century B.C., is one of the oldest of all known medical papyri (Wilkins, 1964). It differs fundamentally from the others in the following ways:

The seventeen columns on the recto comprise part of a surgical treatise, the first thus far discovered in the ancient Orient, whether in Egypt or Asia. It is therefore the oldest known surgical treatise (Wilkins, 1964).

This surgical treatise consists exclusively of cases, not recipes. The treatise is systematically organized in an arrangement of cases,
which begin with injuries of the head and proceed downward through the body, like a modern treatise on anatomy.

The treatment of these injuries is rational and chiefly surgical; there is resort to magic in only one of the forty-eight cases preserved (Wilkins, 1964).

Each case is classified by one of three different verdicts: (1) favorable, (2) uncertain, or (3) unfavorable. The third verdict, expressed in the words, 'an ailment not to be treated,' is found in no other Egyptian medical treatise (Wilkins, 1964).

This unfavorable verdict occurring fourteen times in the Edwin Smith Papyrus marks a group of cases (besides one more case) which the surgeon cannot cure and which he is led to discuss by his scientific interest in the phenomena disclosed by his examination (Breasted, 1980).

It is of special interest to the neurosurgeon because it contains the first descriptions of the cranial sutures, the meninges, the external surface of the brain, the cerebrospinal fluid, and the intracranial pulsations. It also contains the first accounts of surgical stitching and of various types of dressings. Brain injuries are noted to be associated with changes in the function of other parts of the body, especially the lower limbs, and hemiplegic contractures are described in Case 8. Changes in bodily functions are also described in association with injuries of the cervical spine. Case 31 contains the first description of quadriplegia, urinary incontinence, priapism, and seminal emission following cervical vertebral dislocation (Wilkins, 1964).
This demonstrates that the Ancient Egyptians did have method and some science to their approach even if the philosophy behind it was unscientific in nature. They were able to observe, document and categorise in a fashion which we can recognise today and, in some aspects, as we practise today.

Anatomical knowledge remained limited to bones and major organs. As mummification suggests, the Egyptians did not share the taboos that have so widely forbidden tampering with corpses, but embalmers formed a separate guild and were of low caste; moreover, since mummification aimed to preserve the body intact, embalmers did not open cadavers up; they eviscerated and extracted the organs through small incisions. The brain was removed through the nose by hooks (Porter, 1997). This however is interesting in itself, as the modern practice of minimally invasive surgery mimics this practice. A detailed knowledge of anatomy is required by the surgeon to decide which approach to use and where to place their incision. It might be unfair for Porter to be dismissive of the knowledge of the embalmers. Only relatively recently have Neurosurgeons performed surgery via a nasal approach.
2.4 The Greeks

The intellectual development of anatomy began in the golden age of Greece (Philips, 1973). The scientific dissection and vivisection of animals may have begun with the work of Alcmaeon (500 B.C.) of Crotone in Italy and Empedocles (490-430 B.C.) in Sicily. Alcmaeon was both a great physician and anatomist. He published a treatise entitled “On Nature” (Durant, 1939). In preparation for this book, he dissected many animals and described his findings in detail. This great anatomist was the first to describe and locate the optic nerve and the Eustachian tube, and he is also given credit for proposing that the brain is the seat of consciousness, intelligence and emotions (Malomo, 2006).

The pantheon of the Ancient Greeks included many gods and demigods who possessed powers of healing. While they could bring about disease when angered, seeking revenge or punishing a sacrilegious action, they could also cure disease. Among the lower-ranking gods was Asclepius, also known in the West by the Latin name Aesculapius. The story goes that Asclepius went with Jason and the Argonauts to search for the Golden Fleece, the centaur Chiron is said to have taught him how to treat the sick using words, herbs and a knife. Thus, Asclepius, using therapeutic procedures, developed marvelous powers of healing (Sournia, 1992).
Asclepius eventually became a cult figure. During the third century the cult of Asclepius spread, and by 200 B.C every large town in Greece had a temple to the god. The best known of these Asclepieions were the Island of Cos, Hippocrates’ birthplace, and at Epidaurus, thirty miles from Athens, but at least 200 other sites have been uncovered. The major shrines sported splendid temples and their cures were celebrated in memorial inscriptions. Pilgrims stayed the night in special incubation chambers where, before an image of Asclepius, they hoped through ‘temple sleep’ to receive a vision in a dream. The god would either perform the cure himself, or would give the patient a dream to be deciphered by the priest. Physicians rarely acted as dream interpreters, but around the temples religious and secular healing rubbed shoulders (Porter, 1997).

Tradition has it that Hippocrates was born in 460 B.C. on the small island of Cos, near the coast of Asia Minor. We can be sure of his historical existence from what Socrates has to say about his talents, but we know nothing of his life, despite legend attributing voyages and anecdotes to him. His name links him with the well-to-do rural society of the time. He is said to have stayed in Egypt and Scythia, and to have travelled through many Greek provinces. He refused to treat the Persian king despite a very attractive offer of “fees”, and rehabilitated Democritus whom his compatriots considered to be mad. The fame with which his work was associated for many years after his death itself engendered new legends, in particular concerning his glorious medical genealogy. Hippocrates is said to have been the sixty-second descendent of Asclepius in a direct line, which would confer upon him a divine origin, since
Apollo was the father of Asclepius. After him, his son-in-law, his sons and his grandsons allegedly treated all the princes of the ancient world, including Alexander the Great (Sourina, 1992).

Hippocrates was the first to write about human anatomy. Prior to Hippocrates, the Greek's targeted animal anatomy because human dissection was forbidden on religious grounds then. This was largely out of respect for the dead and the then popular belief that dead human bodies still have some awareness of things that happen to it and therefore still had an absolute right to be buried intact and undisturbed (Malomo, 2006). Hippocrates marks the point at which the explanatory role of theology began to recede in favour of a more empirical outlook (Porter, 1997). Hippocrates was the first to write about human anatomy, but anatomical inferences without dissection continued. He did not restrict himself in *sticto sensu* to anatomy (Malomo, 2006). The Hippocratic Oath specifically requires a commitment from the doctors not to perform surgery (Garrison, 1966).

Hippocrates advocates the importance of the relationship between, patient, physician, and disease in the diagnosis and treatment of illness. This philosophy was rejected at a time when diseases were still thought to be punishments from the gods. To him should go the credit for partially freeing medicine from mysticism and magic. In spite of the mythical milieu in which he lived and practised with other physicians, Hippocratic books contained factual passages that were based on the inspection of skeletons as well as from observations of living bodies injured and uninjured. He demonstrated the
sutures of the cranium, the shapes of the bones and their mutual connections. With respect to soft tissues, his ideas were largely erroneous. This error, arose from inadequate observations and unconfirmed opinions, is a pitfall from which we can all still learn today. In this respect, he relied on initial observations and the formulation of ideas. We could say that in spite of his precocious empiricism, he was essentially an idealist. The concepts of hypothesis and experimentation for positive proofs were to come centuries later. He called the brain a gland, from which exudes a viscid fluid. He seems to be unaware of the central nervous system. He used the term nerve, to signify a sinew or a tendon. Many agrarian languages still use the term 'nerves' for 'tendons' today. Even then morphology, nomenclature and taxonomy were not concepts that occurred or were clear to any minds at that time. His belief was that the arteries were filled with air, an idea gained from their emptiness in dead animals (Durant, 1939).

Aristotle (384-322 B.C.) was a Greek philosopher and polymath, a student of Plato and teacher of Alexander the Great. His writings cover many subjects, including physics, metaphysics, poetry, theatre, music, logic, rhetoric, linguistics, politics, ethics, biology and zoology. Together with Plato and Socrates (Plato's teacher), Aristotle is one of the most important founding figures in Western philosophy. Aristotle's writings were the first to create a comprehensive system of Western philosophy, encompassing morality, aesthetics, logic, science, politics, and metaphysics.
Aristotle’s views on the physical sciences profoundly shaped medieval scholarship, and their influence extended well into the Renaissance, although they were ultimately replaced by Newtonian physics. In the zoological sciences, some of his observations were confirmed to be accurate only in the 19th century. His works contain the earliest known formal study of logic, which was incorporated in the late 19th century into modern formal logic. In metaphysics, Aristotelian philosophy had a profound influence on philosophical and theological thinking in the Islamic and Jewish Traditions in the middle Ages and it continues to influence Christian Theology especially the Scholastic tradition of the Catholic Church. Aristotle was well known among medieval Muslim intellectuals and revered as - "The First Teacher". His ethics, though always influential, gained renewed interest with the modern advent of virtue ethics. All aspects of Aristotle’s philosophy continue to be the object of active academic study today. Though Aristotle wrote many elegant treatises and dialogues (Cicero described his literary style as "a river of gold"), it is thought that the majority of his writings are now lost and only about one-third of the original works have survived (Barnes, 1995).

Maximising what was culturally available to him, Aristotle studied animals which he dissected and based his opinions of the human body on his findings in animals. He however merely speculated about the internal organs in humans based on the internal parts of animals most nearly allied to humans. Aristotle laid the foundation of comparative anatomy and established embryology on a scientific foundation by his direct studies of the chick embryo. His preformation theory of embryonic development survived in one form or the other until the
17th century. The first three books of “Historia Animalium”, a treatise consisting of ten books, and the four books on “The Parts of Animals”, constitute the great monument of the Aristotelian anatomy. In human anatomy Herophilus outclassed him, largely because Herophilus had human cadavers for study (Durant, 1939).
2.5 Alexandrian Medical School

In the third century B.C. the modern idea of basing medicine on anatomy and physiology flourished in Alexandria, Egypt. The young Macedonian king, later known as Alexander the Great, founded Alexandria in 322 B.C. The first two Ptolemies after the death of Alexander the Great devoted themselves to making Alexandria the literary and scientific centre of the Western World. The Alexandria Library was the largest and most complete library of antiquity. It was in the temple of Zeus and was founded at the time that Greece was losing some of its intellectual vigor (Gordon, 1949).

From the region of the Bosporus came Herophilus of Chalcedon, a pupil of Praxagoras (Edelstein, 1967; Gillespie, 1980). Chalcedon is in present-day Turkey. Herophilus was a physician and an able surgeon and founded the science of anatomy (he is often called the “father of anatomy”). He was thought to have lived between 325 and 255 B.C. (Von Staden, 1989). Courage, patience and painstakingness are necessary for good science: he engaged in the arduous task of developing the anatomy register by determining anatomic nomenclature and forming the language of anatomy. The first documented human dissection was by him. This led to many anatomical discoveries through dissection of more than 600 cadavers of condemned criminals. Herophilus described the delicate arachnoid membranes, the cerebral ventricles, the venous sinuses especially the confluence of venous sinuses near the internal occipital protuberance (torcular Herophili), origin of nerves (he divided them into motor and sensory tracts) and differentiation of tendons from nerves (which
were confusing at that time), the lacteals, coverings of the eye, liver, uterus, epididymis, amidst many other structures. The name "duodenum" is attributed to him. He knew that damage of the motor nerves led to paralysis. Herophilus is also given the credit for stating that the pulse does not result from a mysterious power within the arteries themselves but that this power is communicated to it through the action of the heart (Von Staden, 1989). The seat of consciousness, intelligence and emotions, which Aristotle ascribed to the heart, was proved to be a function of the brain by Herophilus (Peck, 1965). Science is no respecter of opinions, and is merciless towards those who jump to conclusions. Herophilus first formulated the concept of the "rete mirabile", a vascular plexus or network of blood vessels at the base of the human brain surrounding the pituitary gland. This occurs only in lower animals but not in man. Jacob Berengario da Carp (1470-1550) later corrected the erroneous notion of the "rete mirabile" (Garrison, 1969).

Alexandria began its decline with the Roman invasion lead by Julius Caesar in 47 B.C. This climaxed with the burning of its famous Alexandrian Library. At that time the library housed most of the learning of the ancient world. Egypt subsequently became part of the Roman Empire. Under Roman rule, the Alexandrian library and Museum library gradually fell into decay and in 391 A.D., the main library was destroyed totally by Theodosius I, who was razing all pagan temples (Durant 1939b).
Medicine was still nurtured by Greek and other scholars but was culturally in a Roman environment. Human dissection was either forbidden or not encouraged - a situation that lasted until the late Middle Ages and it was declared unnecessary in the training of physicians. The greatest figure of this time was the physician Claudius Galen.

The accent of this history tour has been based around Mesopotamia and the Greco-Roman world. Ancient India and China had their own pioneers, as did the ancient American cultures. I do not intend to examine them in any detail other than to acknowledge their existence. I will, however briefly mention trepanation in Section 2.10.
2.6 Galen

Claudius Galenus (AD 131-192) was born in Pergamon in Asia Minor, a
flowering centre of Hellenistic culture located near the western coast of what is
now Turkey. His father, Nikon of Pergamon was a renowned architect. He was
a celebrated anatomist and a leading advocate of the doctrines of Hippocrates.
After Hippocrates, Galen is the most famous physician in history (Nuland,
1988).

Galen enjoyed a long and liberal education which included a period as
the physician to a school of gladiators. This deepened his knowledge of the
body and surgery. Moving to Rome, Galen made his name by public dissection
of pigs which demonstrated his deep anatomical knowledge. From 169 AD he
worked in the Imperial service. His knowledge of, and reliance on, anatomy
marked an innovation from the Greek tradition. The doctor had, in his view, to
be trained as a philosopher in order to master the science of knowledge, to
master physics to know nature. To know nature involved its examination
through deep study which entailed detailed anatomical knowledge (Porter,
1997).

Galen’s work was recorded in numerous complex treatises covering all
conceivable aspects of man’s knowledge. He even published a guide to his
writings, entitled “On his own Books.” Galen wrote more than 130 medical
treatises, of which 80 have survived. These classic works became the
unquestionable repository of medical knowledge for more than a thousand
years after his death. As a physician to the gladiators of Pergamon he had access to many human subjects, particularly those who were injured. Many of his human anatomical descriptions were wrong because of his reliance on animal dissection. According to Galen, “The dissection of the animal will teach the seat, the number, the peculiar matter, the size, the shape, and the composition of every part of the body”. The principal subject of his investigation was the monkey, probably the macaque because anthropomorphous monkeys were hardly available and possibly unknown in Rome at that time (Garofalo, 1991).

In Galen’s opinion, the most suitable animals for dissection were those “with a round face”, on the assumption of a close similarity of their nervous systems to that of the humans. The majority of his dissections were performed on ox brains, which he simply bought from the butcher; for in vivo dissection, pigs and goats were used to avoid the horror of the sight of a monkey being dissected alive, even though pigs and goats shout at top of their lungs. The dissection of humans played a minor role, if any, in the anatomic work of Galen. He showed that, in addition to the diaphragm, other muscles were involved in respiration. He left a detailed description of the origin and course of the phrenic nerve, and his discovery of the recurrent laryngeal nerve led him to comprehend voice production by the larynx. He proved that arteries as well as veins carry blood, differentiated between pia and dura mater, and described the ventricular system, pineal gland and pituitary gland. Galen described the Tela choroidea and its relation to the 3rd ventricle. His most notable work was ‘Anatomical Procedures’. This was initially written in the years after AD 177, in Rome as a
mature work and was partially rewritten after AD 192, because of the nearly total destruction of the original work by fire in the Temple of Peace (Garofalo, 1991).

The “rete mirabile” (a marvelous network) at the base of hoofed animals' brains was erroneously believed to be present in human brains. According to him, this was the seat of man’s “animal spirit” which later became transformed into “vital spirit.” He also misrepresented the shape of the human heart, branches from the aortic arch, the location of the kidneys, the shape of the liver, as well as other anatomical structures. Notable among his errors were that of just seven cranial nerves and that air enters the blood via the left ventricle (Badoe, 1994). Presumptive authoritarianism did not allow Galen’s ideas to be criticized; thus many of his erroneous ideas were perpetuated and major progress in the field of anatomy was halted until the sixteenth century. It was a crime to differ from Galen. Vesalius, one of the most famous anatomists of all time was very fearful of differing from him (Adams, 1939).

Galen’s works built upon the foundations of Hippocrates and broadened the anatomical basis upon which medicine was founded. But for his studies in anatomy, the course of medical history could have been very different. Galen’s works ensured the recognition of anatomy’s value as a fundamental part of medicine for the future (Porter, 1997).
2.7 The Dark Ages, Islam and the Renaissance

With the decline of Rome, the Dark Ages descended on Europe, while in the East, the birth of a new religion in the seventh century (Islam) ushered in a renewed interest in scientific doctrine. Islam is credited with saving the knowledge of the Greeks as well as with the advancement of science as a whole. The term Islamic medicine is a very general one. It is perhaps more apt to use the phrase ‘medicine in the Islamic empire’ for the protagonists are a mixture of races and faiths. There were the Arabs and Turks often referred as Saracen, or as Moors in Spain and the Barbary coast. They were predominately Muslims. However there also were the Persians and Kurds. Jews, Christians and Zoroastrians were all allowed to practice the healing arts and the study of science. We may perhaps consider this time a more enlightened era than the world we sometimes view today (Meyerhof, 1984)

Islamic civilisation once extended from India in the east to the Atlantic Ocean in the west. Buildings in Andalusia such as the Alhambra in Granada, the Mezquita in Cordoba, and the Giralda in Seville are reminders of the architectural imprint this civilisation left on Western Europe. Less well remembered, however, is the impact of Islamic civilisation on Western science, technology, and medicine between the years 800 and 1450. Today’s Western World might look very different without the legacy of Muslim scholars in Baghdad, Cairo, Cordoba, and elsewhere (Majeed 2005).
As Islam spread out of the Arabian Peninsula into Syria, Egypt, and Iran it met long established civilisations and centres of learning. Arab scholars translated philosophical and scientific works from Greek, Syriac (the language of eastern Christian scholars), Pahlavi (the scholarly language of pre-Islamic Iran), and Sanskrit into Arabic. The process of translation reached its peak with the establishment of the “House of Wisdom” (Bait-ul-Hikma) by the Abbasid Caliph Al-Mamun in Baghdad in 830. It made Arabic the most important scientific language of the world for many centuries and preserved knowledge that might otherwise have been lost forever.

As well as assimilating and disseminating the knowledge of other cultures, Arab scholars made numerous important scientific and technological advances in mathematics, astronomy, chemistry, metallurgy, architecture, textiles, and agriculture. Techniques they developed—such as distillation, crystallisation, and the use of alcohol as an antiseptic—are still used (Majeed, 2005).

Arab physicians and scholars also laid the basis for medical practice in Europe. Before the Islamic era, medical care was largely provided by priests in sanatoria and annexes to temples. The main Arabian hospitals were centres of medical education and introduced many of the concepts and structures that we see in modern hospitals, such as separate wards for men and women, personal and institutional hygiene, medical records, and pharmacies.
Ibn Al-Nafis, a 13th century Arab physician, described the pulmonary circulation more than 300 years before William Harvey. Surgeon Abu Al-Qasim Al-Zahrawi wrote the Tasrif which, translated into Latin, became the leading medical text in European universities during the later Middle Ages. Al-Zahrawi was also a noted pathologist, describing hydrocephalus and other congenital diseases as well as developing new surgical technologies such as catgut sutures (Aschoff, 1999).

Some describe Al-Razi (Rhazes), born in 865, as the greatest physician of the Islamic world. He wrote Kitab Al-Mansuri (Liber Almartsoris in Latin), a 10 volume treatise on Greek medicine, and also published on smallpox and measles: his texts continued to be reprinted well into the 19th century. The medical texts of Ibn Rushd (Averroes) were also widely used in European universities (Hassani, 2004).

Ibn Sina (Avicenna) was known in the West as "the prince of physicians." His synthesis of Islamic medicine, al-Qanun fil tibb (The Canon of Medicine), was the final authority on medical matters in Europe for several centuries. Although Ibn Sina made advances in pharmacology and in clinical practice, his greatest contribution was probably in the philosophy of medicine. He created a system of medicine that today we would call holistic and in which physical and psychological factors, drugs, and diet were combined in treating patients (Wear, 1993).
Eventually, the Islamic civilisation constructed by the Arabs went into decline. In the east, new powers rose: first the Mongols, who in 1258 devastated Baghdad, the greatest Arab city of its day, and later the Ottoman Turks, who brought large parts of the Arab world into their new empire from the 14th century onwards. Weakened by internal strife and civil conflict, most of the Islamic cities of Spain had been conquered by Christian armies by the 14th century. The last Islamic state in Spain, Granada, surrendered to the Spanish in 1492 and its ruler, Boabdil, was exiled to North Africa (Fletcher, 2001).

The flow of technology and ideas from the Islamic world to the West slowed and, in the past 600 years, has reversed. Academics and politicians still debate the reasons for and consequences of this decline in Islamic science and technology. The legacy of Islamic civilisation, though, remains with us in making possible Europe’s own scientific and cultural renaissance (Bulut, 2004).

As in the Old Testament, the Quran contains many verses relating to hygiene and health (Neuburger, 1868). In Islam the corpse is considered unclean and thus should not be touched. Muslim burial rites stipulate that the dead should be buried before sundown of the day of death, creating an obvious technical hurdle if one wishes to perform any human dissection. In Islam, as in Christianity, there is a belief that any interference with the body could prevent the soul from reaching the afterlife. In the Islamic world there was thus little appetite for dissection, teachers of medicine placed great reliance on the texts they used rather than empirical anatomy (Afnan 1958; Goodman, 2006).
The conversion of the Roman Empire to Christianity marked the rise again of a religious outlook in the sciences, particularly philosophy. Christian doctrine and theology affected the understanding of medicine. Whereas under Hippocrates a critical empirical and materialist outlook had begun to inform medical thought, the advent of Christianity brought to the Late Roman world an overarching political, social, and intellectual ideology. Christianity's philosophical and scientific outlook depended heavily on Classical authors such as Aristotle and Plato. St. Augustine and St. Thomas Aquinas among others drew heavily on the Classical philosophers to shape a Christian world view. Because Galen had had recourse to Plato to explain those elements of medicine which he could not verify through human dissection, he merged easily into the Christian scientific world. He became the greatest intellectual influence on medicine until the advent of modern materialist empirical science. However this also had one further impact; Galen's reliance on philosophy guaranteed that human dissection was relegated to a minor position in medical education.

Sicily, under the Norman King of the Guiscard family, boasted a public administration which included Greek, Latin and Arabic elements. It became a centre of intellectual life and interchange. Archbishop Alphonus of Salerno (d. 1085) introduced Galenic medicine to Sicily through the translation of Greek Byzantine texts. The 'Salernian' school of translations created a new canon of medical texts in the West (Porter, 1997).

The Galenic concepts, both accurate and inaccurate, became canonized as the theoretical basis of medicine and surgery for 15 centuries.
2.8 The Renaissance.

Fresh air and light fell upon human learning again as the renaissance broke undue bounds. The Renaissance was a period during which there was a revival in the ideas of ancient Rome and Greece. Ideas flourished and the newly invented printing press allowed books to be produced quickly. Before this, books were slowly and painstakingly copied by hand. Although very few people could read and write, the printing press was a revolution in information technology and resulted in ideas spreading around Europe like never before (Malomo, 2006).

By the end of the thirteenth century, the demand for accurate information was so great that the medical dissection of human corpses began in earnest. Freedom from the restriction imposed by presumptive authoritarianism on human dissection had its origin in Italy. Anatomists at this time were still conditioned to revere the outdated notions of Aristotle and Galen, and if an autopsy revealed a deviation from prior teachings, the anatomists concluded that the body was abnormal. Towards the end of the 13th century Mondino de Luzzi a surgeon-anatomist, revived anatomical dissection in Bologna; although dissections were still often confined to the bodies of animals and sometimes they were really autopsies performed to ascertain the cause of demise especially if foul play was a possibility. These were usually the responsibility of Surgeons. Mondino also dissected the bodies of executed criminals. He produced the first manual for dissection in 1316. The fourteenth century brought a more scientific attitude to the study of the human body. To some
extent, artists, rather than scientists, set the pace in revealing new aspects on human anatomy. Leonardo da Vinci (1452-1519) was undoubtedly the most industrious artist, producing hundreds of anatomical drawings made from dissections (Malomo, 2006).

Mondino’s significance lies in the fact that he managed to bring anatomy to the fore as part of the teaching of doctors. The first public dissection in Spain took place at Lerida in 1391 and Vienna in 1404. England lagged behind; routine anatomy classes using cadavers did not begin until the 1550s. Some of the errors of the Greeks and Arabs were also recorded by Mondino. His great insight lay in the realisation that the university students of his time needed a practical, introductory, manual to the art of anatomy. Mondino and his contemporaries asserted that anatomy should play a central role in the medical curriculum. In 1478 the first printed edition of Mondino’s work appeared and ran to over forty editions (Porter, 1997).

Andreas Vesalius was born in Brussels on December 31, 1514 into a family of physicians (Simeone, 1984). His ancestors were intellectuals, well versed in the natural sciences, music, ancient languages and philosophy. For at least four generations they served in the imperial medical services (O’Malley, 1954). Vesalius was educated in Brussels and Paris and he went to Padua to finish his medical studies. He broke the then established rigid and fabricated way of teaching anatomy and introduced the modern concept of learning based on observations using illustrations combined with a critical spirit and sense of
experiment (Jackson, 1992). He was a surgeon-anatomist and the founder of modern anatomy.

The illustrations of Vesalius’ dissections were rendered with remarkable clarity by an extraordinary artist, Jan Stephan Kalkar, and were reproduced both as woodcuts and copper plates. A transformation occurred in the precise anatomy of humans with the publication in August 1543 of “De humani corporis fabrica” (the 7th and last of his fabrica) by Vesalius who was then just 28 years of age (O’Malley, 1954). This folio-sized book is the foundation of modern topographic human anatomy and one of the most important books in the history of medicine. It included plates of osteology and a myology series. Vesalius spoke of the “Divinus opifex” i.e. the Divine designer and constructor of the universe and of man or of the “Divinus artifex”, the divine artisan who organized minute details and fastened together the various parts. Vesalius’ description of the cerebral vessels is generally adequate but he overlooked the hexagonal ring of communicating arteries at the base of the brain. Like da Carpi, he disputed Galen on existence of the “rete mirabile”, stating that it is almost non-existent in humans. Authority has a fragile confidence, because it rightly suspects that it could be wrong. The demonstrations of the many errors in the anatomic publications of Galen were initially met with mixed reactions. Especially vehement was the reaction from his former teacher of a few years earlier, Jacob Sylvius who called his work “filth and sewage”. Impulsive and not entirely rational, Vesalius burned all his manuscripts. This ended his 5 years of academic work; the next 20 years were to be boring and barren. Sylvius was
wrong while Vesalius was right; but the right course was under erroneous authority and progress suffered (Malomo, 2006).

Renaissance anatomists enormously elevated the standing of the subject. Its status had been low, it was not listed among the ancient major divisions of medicine and surgery which were to be incorporated into the wider humanist medical movement, and was stigmatized by its surgical connexions: but the appointment of Vesalius at Padua served notice that anatomy and surgery were to be incorporated into the wider humanist medical movement. The *Fabrica*'s preface argued for the unity of the different medical arts: physicians should not disdain to use their hands, an adage equally dear to contemporary natural philosophers (Porter, 1997).

Anatomy became integrated into learned medicine–even in backward England, thanks to John Caius (1550-1973). Caius was a Galenist physician and protégé of Thomas Lincare, who had been largely responsible for the founding of the College of Physicians in 1518, and for the medical lectureships at Oxford and Cambridge (Porter, 1997).

Anatomy was now a substantiated science integrated into a medical curriculum, although based on works by Hippocrates and Galen, the Galenic philosophy was waning which gave rise to an Age of Reason.
2.9 *The Age of Reason through to the Age of Enlightenment*

Renaissance anatomy further subverted the Greek medical legacy it admired through its finest achievement: William Harvey's demonstration of the circulation of the blood. Building on Vesalian anatomy and developing a new physiology, Harvey's (1578-1657) revolutionary work convinced later investigators that medical science had to be put on a new footing (Porter, 1997).

During the sixteenth century, anatomists made observations with the naked eye and had been limited accordingly. However, the seventeenth century brought the development of a new instrument: the microscope. Galileo had already been able to make a close examination of parts of insects using lenses of his astronomical telescope. In Holland, opticians had made increasingly successful attempts at creating a microscope, but it was Antione van Leeuwenhoek (1623-1723) who finally revolutionised scientific observation as a whole, and medicine in particular. It was to undergo continuous refinement over the years, resulting in the tremendously powerful microscopes we know today (Sourina, 1992).

New horizons were opened up by the microscope and the autopsy. The term "pathological anatomy" was coined by one of the polymaths, a certain Friedrich Hoffmann (1660-1742) from the productive University of Halle. Normal anatomy had attracted enormous interest in the sixteenth century, in the seventeenth century and eighteenth centuries there were outstanding scientists
working in this area, such as the Dane, Jacques Benigne Winslow (1669-1750), who was based in Paris and converted to Catholicism. However, all these dissectors noted lesions in corpses they examined. Therefore, alongside normal anatomy, pathological anatomy merits more than a passing mention: Giovanni Battista Morgagni (1682-1771) advanced it into a discipline which is an essential part of medicine. Having studied at Bologna under Valsalva and then taught at Padua, he published in 1761 a voluminous work entitled *De sedibus et causis morborum per anatomiam inquisitionem*, in which he gave accounts of over six hundred autopsies undertaken by him and his superior. Many of the corpses were those of patients under his care. As good an observer of the dead as of the living, Morgagni was the first to establish a retrospective link between lesions found in the body and clinical symptoms (Sourina, 1992).

Throughout Europe many academic and royal societies for the pursuit of knowledge were being formed.

In France, the doctors knew classical literature, both Greek and Latin; they were often proved to be better read than the notable religious and lay people with whom they rubbed shoulders in academies recently founded in the provincial capitals. They met erudite men of all disciplines within the scholarly societies which were then springing up throughout Europe. This period also witnessed the birth of scientific reviews in which researchers reported their work in Latin or their own language.
Doctors were not alone in practising the healing art with varying degrees of success. They still needed the collaboration of surgeons, for in the eighteenth century medical practitioners still did not know how to bandage, reduce a dislocation, lance an abscess, set a fracture or remove a tumour.

In comparison with doctors, surgeons appeared, less affluent and less respected in society. After an age-old battle against doctors and a number of derisory disputes, some of which even went to court, they were rehabilitated in France in the eighteenth century. They dissociated themselves definitively from any professional relations with barbers, succeeded in creating the Royal Academy of Surgery-despite the fury of the Faculty of Paris- and thus like doctors, could then endorse theses and in fact become doctors. Finally, in Paris, doctors and surgeons found themselves side by side in the Royal Society of Medicine, which the Faculty soon accepted (Sourina, 1992).

France was not alone in these developments. Alexander Munro (primus) (1697-1767), first incumbent of the Edinburgh chair of anatomy and surgery, was himself a surgeon who gave instruction in operations to medical students and surgical apprentices as well as pioneering anatomy teaching. Edinburgh education thus eroded the old divisions between physic and surgery, and its students equipped themselves in both skills, since most were likely to become surgeon-apothecaries or, as they would soon be called, general practitioners (Porter, 1997).
2.10 A brief mention of other cultures

Trepanation is perhaps the oldest surgical procedure for which there is archaeological evidence, and in some areas may have been quite widespread. Out of 120 prehistoric skulls found at one burial site in France dated to 6500 BC, 40 had trepanation holes. Many prehistoric and pre-modern patients had signs of their skull structure healing, suggesting that many of those subjected to the surgery survived. Evidence of trepanation has been found in prehistoric human remains from Neolithic times onwards. Cave paintings indicate that people believed the practice would cure epileptic seizures, migraines, and mental disorders (Brothwell, 1969). It appears to have been practiced throughout Pre-Columbian Mesoamerica. The reasoning behind the process is unclear but at the very least some basic anatomical knowledge must have been known.
2.11 The teaching of anatomy at the Royal College of Surgeons in Ireland

The origins of the first Royal College of Surgeons go back to the fourteenth century with the foundation of the 'Guild of Surgeons within the City of London. There was dispute between the surgeons and barber surgeons until an agreement was signed between them in 1493, giving the fellowship of surgeons the power of incorporation. This was followed in 1505 by the incorporation of the Barber Surgeons of Edinburgh as a Craft Guild of Edinburgh. This body was granted a royal charter in 1506 by King James IV of Scotland. It was followed by the Royal College of Physicians and Surgeons of Glasgow, royally chartered by James VI in 1599, as the Glasgow Faculty.

The union in London was formalised further in 1540 by Henry VIII of England between the Worshipful Company of Barbers (incorporated 1462) and the Guild of Surgeons to form the Company of Barber-Surgeons. In 1745 the surgeons broke away from the barbers to form the Company of Surgeons. In 1800 the Company was granted a Royal Charter to become the Royal College of Surgeons in London. A further charter in 1843 granted it the present title of the Royal College of Surgeons of England (Fu, 2000).

The RCSI was granted its Charter by King George III on the 11th of February 1784. The College emerged within the context of the rapid development of medicine and surgery which was occurring in both England and Scotland under such men as William Hunter and Alexander Monro in the late
eighteenth and early nineteenth centuries. A year later, John Halahan (1753-1813) was appointed first Professor of Anatomy and Physiology. As the college was without premises, the professors had at first to teach at their own homes but in 1789 a building was acquired. The centre of activity was the dissecting room where anatomy was taught (O’Brien, 1982).
2.12 Abraham Colles

Colles was born in Millmount Kilkenny, and graduated from the College of Surgeons in 1795 from where he went to Edinburgh and then to London in search of expertise. He returned to Dr Steevens’ Hospital, and in 1804 was appointed to the chair of Anatomy and Physiology in the College as well as to the chair of Surgery, both of which he held for thirty-two years. Colles was an innovative anatomist and by the standards of his day a brilliant surgeon (O’Brien, 1982).

Colles revolutionised the manner in which anatomy was taught; Halahan and Hartigan and those who came before them had dissected and taught anatomy in a system based fashion, rather than in a regional fashion. Colles thought that this was like trying to ‘explain the mechanism of a watch by taking it to pieces and giving a separate description of every particular wheel and spring without afterwards attempting to show by what contrivance one moves the other. The student who has been shown the venous, arterial and nervous systems of the arm does not know how each of them lies with respect to each other’ (Colles, 1811).

Colles was responsible for the first topographical anatomical book published in Dublin; previously Hartigan and Lawless had printed the lecture syllabus (which was done in a systems based fashion), A Treatise on Surgical Anatomy was published in 1811 and changed the method of teaching anatomy, from systematic to topographical. In it, he also described the fascia and
ligament which bear his name. Abraham Colles described the fracture of the
distal radius, with posterior displacement of the distal fragment, in the
Edinburgh Medical and Surgical Journal in 1814.
2.13 The Murder Act, the Resurrectionists and the Anatomy Act

The growth of medical science and medical practice created an increased demand for human cadavers for use in medical colleges, particularly for anatomy demonstrations. Before the 19th century, most were bodies of executed criminals or, more rarely, corpses donated by relatives. However, as demand began to outstrip supply, the shortage of corpses often discouraged medical schools from scrutinising their suppliers too closely. Criminal elements were attracted to the lucrative trade and body snatchers (known also as 'resurrectionists') resorted to grave robbing to supply the market.

Before 1832, the Murder Act 1752 stipulated that only the corpses of executed murderers could be used for dissection. By the early nineteenth century, the rise of medical science, occurring at the same time as a reduction in the number of executions, had caused demand to outstrip supply.

In Dublin the medical schools of the 18th and 19th centuries were on a constant hunt for bodies. Bullys' Acre or Hospital Fields at Kilmainham was a rich source of anatomical material as it was a communal burial ground and easily accessed. Soldiers attached to the nearby Royal Hospital were always on the alert for grave robbers mainly because many of their comrades were buried there. In November 1825 a sentry captured Thomas Tuite, a known resurrectionist, in possession of five bodies. When searched, his pockets were found to be full of teeth—in those days a set of teeth fetched £1 (about £50 in
2011). Many other graveyards were targets of the medical students or those who made robbing graves their profession. The largest cemetery in Ireland, Glasnevin Cemetery, laid out in the 19th century, had a high wall with strategically placed watch-towers as well as blood-hounds to deter body snatchers (Fleetwood, 1988)

Robert Harrison was Professor of Anatomy and Physiology at the RCSI, and later of Anatomy and Chirurgery at the Trinity School of Physic. Harrison’s *Dublin Dissector* appeared in 1829, and became a standard anatomical textbook for many years, even in American schools. Robert Edmond Grant produced his in 1941. Henry Gray published in 1858 and Professor David John Cunningham wrote Cunningham’s Manual of Practical Anatomy in 1902, it is currently in its 15th edition. The Anatomy course at the RCSI is ostensibly taken from Cunningham’s.

One particular case caught the public imagination due to its gruesome nature. The Burke and Hare murders (nickname West Port murders) were serial murders perpetrated in Edinburgh, Scotland, from November 1827 to October 31, 1828. The killings were attributed to Irish immigrants William Burke and William Hare, who sold the corpses of their 17 victims to provide material for dissection. Their purchaser was Doctor Robert Knox, a private anatomy lecturer whose students were drawn from Edinburgh Medical College. Their accomplices included Burke’s mistress, Helen McDougal, and Hare’s wife, Margaret Laird. From their method of killing their victims has come the word
"burking", meaning to purposefully smother and compress the chest of a victim, and a derived meaning, to quietly suppress (Adams; Bailey, 2002)

The Anatomy Act of 1832 was passed to obviate the need for body snatching and made lawful donated bodies for dissection. It was promulgated in reaction to public fear and revulsion of the illegal trade in corpses. One must remember that at this point in history Ireland was not a republic and was part of the United Kingdom

In the UK the Human Tissue Act only replaced the Anatomy Act in 2004. In the Republic of Ireland the procurement of cadavers is still governed by the Anatomy Act of 1832.
2.14 Current Anatomy at the Royal College of Surgeons in Ireland

Human Anatomy is now well understood and documented. The procurement of cadavers an open process that is state legislated. Technology moves on. Professor Stanley Monkhouse was at the helm of the Department of Anatomy when Anatomy went digital, the curriculum was revised and information technology applied to the teaching. Histology-on-Line is now available throughout the College network and has introduced a high level of interactivity to the teaching of the subject (Lee, 2006a).

In 2002 two undergraduate medical students decided to apply the technology of the day to dissection classes (Inwood and Ahmed, 2005). They produced a fabulous piece of work, a disector on Digital Video Disc, which proved immensely popular with the student body. For their work they were awarded the Barker Dissection Prize in 2002. This DVD is the next evolutionary step.
2.15 Conclusion

Journeying through time and history while examining humanity and civilisation's achievements by looking at how the discipline of anatomy has come to be what it is today is not a linear journey. The common factor is that there were times of great observation, insight, intuition and deduction, interspaced with long periods of stagnation hampered by flawed and authoritarian dogma that crippled development of knowledge itself not just the science of anatomy. What is fascinating is how knowledge is lost; disappearing from history, then at times (often by a chance discovery) it reappears. It took the human species 5,000 years to advance from examining the entrails of lambs to predict the future to elevate anatomy as a modern science at the core of medical education fundamental to the practice of modern medicine and surgery. Different pioneers, who despite the passage of time are still known to us, years after their passing, have achieved this. Through our eyes some of what they achieved may seem trivial, there deductions laughable, the replication of errors unforgivable. Who knows what future scientists and historians will make of the lacunae in our knowledge?

Anatomy is now at the core of medical education; it would be foolish of us not to continue to allow the discipline to evolve with current and future technology. Anatomy as a science does not change but the way anatomy is taught is changing and the debate how best to teach anatomy continues (Kimberly, 2004).
There are already pre-existing video disectors, digital images available on websites such as www.netanatomy.com and many others. We wanted to create a product that is tailored for the course that we teach and thus the pertinent content and detail that we wish to impart to the student. It is not meant to replace the anatomy dissection room, tutorship from the prosectors, or the lectures. We want to create a digital aid that the student can use to preview the class, then attend and conduct dissection. Finally they can review and rereview at leisure with the ability to self-test. We did not want to intimidate the student with a task that would seem daunting and impossible to replicate, while not being amateurish. In the words of Goldilocks “just right!” (Southey, 1837)
### Chapter 3: Materials & Methods

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3.1 Introduction

Our aim was to produce a series of educational "movies". Like any modern film this required: a script, an actor and their tools, a director, camera and film crew, and post production special effects to keep the audience's attention!

The plan was to perform regional dissection on a single male cadaver (the lead actor) using a basic dissecting kit, which was composed of:

- Scapel (with number 10 and 12 blades)
- Dissecting scissors
- Forceps
- Dissecting probes
- A fine paint brush (used as a pointer)

The dissection was carried out using the preexisting dissecting instructions, which have been used at the RCSI Anatomy department since 1996. The dissection instructions were originally based on Cunningham's Manual of Practical Anatomy 15th edition.

To go back to the Movie analogy the film is based on a book by Cunningham. Thus the first job was to create a script by adapting the current dissection instructions. Each session was filmed continuously; the captured video footage was then edited as part of the postproduction work. The two
actors, with the cadaver in the lead role and myself as surgical
prosector/narrator also taking on the roles of writer and director.

The set that was chosen was the Harold Browne Lecture Theatre in the
Department of Anatomy at the RCSI. We positioned the cadaver on a
dissecting table and squared off the area that was to be dissected for each
given session. The dissection instructions as well as relevant anatomical
diagrams and pictures were posted up onto a corkboard out of camera shot, to
act as cue cards. It was also understood that as there are normal variations in
human anatomy, the script was present but the need to ad lib was catered for.
At the same time lighting and camera would be set up before the phrase “lights,
camera, action!” could be shouted out.
3.2 Lighting

For most part, the user of a typical home video camera does not consider proper and professional lighting techniques, however good technical lighting was one of the main considerations for taking on this project, as it was the main criticism of previous efforts, where lack of clarity of the images was essentially due to poor lighting (Inwood And Ahmed, 2005). To produce quality images, lighting is essential, as the video is recording reflected light. We reviewed previous videos in this field and a practice dissection was performed on the left forearm of the cadaver.

We noted that the casting of shadows by the dissection implements and the dissector themselves, particularly their head and hands, were a major factors. Movement was distracting to the viewer, especially of the dissectors hands, so keen attention to positioning of instruments, the dissector and the movement of the dissector had to be paid at all times. This proved harder than we expected as the dissector/director was in front of the camera in the camera shot while the cameraman/second director was an electronic engineer and a novice in anatomy, and thus was not always aware of what the dissector intended to be seen, but could point out that there was shadowing being cast. Much was learnt producing the rough shots regarding eliminating trivial errors in filming practice that could have profound effects on the captured images. In deeper dissections, detail would be almost impossible, as the light did not penetrate to the desired depth as it was blocked either by the disector or by other parts of the cadaver.
With attention to these details, we moved ahead to experiment with the lighting to eventually fine tune the technique in our rough shots. The idea was that when we came to the actual intended dissection we would have perfected the technique.

### 3.2.1 Lighting Essentials

This section is a brief synopsis of our experience of video lighting with regard to this project. It is an overview of the fundamental points that we found were essential to obtain quality lighting for the video filming that was performed.

#### 3.2.1.1 Lighting on the Set

In the Harold Browne Lecture Theatre in the Department of Anatomy at the RCSI there are two light sources. The natural ambient light, which entered through the windows, was an unreliable source and dependent on factors as the time of the day and the weather.

The second source is the lighting system within the lecture theatre, which were ceiling suspended fluorescent tube lighting.
3.2.1.2  **Multiple Sources**

To obtain lighting that is adequate to produce clear video images, three lights should be used. The resultant images will be well lit, giving definition to the structures and have shadow control.

A *fill* light that bathes the subject with a low light level is shadow eliminating, as it "fills" in the areas of shadow. The light from this source has to appear as though it is directionless and originating from all directions washing the subject in its glow, so careful consideration of positioning of the light with regards to the subject was required.

The disadvantage with using this type of light source was that, as it eliminated shadow, the image appeared flat and so the detail was lost. To overcome this, a second light source is utilised: the *key* light. This light source is aimed directly at the subject and gives the images a three dimensional effect. This light source was positioned directly behind the camera. This light source had the disadvantage of producing a lot of heat, as it was generally directly behind the camera both the camera operator and the dissector were exposed to this heat. It was usually less pleasant for the dissector as he was dressed in surgical gowns.
There was a very narrow range in the distance that was optimal between the key light and the camera. If it was too close, too much light was shone at the subject and would drown out the definition that we were trying to achieve. If it were too far away it would cast shadows. Getting the distance right was probably the hardest component of the lighting set up.

Lastly a back light is needed. This third and final light source helps to give further definition to the subject allowing it to stand out from the background. It is normally placed behind the subject or directly above the subject. In our case this was neither practical nor feasible and was abandoned, with little detriment of the overall lighting.

I would like to mention a further light source that we experimented with but did not use, a flexible fibre optic light, which could be directed. However, it created far too much shadowing and the operator of the light would not be able to hold it for long as it heated up to quite a high temperature. The concept that if you shine a simple light at a subject making all the structures clearly visible to the naked eye is not brought out on camera.
3.2.1.3 The Physics and Physical Properties of Light

As light travels in a straight line it will not bend around a corner (in context of filming). Light will be blocked by non-transparent objects in its path. Light reflects off surfaces. Light is not all one colour unless it is pure white light, which is composed of all the continuous spectrums of visible wavelengths of light.

Ambient natural light that originates from the sun is filtered through the atmosphere of the blue Earth, due to the water in the atmosphere, and thus appears blue. The fluorescent tube lighting is green and our three tungsten lights were orange. A white balance allows for the different light from the different sources (light of different wavelengths) to pass through filters to balance them to a uniform colour. This function on the camera allows the camera to compensate for the different colours produced by the various filtered and reflected light sources.

3.2.2 The Lighting Equipment

Two types of filters were employed for these lamps. Diffusion filters which scatter the focused beam of the spot lights and green colour balancing filters, to compensate the overhead ceiling tube lighting with the recheads.
3.3 Camerawork

In order to capture good quality video the lighting, camera angles, focus, stability all have to have due time and attention paid to them. Good planning at the pre-production level is essential to producing a quality product rather than relying on post-production clean up and corrections.

In our rough shots, we originally considered using two cameras- a static camera to be tripod mounted for overhead shots and a hand held camera for close up imaging.

It became apparent that integrating the two sets of images would be very complicated. The static camera had a good level of stability but the hand held was very unstable producing shaky, distracting images.

3.3.1 Equipment

A Cannon XM2 DV (digital video) camcorder was our camera of choice. This camera is of a semi-professional type, with a variety of manual and automatic functions available. The camera was tripod mounted. This was a heavy-duty tripod, which ensured excellent camera stability. We had attempted using a lighter weight mounting but it was noted that if any heavy traffic passed by outside the camera stability was compromised.
Many of the camera's automatic functions were disabled, as movement and the reflectance of certain surfaces could distract the auto focusing system and the aperture control. If the dissector's hands or dissecting equipment moved suddenly into the camera shot, this would cause the camera to focus on the new object and blur out the intended subject, which was now in the background. The dissector's white gloves particularly if they were wet, caused light to be reflected and the camera automatically reduced the aperture resulting in a darker image. Relying on manual focus and fixing the aperture at a given setting resolved the problem.

The white balance, previously mentioned while discussing lighting, was the subject of much experimentation for the later planned auto-editing process. The captured video images were stored on multiple one-hour MiniDV tapes.
3.4 Filming

3.4.1 The Set Up

The cast and crew consisted of:

- The cadaver.
- The dissector/surgical prossector also credited as the script writer and director
- The cameraman also acting as the lighting man, sound engineer, editor and special effects engineer.
- Supplementary crew: which consisted of volunteer assistance from the Anatomy Technicians.

The relevant practical dissection instructions and reference anatomy diagrams were pinned onto a corkboard, placed against a wall, off camera but visible to the dissector, and served as my cue cards.

The cadaver was placed on a steel-dissecting table and the relevant geographical area, which was to be dissected, was squared off by surgical drapes. The drapes were also used to cover the steel-dissecting table as the reflectance from its surfaces, particularly if wet, caused significant reflectance and glare from the lighting and interfered with the camera.
Lighting and camera were set up at this point. The rig was composed of
the camera mounted on its heavy tripod, the three light sources and their
stands. The overhead fluorescent tube lighting, which was suspended from the
ceiling, was all turned on. This provided the first element of the fill light and
bathed the subject with an omnipresent fill. As the lights were ceiling mounted,
the dissector would often block this light. So as to overcome this two of the
tungsten lights were used. Two white sheets were hung up with assistance of
some of drip stands reinforced with duct tape. These white sheets were
reflectors that were placed to the left and right of the subject to complete the fill
effect. The lights had colour filters with green gels that produced the same
wavelength of light as that produced by the overhead ceiling lights.

The remaining light was used as the key light, as previously mentioned
the back light was abandoned. This remaining spotlight was normally placed to
the side of the cadaver. This light had a diffusion filter so as to reduce the
reflectance and glare caused by the reflective surfaces when they were wet. To
minimise the shine and glare of these so called specular surfaces, paper hand
towel was used to dry the wet surface.

The key light filter did reduce the intensity of the spot light which in turn
did reduce the texture definition of the subject surfaces; however it was
considered an acceptable reduction in texture definition to avoid the greater
problem of shadowing. The key light had the same filter as the fill lights fitted
for the same colour balance.
3.4.2 Introducing the Camera

The positioning of the camera relative to the subject, lights and which camera angle to use was determined by reading through the script while simulating the given practical dissection. It was found that the best camera angle was in the range of 30 degrees with the camera mounted on the tripod. The advantage of these high shots was that the dissector would not block the view. This was not always the ideal camera angle for the given dissection practical, and the camera would then have to be mounted much lower. The various practical dissections often use a different variation of the rig set up, customising the best lighting set up and camera angles for the given scene.

3.4.3 Instant feedback

A frustration for all was that the dissector could not see what the camera was picking up and relied on the cameraman to inform and direct him. We realised in the rough shots that this would hamper the time taken to film by having to reshoot, by which time a bit of permanent destructive dissection could have taken place.

It was decided that the dissector could see the footage live and be able to auto-direct and predict where to position himself to minimise blocking of the camera and thus minimise filming time.

A simple solution was to feed the camera direct to a small television screen, placed on the floor about a meter away from the dissector’s feet so he
could see the screen. It was not an high definition screen and subtleties of light
dimming and glare were not picked up but the overall picture was clear and the
dissector could place himself in the appropriate place so as not to block the
camera shots.

It is only at this point that we donned our costume and got into character
to film the scene. It was decided early on to have the dissector wearing a
surgical gown and gloves to give a more professional and clinical feel to the end
product. There would be uniformity for each dissection practical. It would be
the same colour and so would not require any change to the lighting and colour
balance for the camera.

We would then film the dissection, compromising approximately 40
minutes to an hour of footage.
3.5 Sound

While we were filming we also recorded sound, but realized there was far too much background noise. We experimented with various sound recording modalities such as having a microphone tapped to the dissector, but in the end too much ambient sound was picked up. Originally we believed that we could clean up this sound in postproduction editing, but the results were less than satisfactory.

We did however still record for two reasons: Firstly we were still hopeful that we might develop a technique that could clean up the sound. Secondly we hoped that we could use the audio as recognition tools for the auto-editing process.
3.6 Cues for special effects

This project was not to simply film dissection work but also to use pre-existing software techniques and possibly develop new tailor-made software to enable the unedited footage to be speedily edited down to the important material that we intended to be viewed and highlighted.

To make this process easier we developed certain cues, which would be easier for any programs to recognize.

3.6.1 Audio cues

If the dissector is talking it is safe to assume that he is reading from the script and that the footage at that point is showing relevant structures rather than simple dissection work. We also used verbal cues for direction such when we wanted a close up or to zoom out and when the dissector wanted to draw attention to relevant structures.

We also developed some simple word commands for direction and audio cues - these were:

- Zoom in
- Zoom out
- Important detail
- End detail
When we wanted a close up of the dissection field the dissector would call for a 'zoom in', when we wanted an over view of the field 'zoom out' would be called. When relevant important detail was to be pointed out 'important detail' would be called and when this was over "end detail".

A back up system to the commands was developed which proved to be a simple, low tech and reliant way to aid the editing process, and was the easiest way to whittle away what we considered to be irrelevant footage.

As the video and audio are recording there is a timer running like any home video system tape or digital videodisc player would have. When the dissector was talking from the script, the time setting was recorded, and when he stopped it was also recorded, and when the other oral commands/directions were made those times were recorded.

This simple technique later proved invaluable to removing large sections of unwanted footage.

3.6.2 Visual Recognition cues and tools for highlighting

The proposed software would need to recognise what was relevant from what would be deemed unimportant data and to be able to see the structures, which we later wanted to highlight.

When filming the rough shots much time was spent trying to develop techniques in order to perfect the technical details of the lighting and colour.
contrast, which is necessary as editing programs are dependent on being able to use the rough footage produced to create the necessary content analysis as the auto-editing software, as well as the high-lighting and labeling programmes.

When filming the rough shots, we were still developing techniques and at this point in time had not yet abandoned the idea of using a fixed camera and a static camera.

We needed a cue to be able to switch from one camera to the other, so a cue card was developed. It can sometimes be seen in one of the corners of the screen of the finished dissection footage. It is approximately one inch square in dimensions and the two faces have different colors. Green and blue were decided on so the content analysis programs could easily recognize them. The normal face shown is green; however when the dissector wishes for part of the dissection to be brought to attention, the card is flipped showing the blue face which in turn would be recognised by the programme.

For highlighting the anatomical structures, a pointer would need to physically run along the structure, which would then be recognized and labeled. Various materials were tried. Experimenting with various colours and materials we finally discovered the ideal tracking pointer, a paintbrush wrapped in red electrical tape.
3.7 Processing

Now we had captured our filming of the dissection on a DV tape, we had to transfer this video data onto a computer so we could edit the footage with our content analysis software and process the footage so we could add our desired special effects. Here I shall give an overview of the steps involved.

3.7.1 Transfer of Data

We needed to transfer the video data from its original tape format to a computer in so doing changing its format and storing it for processing. It was also stored so as to have a backup, with the ability to transfer the data onto a DVD.

3.7.2 Equipment

The majority of this process was performed at the Electrical and Electronic Engineering Department at TCD. The DV tape that had been filmed for the given session was played back to the computer on a JVC SR-DVM70 DV deck. The deck was hooked up to a computer with a specific Firewall cable.

On the computer the programme Adobe Premiere Pro 1.5 was the software of choice used to capture the uploaded data and save and store it in Microsoft DV video format in an uncompressed file format.
The size of 40 minutes of uncompressed video footage could be as high as 10 Gigabytes of data. As storage and backing up the files for safety could rapidly become a problem, an external hard drive was utilized to back up the files.

3.7.3 Editing the Video

The original plan of having two cameras: one fixed or static, for panoramic view and one for close up work would have been harder to splice together as there would have been more data to sift through. This was not the reason that one camera was used, but did also have this added benefit.

Our chief editing instrument was that the audio was also simultaneously recorded and when full dissection video was imported into Adobe Premiere Pro 1.5 we were able to use the program's editing tools with the audio cues and prompts to rapidly edit a 40-minute to 1 hour video into a short relevant 6 to 8 minute short video.

It should be noted that the final audio for the video was recorded separately and synchronized to the relevant short video.
3.7.4 Highlighting the video

In order to highlight the anatomical structures of importance the pointer traverses its surface. In order to pick this out from the rest of the background footage a series of processes must occur. We can break this up into three different parts. (1) Location by way of image segmentation. (2) Edge detection followed by the use of a Hough Transform assisted in the tip of the pointer against the anatomical structure, this information is then used to piece the footage into relevant pieces of film. (3) Augmenting this visual information in the important parts of the footage to highlight the structure for the student to identify.

In this case the location aspect to the process involves the pointer. From the footage a single frame is taken (there are twenty-five frames a second). The pointer is then segmented in this frame. A process of colour segmentation is used. Retrieving a sample of colour from the pointer carries this out; this is why bright red electrical tape was decided on as it had easily identifiable (thus traceable) distinctive color from the surrounding background footage. From this sample of colour, a model of the colour was created, which describes the all variants of shade of that colour (which is thus the colour of the pointer and hence represents the pointer) from the different shades of colour of the background footage.
In this model, each colour has hue and saturation, and a Hue and Saturation value can be allocated using the colour space as variables. From this a multivariate Gaussian model is constructed. This model can then be applied to provide a method to separate out the pixels of the frames. Two classes are formed.

Class 1, which represent the variable shades of possible colour of the pointer. Class 2, which represent the variable shades of possible colour of the background footage. This model can then classify the pixels into the possible variants of colour of the pointer but not in the area of the pointer within the footage and areas of footage within the vicinity of the pointer but of the colour variants of the background footage.

At the same time the pointer cannot be located in two different regions of the frame at the same time. This information was also incorporated into the image segmentation process. This information is based on the premise that pixels that are located near each other are likely to be similar in colour. The pixels can then be organized into neighborhoods.

The colour of pixels can then be classified as a function of the shade of the colour, and the location of the pixel in the image using the Bayesian Theorem. So, further information can be added to the segmentation process. The class 0 pixels are classified as pixels that contain shades of colour that are the shades of colour of the pointer and located in the region of the frame where the pointer is found. Class 1 pixels are classified as pixels that contain shades
of colour of the background footage and are located in the region of the frame where the pointer is not. Bayesian Theorem calculates the probability that a pixel could belong to each class; the class with the higher probability is then selected to be the class of the pixel. This made the segmentation process more accurate.

With the pointer identified, the problem arises of being able to pick out the structure the pointer is identifying. This is the process of image tracking. In order to do this, edge detection has to be carried out so the boundaries of the pointer can be identified. The edge detection is carried out by taking the images containing only the segmented pointer (i.e. no background footage). Zero-cross edge detection was performed to trace the boundary at its pixel location in the frame. This produced a boundary of the pointer, which is similar to the shape of an isosceles triangle. The vertex of the two longest lines pointed in the direction of the target.

A Hough Transform was used to extract the location of the two longest lines. The Hough Transform converts the line from Cartesian coordinate space to coordinates in the parameter space. This transformation permits a line, which is represented by many points in the Cartesian space, to be represented by only one point in the Hough Transform space.

The lines generated by the Hough Transform, join all collinear points in the dimensions of the frame, so instead of the vertex of a triangle formed by the two lines, one finds an intersection of the two lines. However this may not
always occur, the pointer could be located at the perimeter of the frame and so
the intersection would occur out of frame; in close up-shots the pointer is
magnified and this separates the two longest lines out, so we lose part of the
guide to locate the intersection point.

The location of the intersection or the guide to locate the intersection
point is the basis to identify the tip of the pointer closest to the target structure.
The segmented image is then confined to a smaller area, where the segmented
image is located on the four sides of the area’s perimeter, the four corner points
of the perimeter are then located, the perimeter point that is closest to the
intersection point of the pointer represents the pointer tip traversing the given
anatomical structure which can then be tracked. As it can be identified and
tracked, it can be highlighted.

The work then had to continue along the direction of cartoonising the
anatomical structure, but this was not achieved. A practical compromise was
worked out. We had not intended the structures we wanted highlighted to be in
the moving images of the video. In fact this might have seemed distracting.
Still images would more than suffice to be labeled and highlighted for both the
video segment and for the quiz segment. Annotation software could be
employed for this process, which could be independent of content analysis.
3.7.5 Annotation Software

This particular piece of software is how we eventually added our special effects to highlight the desired anatomical structures and label them appropriately. The annotated images were also used for the quiz section.

As we had specific annotation purposes that we intended for the end product, it was decided to use a custom annotation software program rather than one of the many that are commercially available. The information was available from our colleagues at TCD, in fact it was at their suggestion that it was carried out in this fashion as a commercially available package is designed to be for general purpose and would therefore introduce complicated system interface issues which are best to avoid.

We needed to annotate our videos with basic text and simple graphics as well as using a simple globally accepted colour code (Red for arteries, blue for veins, yellow for nerves etc.). Very simple geometric shapes were to be used, straight lines and arrows, quadrangles, triangles, circles.

Our edited short video, which was exported from Adobe Premiere Pro1.5, would then be imported into the Video Annotation Application. From the tools available, the selected image can then have the desired graphics assigned to them.
With the mouse, and using a toolbar function, an image can be selected to have the desired graphic drawn onto it in the relevant colour and be labeled with the appropriate text. Once the desired special effect had been obtained this would be saved. The process could then be repeated as many times as needed for the short video.

Once we were happy with our annotation, the finished video was exported back into Adobe Premiere Pro 1.5 and was merged with its matching accompanying audio track to give us a finished and complete video.
3.7.6 File compression

Starting with a piece of footage which could be 40 minutes to an hour long ranging from 10 GB to 12 GB, the finalized edited and annotated video would still be about 1.0 GB. This is still a very large file.

Many of these files would need to be placed onto the DVD, which would soon not have enough storage capacity for all the data. We did not want to produce a whole series of DVDs and so the answer is to shrink the files to a more acceptable size of about 50 MB.

This process of is called compression. The process uses mathematical and statistical tricks to remove redundant data.

One example is that in an uncompressed piece of video, the images are shown frame by frame in their normal sequential order. In a compressed video file, the subject matter, often in the foreground, will be left untampered. In our videos the background was essentially static. Rather than showing the same repeated background in each frame, a short hand of the background is sent which simply updates the background rather than sending new data.

A whole host of criteria and variables could be altered by the compression and decompression of the video, all of which would give a different effect to the video at the end of the process.
Apple has produced the QuickTime video format, which was ideal for our purposes and negated a trial and error approach to compressing and decompressing our video.
3.8 Audio

The audio was essential to aid a speedy editing process, but was too poor to be used as the audio track. Attempts to clean the audio of unwanted noise were unsuccessful. In order to get good quality sound you need to be in a quiet place that does not have echoes and has a capacity to record.

3.8.1 Equipment

Our colleagues at TCD have a recording studio with a sound proofed room within it that has an anti-reverberation design to its interior. Looking at a computer screen we could view our video and record a new audio track for it by speaking into the microphone. A Rode NT-2000 1" condenser microphone was used that had a pop guard (this is a simple shielding device that prevents sudden release of air from hitting the microphone) mounted in front of it.

The mixing console employed was a Mackie analogue model, and the output signal was converted from an analogue format to a digital format was fed into a patch-bay to a DigiDesign analog to digital converter, which was hooked up to an Apple G4 Power mac via a USB link. The computer programme Pro Tools then recorded and saved digital audio, which was synchronized to the appropriate short video. All the audio connections used high-end leads to allow for elimination of background noise.
3.9 Diagrams

Images from Cunningham's Manual, featuring on the corkboard during the filming sessions, were on the DVD as well so there would be a diagrammatic reference for the student.

A Canon CanoScan flatbed scanner at 600 dots per inch was used to scan the images. The images had a dirty greyish blue appearance, as text or images on the other side of the page had been picked up.

We used the software program Adobe Photoshop to clean up the images. This is a user-friendly program that has a large amount of automacy incorporated into it. This made it a comparatively simple and fast process once the first two to three images had been completed, as the settings could be locked in and the process quickly repeated for the next diagram.
3.10 Quizzes

Our intention was that the student would review the material prior to the corresponding lecture and then proceed to the dissection practical. Later they would be able to re-review and self-assess their knowledge. The DVD would give them the facility to review and self appraise by performing the testing section, which we named the Quiz. We decided to call it a quiz rather than a test or examination as it suggests a more interactive nature and sounds less intimidating.

We had already filmed, edited and annotated our video material. Now we had to create a way for the images and the corresponding graphics and labels to be incorporated into an interactive test, which would be able to mark itself once the student, had completed it and give them a grade.

3.10.1 Web Based Software

For the quiz to be a successful part of the product and be received well by the students for whom it was intended it would need to satisfy several criteria. The quiz would have to be easy to access and easy to operate (user friendly) in a prompt and timely fashion. This along with the dissection instructions, videos, and corresponding diagrams all had to be placed on the DVD. This posed challenges in terms of the capacity of the DVD and the need for cross-system interoperability while being able to operate autonomously, meaning it had to be able to be loaded into a student's computer and be played
without the need for further software to be loaded onto the computer to be able to play the DVD.

Due to these necessities a 'Web Based' system was chosen. Web-based systems use pre-existing web technology and programs but can be independent of the Internet. So the web browser that is already on the student's computer can run the system but does not need to be connected to the Internet when it is performing its function.

This choice was made out of necessity, but had a significant benefit for future developments and evolution of this project.

A web-based system was ideal because:

- All modern operating systems have a web browser, which is designed to easily open and operate a web-based system.
- They have a small file size, meaning they are designed so as not to use much storage.
- They are compatible with older, current and future systems.
3.10.2 *Language of the Technology*

Different disciplines have their own language and this holds true in Engineering and the ‘World Wide Web’ and we needed to use programs that were written in the computer equivalent of Esperanto.

There are multiple web-based systems that are in existence. To increase the universal nature of the chosen system so that we could ensure that all of our audience could use it, a basic and standard set of programs should be used.

The World Wide Web Consortium sets standards for the Web. For this reason the following technology was used:

- XHTML (Extensive Hypertext Markup Language)
- CSS (Cascading Style Sheets)
- JavaScript
- XML (Extensive Markup Language)

The basic web interface (program) was written using XHTML which is the standard language for defining web content as set by the World Wide Web Consortium. In addition, CSS was used which is also the defined standard language for controlling layout and presentation of web content. These technologies are widely used and supported by web browsers. With these, the basic web pages were constructed, but the interactivity that was required by the quiz needed further solutions.
This was achieved using JavaScript, (which is the standard web programming language for dynamic content) and XML, which is the Web Consortium standard mark-up language for storing data and information.

A Master XML file, which contains all the images, annotations, questions and correct answers is created with a very simple program. This is then loaded into the previously created web page. The JavaScript program then controls the practical sessions that can be chosen and the questions and answers. The student inputs their answer, which the JavaScript program can cross-reference to the Master XML file; this can then be graded giving the student a result.

With this done it, could all be burned onto a DVD-ROM as a completed product with the dissection instructions, Video footage with highlighted and labeled features, anatomical diagrams and the quiz.
Chapter 4: Results

The Dissection guide is enclosed in a DVD with this thesis. It consists of the following parts:

- Videos
- Dissection Instructions
- Quizzes

While we have permission from copyright holders to included the diagrams from Cunningham's Manual of Practical Anatomy (15th edn.) within the Dissection guide on Moodle, we were unable to include them on the DVD produced for external distribution as copyright permissions are more restrictive in this context.

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4.1 Thoracic dissection instructions

4.1.1 Thorax Practical 1: Surface anatomy of the pectoral region & basic dissection instructions.

In this dissection we shall begin by identifying surface markings and structures on the cadaver:

- The suprasternal notch.
- The sternal angle of Louis.
- The xiphoid process.
- The right and left clavicles.
- The right and left costal margins.
- Note the nipples surrounded by the areolar tissue.

Now we shall make the following skin incisions:

- Along the clavicular border.
- In the midline above the sternum from the sternal notch to the xiphoid process.
- Diagonally in the midaxillary line meeting the incision at the xiphoid process.
- Inferior to the lower border of the pectoralis major muscle.
- Around the nipple.
- Along the deltoïd muscle.

Repeat these incisions on the other side.

Using these incisions, create skin flaps and reflect the skin off the anterior chest wall, incise and remove the skin flaps.

The scalpel is used for skin incisions, most dissection is done with scissors either curved or blunt. You advance the closed blades of the scissors then open them to split the tissue without cutting important structures. The best dissection instruments are your fingers, called blunt finger dissection, using your fingers to split the different tissue layers.

Now remove any fat and fascia from the anterior chest wall.
4.1.2 Thorax Practical 2: (Breast) Pectoral muscles and the clavipectoral fascia.

(Female Breast: Most specimens will be atrophied, however note that there are between 16-20 openings around the nipple and attempt to pass a probe into one if you can. Bluntly dissect out one of the lobes. Now remove the entire breast from the anterior chest wall. Do not follow the tail of the breast into the axilla.)

Note the pectoralis major muscle with its clavicular attachment, sternal attachment and insertion on the humerus. Note the deltoïd muscle. Identify the deltopectoral groove and dissect out the cephalic vein that runs in it.

With the scalpel, incise along the inferior border of the pectoralis major muscle to approximately five centimetres lateral to the sternum and continue this incision superiorly, make a second incision along the clavicular head.

You can now reflect the pectoralis major muscle revealing the pectoralis minor muscle and the clavipectoral fascia.

Dissect out the clavipectoral fascia to identify the structures within it. You should be able to identify the lateral pectoral nerve, branches of the thoraco-acromial artery and the continuation of the cephalic vein.

Repeat this on the other side.

Incise the pectoralis minor muscle along its inferior and lateral borders running the incision medially so you can reflect the pectoralis minor muscle to expose the deeper intercostal muscles.
4.1.3 Thorax Practical 3: Thoracic cavity, intercostal spaces and neurovascular bundle.

We begin this dissection by identifying the intercostal muscles. Note the direction of the fibers of the external intercostal muscles and those of the internal intercostal muscles. If they are not clearly visible you will have to carefully dissect out one of the intercostal spaces.

To reflect the anterior chest wall we will have to free it. Saw through the lateral aspect of the clavicle. Repeat this process on the other side. Using the rib shears, cut through the ribs in the anterior axillary line. Note that the first rib is deep so it is often easier to access the second rib first, taking care not to damage the deeper structures such as the pleura or the lungs.

Before we can free the chest we have to cut through the sternocleidomastoid muscles. Now reflect the anterior chest wall.

Once you have done this identify the:

- Right and left lungs.
- Parietal pleura.
- Mediastinum.
- The internal thoracic vessels. dissect them out and follow their course.
- Identify the thymus gland- this may or may not be present.

Now bluntly dissect out the lungs with your hands, once you have freed them as much as possible incise the lungs at the hilum. Now remove the lungs from the thoracic cavity.

With the lungs now out of the way dissect out the neurovascular bundle in the intercostal space.
4.1.4 Thorax Practical 4: Anterior mediastinum, pericardial cavity, heart and coronary vessels.

The anterior mediastinum will be covered with much fat and connective tissue that should cleared to view the structures. Once you have done this, you should be able to identify the:

Ascending aorta and its branches, on the right the brachiocephalic trunk with the right subclavian, and on the left the left common carotid and the left subclavian artery. The pulmonary trunk should also be identified.

Identify and dissect out the right and left phrenic nerves.

Now, using forceps, grasp the pericardium and make an incision in it, extend this so that you can pass your hand into the pericardial sac. Note the dimensions of the oblique sinus posterior to the heart, and the transverse sinus between the aorta and pulmonary artery and the great vessels.

Remove the remainder of the pericardium from the heart, cut the great vessels close to their origins at the heart, and remove the heart from the thoracic cavity.

Clear as much pericardial fat from the heart as you can. Now identify:

- The right atrium and right atrial appendage.
- The right ventricle.
- The left ventricle.
- The left atrium and atrial appendage.
- The anterior interventricular groove.
- The atrioventricular groove.
- The ascending aorta.
- The pulmonary trunk.
Posteriorly identify:

- The inferior vena cava.
- The superior vena cava.
- The posterior interventricular groove.

Now dissect out the coronary vessels, taking care as they can be quite delicate. Identify:

- The right coronary artery in the atrioventricular groove.
- The marginal branch.
- The posterior interventricular artery in the posterior interventricular groove.
- The left coronary artery.
- The anterior interventricular artery in the interventricular groove.
- The circumflex branch.

Identify:

- The coronary sinus.
- The middle cardiac vein.
- The great cardiac vein.
- The small cardiac vein.
4.1.5 Thorax Practical 5: Chambers of the heart.

Start this session by refamiliarising yourself with the basic structure of the heart: Identify the right and left atria and the ventricles, the ascending aorta, the pulmonary trunk, the superior vena cava and the inferior vena cava.

Open the right atrium by making an incision from the inferior vena cava to the superior vena cava. Now identify the:

- Crista terminalis.
- Pectinate muscles.
- Fossa ovalis.
- Tricuspid valve.

Incise along the margin of the right ventricle two centimetres from the interventricular groove and extend the incision superiorly to the pulmonary trunk. Now identify:

- Tricuspid valves and its cusps.
- Chordae tendinae.
- Papillary muscles.
- Interventricular septum.
- Pulmonary valve and its cusps.

Incise the left ventricle from the apex towards the left atrium, this is the largest chamber and will be full of thrombus so you will need to wash it out. Identify the:

- Bicuspid valve and its cusps.
- Chordae tendinae.
- Papillary muscles.

Note how much thicker the myocardium of the left ventricle is than the right ventricle.

Now open the aorta to view the aortic valve, note the three different cusps and the aortic sinus with the origins of the left and right coronary arteries.
4.1.6 Thorax Practical 6: Lungs and segments.

The lungs have already been removed from the thoracic cavity in Practical 3.

The right lung is composed up of three lobes separated by two fissures (view the lungs anteriorly and laterally) identify:

- The upper, middle and lower lobes.
- The oblique and horizontal fissures.
- Superiorly: Note the apex with the groove for the first rib and subclavian sulcus.
- Inferiorly: Note the diaphragmatic surface.
- Medially: Note the:
  - Groove for the oesophagus.
  - Groove for the superior vena cava.
  - Groove for the azygos vein.
- At the hilum note the pulmonary vein, artery and bronchus.

The left lung is obviously similar to the right lung with the major exception that it is composed of two lobes, separated by only one fissure. (View the lungs anteriorly and laterally) identify the:

- Upper and lower lobes.
- Oblique fissure.
- Lingula and cardiac notch.
- Superiorly: Note the apex, groove for the first rib and subclavian sulcus.
- Inferiorly: Note the diaphragmatic surface.
- Medially: Identify:
  - Groove for the aorta.
  - Groove for the oesophagus.
  - Cardiac notch.
  - Lingula.
- At the hilum, identify the pulmonary artery and vein and left main bronchus.
4.1.7 Thorax Practical 7: Superior and posterior mediastinum, diaphragm and root of the neck.

In this practical we start by removing the remains of the clavicles and first ribs, which will require some force, yet take care not to damage the surrounding structures.

Once you have done this, clear the fat around the great vessels and the root of the neck.

Identify the subclavian veins forming the brachiocephalic veins entering the superior vena cava.

Identify the ascending aorta, the arch of the aorta and the descending aorta. Note the branches of the aorta on the right- the brachiocephalic trunk giving rise to the right common carotid and the right subclavian artery. On the left are the common carotid and the left subclavian arteries.

Identify the trachea and the left and right main bronchi, note the carina.

Identify the left and right phrenic nerves and follow their courses to the diaphragm.

Identify the oesophagus, identify the left and right vagus nerves and note their courses in relation to the oesophagus.

Identify the oesophageal plexus and the greater splanchnic nerves.

Find the azygos and the hemiazygos system of veins.

Note how the inferior vena cava, oesophagus and aorta pass through or behind the diaphragm.

Inspect the diaphragm, identify the right and left lobes of the diaphragm note the muscular and tendinous parts of it. Pass your hand into the costophrenic recess and note the depth.
4.2 Illustrations

Illustration 1. Cunningham's Manual - Figure 14 (Page 25)

Illustration 2: Cunningham's Manual - Figure 16 (Page 26)
Illustration 3: Cunninghams's Manual - Figure 22 (Page 31)

Illustration 4: Cunninghams's Manual - Figure 33 (Page 24)
Illustration 5: Cunningham's Manual - Figure 37 (Page 30)

The trachea, bronchi, and lungs of a child, hardened *in situ*.

Illustration 6: Cunningham's Manual - Figure 40 (Page 32)

The medial surface of the left lung hardened *in situ*.
The medial surface of the right lung hardened in situ.

Illustration 7: Cunningham's Manual - Figure 41 (Page 33)

The thyroid gland and thymus in a full-thorax view.

Illustration 8: Cunningham's Manual - Figure 48 (Page 38)
Illustration 9: Cunningham's Manual - Figure 49 (Page 39)

Illustration 10: Cunningham's Manual - Figure 51 (Page 41)
The pericardium and great vessels after removal of the heart. The arrows lie in the transverse sinus of the pericardium and the posterior wall of the oblique sinus lies between the right and left pulmonary veins. Pulmonary arteries and veins uncoloured.

Illustration 11: Cunninghams's Manual - Figure 52 (Page 42)

The base of the ventricular part of the heart after removal of the atria. The right coronary artery usually extends further to the left than in this specimen. The sternocostal surface is to the right.

Illustration 12: Cunninghams's Manual - Figure 55 (Page 45)
A diagram of the tributaries of the coronary sinus.

Illustration 13: Cunningham's Manual - Figure 56 (Page 46)

Illustration 14: Cunningham's Manual - Figure 57 (Page 47)
Illustration 15: Cunningham's Manual - Figure 58 (Page 48)

Illustration 16: Cunningham's Manual - Figure 65 (Page 55)
A diagram of the base of the ventricular part of the heart with the atria and great vessels removed. The atrioventricular groove is shown piercing the fibrous skeleton of the heart.

Illustration 17: Cunningham's Manual - Figure 66 (Page 55)

A section through the heart to show the interatrial, atrioventricular, and interventricular septa, and the fibrous rings that surround the atrioventricular orifices.

Illustration 18: Cunningham's Manual - Figure 67 (Page 56)
Illustration 19: Cunningham's Manual - Figure 76 (Page 64)

A dissection of the diaphragmatic and posterior surfaces of the heart.

Illustration 20: Cunningham's Manual - Figure 80 (Page 70)

A dissection of the upper part of the posterior mediastinum after removal of the heart and posterior wall of the pericardium.
Illustration 21: Cunningham's Manual - Figure 81 (Page 70)

Illustration 22: Cunningham's Manual - Figure 82 (Page 71)
4.3 Interactive Quiz

4.3.1 Thorax Practical 1: Quiz 1

Illustration 23: Image from Thorax Practical 1: Quiz 1

Identify 1: suprasternal notch; sternal angle of Louis; areolar; tissue; costal margin; xiphoid process; nipple; left clavicle; right clavicle;

Identify 2: suprasternal notch; sternal angle of Louis; areolar tissue; costal margin; xiphoid process; nipple; left clavicle; right clavicle;

Identify 3: suprasternal notch; sternal angle of Louis; areolar tissue; costal margin; xiphoid process; nipple; left clavicle; right clavicle;
Identify 4: suprasternal notch; sternal angle of Louis; areolar tissue; costal margin; xiphoid process; nipple; left clavicle; right clavicle.

Identify 5: suprasternal notch; sternal angle of Louis; areolar tissue; costal margin; xiphoid process; nipple; left clavicle; right clavicle.

Identify 6: suprasternal notch; sternal angle of Louis; areolar tissue; costal margin; xiphoid process; nipple; left clavicle; right clavicle.

Identify 7: suprasternal notch; sternal angle of Louis; areolar tissue; costal margin; xiphoid process; nipple; left clavicle; right clavicle.

Identify 8: suprasternal notch; sternal angle of Louis; areolar tissue; costal margin; xiphoid process; nipple; left clavicle; right clavicle.
4.3.2 Thorax Practical 2: Quiz 1

Illustration 24: Image from Thorax Practical 2: Quiz 1

Identify 1: cephalic vein; deltoid; pectoralis major

Identify 2: cephalic vein; deltoi; pectoralis major

Identify 3: cephalic vein; deltoi; pectoralis major
4.3.3 Thorax Practical 2: Quiz 2.

Illustration 25: Image from Thorax Practical 2: Quiz 2

Identify 1: cephalic vein; insertion of pectoralis major onto the humerus; sternal attachment of pectoralis major; clavicular attachment of pectoralis major: deltoid

Identify 2: cephalic vein; insertion of pectoralis major onto the humerus; sternal attachment of pectoralis major; clavicular attachment of pectoralis major: deltoid

Identify 3: cephalic vein; insertion of pectoralis major onto the humerus; sternal attachment of pectoralis major; clavicular attachment of pectoralis major; deltoid
Identify 4: cephalic vein; *insertion of pectoralis major onto the humerus*; sternal attachment of pectoralis major; clavicular attachment of pectoralis major; deltoid

Identify 5: cephalic vein; insertion of pectoralis major onto the humerus; sternal attachment of *pectoralis major*; clavicular attachment of pectoralis major; deltoid
4.3.4 Thorax Practical 2: Quiz 3

Illustration 26: Image from Thorax Practical 2: Quiz 3

**Identify 1:** pectoralis minor; serratus anterior; latissimus dorsi; pectoralis minor muscle insertion on the coracoid process of the scapula

**Identify 2:** pectoralis minor; serratus anterior; latissimus dorsi; pectoralis minor muscle insertion on the coracoid process of the scapula

**Identify 3:** pectoralis minor; serratus anterior; latissimus dorsi; pectoralis minor muscle insertion on the coracoid process of the scapula

**Identify 4:** pectoralis minor; serratus anterior; latissimus dorsi; pectoralis minor muscle insertion on the coracoid process of the scapula
4.3.5 Thorax Practical 2: Quiz 4

Illustration 27: Image from Thorax Practical 2: Quiz 4

**Identify 1:** arterial branch of the thoraco-acromial artery; lateral pectoral nerve; medial pectoral nerve; cephalic vein

**Identify 2:** arterial branch of the thoraco-acromial artery; lateral pectoral nerve; medial pectoral nerve; cephalic vein

**Identify 3:** arterial branch of the thoraco-acromial artery; lateral pectoral nerve; **medial pectoral nerve;** cephalic vein

**Identify 4:** arterial branch of the thoraco-acromial artery; **lateral pectoral nerve;** medial pectoral nerve; cephalic vein
4.3.6 Thorax Practical 3: Quiz 1.

Illustration 28: Image from Thorax Practical 3: Quiz 1

**Identify 1:** direction of fibres of internal intercostal muscles; tributary of an intercostal vein; **direction of fibres of external intercostal muscles**

**Identify 2:** direction of fibres of internal intercostal muscles; tributary of an intercostal vein; direction of fibres of external intercostal muscles

**Identify 3:** direction of fibres of internal intercostal muscles; **tributary of an intercostal vein**; direction of fibres of external intercostal muscles
4.3.7 Thorax Practical 3: Quiz 2

Illustration 29: Image from Thorax Practical 3: Quiz 2

**Identify 1:** right lung; mediastinum; left lung; sternocleidomastoid muscle

**Identify 2:** right lung; mediastinum; left lung; sternocleidomastoid muscle

**Identify 3:** right lung; mediastinum; left lung; sternocleidomastoid muscle

**Identify 4:** right lung; mediastinum; left lung; sternocleidomastoid muscle
4.3.8 Thorax Practical 3: Quiz 3

Illustration 30: Image from Thorax Practical 3: Quiz 3

Identify 1: right internal thoracic vein; left internal thoracic artery; left internal thoracic vein; right internal thoracic artery

Identify 2: right internal thoracic vein; left internal thoracic artery; left internal thoracic vein; right internal thoracic artery

Identify 3: right internal thoracic vein; left internal thoracic artery; left internal thoracic vein; right internal thoracic artery

Identify 4: right internal thoracic vein; left internal thoracic artery; left internal thoracic vein; right internal thoracic artery
4.3.9 Thorax Practical 3: Quiz 4.

Illustration 31: Image from Thorax Practical 3: Quiz 4

**Identify 1:** artery of the neurovascular bundle; nerve of the neurovascular bundle; **vein of the neurovascular bundle**

**Identify 2:** artery of the neurovascular bundle; nerve of the neurovascular bundle; vein of the neurovascular bundle

**Identify 3:** artery of the neurovascular bundle; **nerve of the neurovascular bundle**; vein of the neurovascular bundle
**4.3.10: Thorax Practical 4: Quiz 1**

**Illustration 32: Image from Thorax Practical 4: Quiz 1**

**Identify 1:** left brachiocephalic vein; right phrenic nerve; outline of the heart; left phrenic nerve; superior vena cava; right brachiocephalic

**Identify 2:** left brachiocephalic vein; right phrenic nerve; outline of the heart; left phrenic nerve; superior vena cava; right brachiocephalic

**Identify 3:** left brachiocephalic vein; right phrenic nerve; outline of the heart; left phrenic nerve; superior vena cava; right brachiocephalic

**Identify 4:** left brachiocephalic vein; right phrenic nerve; outline of the heart; left phrenic nerve; superior vena cava; right brachiocephalic

**Identify 5:** left brachiocephalic vein; right phrenic nerve; outline of the heart; left phrenic nerve; superior vena cava; right brachiocephalic

**Identify 6:** left brachiocephalic vein; right phrenic nerve; outline of the heart; left phrenic nerve; superior vena cava; right brachiocephalic
4.2.11 Thorax Practical 4: Quiz 2

Illustration 33: Image from Thorax Practical 4: Quiz 2

**Identify 1:** arch of aorta; right atrial appendage; right ventricle; right atrium; ascending aorta.

**Identify 2:** arch of aorta; right atrial appendage; right ventricle; right atrium; ascending aorta

**Identify 3:** arch of aorta; right atrial appendage; right ventricle; **right atrium;** ascending aorta

**Identify 4:** arch of aorta; **right atrial appendage;** right ventricle; right atrium; ascending aorta

**Identify 5:** arch of aorta; right atrial appendage; **right ventricle;** right atrium; ascending aorta
4.3.12 Thorax Practical 4: Quiz 3

Illustration 34: Image from Thorax Practical 4: Quiz 3

**Identify 1:** left common carotid; left pulmonary artery; *brachiocephalic trunk*

**Identify 2:** *left common carotid; left pulmonary artery; brachiocephalic trunk*

**Identify 3:** left common carotid; *left pulmonary artery; brachiocephalic trunk*
Illustration 35: Image from Thorax Practical 4: Quiz 4

**Identify 1:** brachiocephalic trunk; left subclavian vein; left brachiocephalic vein; arch of aorta; right atrium; right phrenic nerve; left phrenic nerve; right atrial appendage; superior vena cava; ascending aorta; right brachiocephalic vein; left common carotid; right subclavian vein

**Identify 2:** brachiocephalic trunk; left subclavian vein; left brachiocephalic vein; arch of aorta; right atrium; right phrenic nerve; left phrenic nerve; right atrial appendage; superior vena cava; ascending aorta; right brachiocephalic vein; left common carotid; right subclavian vein

**Identify 3:** brachiocephalic trunk; left subclavian vein; left brachiocephalic vein; arch of aorta; right atrium; right phrenic nerve; left phrenic nerve; right atrial appendage; superior vena cava; ascending aorta; right brachiocephalic vein; left common carotid; right subclavian vein
Identify 4: brachiocephalic trunk; left subclavian vein; left brachiocephalic vein; arch of aorta; right atrium; right phrenic nerve; left phrenic nerve; right atrial appendage; superior vena cava; ascending aorta; right brachiocephalic vein; left common carotid; right subclavian vein

Identify 5: brachiocephalic trunk; left subclavian vein; left brachiocephalic vein; arch of aorta; right atrium; right phrenic nerve; left phrenic nerve; right atrial appendage; superior vena cava; ascending aorta; right brachiocephalic vein; left common carotid; right subclavian vein

Identify 6: brachiocephalic trunk; left subclavian vein; left brachiocephalic vein; arch of aorta; right atrium; right phrenic nerve; left phrenic nerve; right atrial appendage; superior vena cava; ascending aorta; right brachiocephalic vein; left common carotid; right subclavian vein

Identify 7: brachiocephalic trunk; left subclavian vein; left brachiocephalic vein; arch of aorta; right atrium; right phrenic nerve; left phrenic nerve; right atrial appendage; superior vena cava; ascending aorta; right brachiocephalic vein; left common carotid; right subclavian vein

Identify 8: brachiocephalic trunk; left subclavian vein; left brachiocephalic vein; arch of aorta; right atrium; right phrenic nerve; left phrenic nerve; right atrial appendage; superior vena cava; ascending aorta; right brachiocephalic vein; left common carotid; right subclavian vein

Identify 9: brachiocephalic trunk; left subclavian vein; left brachiocephalic vein; arch of aorta; right atrium; right phrenic nerve; left phrenic nerve; right atrial appendage; superior vena cava; ascending aorta; right brachiocephalic vein; left common carotid; right subclavian vein
Identify 10: brachiocephalic trunk; left subclavian vein; left brachiocephalic vein; arch of aorta; right atrium; right phrenic nerve; left phrenic nerve; right atrial appendage; superior vena cava; ascending aorta; right brachiocephalic vein; left common carotid; right subclavian vein

Identify 11: brachiocephalic trunk; left subclavian vein; left brachiocephalic vein; arch of aorta; right atrium; right phrenic nerve; left phrenic nerve; right atrial appendage; superior vena cava; ascending aorta; right brachiocephalic vein; left common carotid; right subclavian vein

Identify 12: brachiocephalic trunk; left subclavian vein; left brachiocephalic vein; arch of aorta; right atrium; right phrenic nerve; left phrenic nerve; right atrial appendage; superior vena cava; ascending aorta; right brachiocephalic vein; left common carotid; right subclavian vein

Identify 13: brachiocephalic trunk; left subclavian vein; left brachiocephalic vein; arch of aorta; right atrium; right phrenic nerve; left phrenic nerve; right atrial appendage; superior vena cava; ascending aorta; right brachiocephalic vein; left common carotid; right subclavian vein
4.3.14 Thorax Practical 4: Quiz 5.

*Illustration 36: Image from Thorax Practical 4: Quiz 5*

Identify 1: ligamentum arteriosum; brachiocephalic trunk; left pulmonary artery; arch of aorta

Identify 2: ligamentum arteriosum; brachiocephalic trunk; left pulmonary artery; arch of aorta

Identify 3: ligamentum arteriosum; brachiocephalic trunk; **left pulmonary artery**; arch of aorta

Identify 4: ligamentum arteriosum; **brachiocephalic trunk**; left pulmonary artery; arch of aorta
4.3.15 Thorax Practical 4: Quiz 6

Illustration 37: Image from Thorax Practical 4: Quiz 6

Identify 1: right atrium; left ventricle; pulmonary trunk; atrioventricular groove; right border; left border; apex; anterior interventricular groove; ascending aorta; left atrial appendage; right ventricle; right atrial appendage

Identify 2: right atrium; left ventricle; pulmonary trunk; atrioventricular groove; right border; left border; apex; anterior interventricular groove; ascending aorta; left atrial appendage; right ventricle; right atrial appendage

Identify 3: right atrium; left ventricle; pulmonary trunk; atrioventricular groove; right border; left border; apex; anterior interventricular groove; ascending aorta; left atrial appendage; right ventricle; right atrial appendage
Identify 4: right atrium; left ventricle; pulmonary trunk; atrioventricular groove; right border; left border; apex; anterior interventricular groove; ascending aorta; left atrial appendage; right ventricle; right atrial appendage

Identify 5: right atrium; left ventricle; pulmonary trunk; atrioventricular groove; right border; left border; apex; anterior interventricular groove; ascending aorta; left atrial appendage; right ventricle; right atrial appendage

Identify 6: right atrium; left ventricle; pulmonary trunk; atrioventricular groove; right border; left border; apex; anterior interventricular groove; ascending aorta; left atrial appendage; right ventricle; right atrial appendage

Identify 7: right atrium; left ventricle; pulmonary trunk; atrioventricular groove; right border; left border; apex; anterior interventricular groove; ascending aorta; left atrial appendage; right ventricle; right atrial appendage

Identify 8: right atrium; left ventricle; pulmonary trunk; atrioventricular groove; right border; left border; apex; anterior interventricular groove; ascending aorta; left atrial appendage; right ventricle; right atrial appendage

Identify 9: right atrium; left ventricle; pulmonary trunk; atrioventricular groove; right border; left border; apex; anterior interventricular groove; ascending aorta; left atrial appendage; right ventricle; right atrial appendage

Identify 10: right atrium; left ventricle; pulmonary trunk; atrioventricular groove; right border; left border; apex; anterior interventricular groove; ascending aorta; left atrial appendage; right ventricle; right atrial appendage
Identify 11: right atrium; left ventricle; pulmonary trunk; atrioventricular groove; right border; left border; apex; anterior interventricular groove; ascending aorta; left atrial appendage; right ventricle; right atrial appendage

Identify 12: right atrium; left ventricle; pulmonary trunk; atrioventricular groove; right border; left border; apex; anterior interventricular groove; ascending aorta; left atrial appendage; right ventricle; right atrial appendage
Illustration 38: Image from Thorax Practical 4: Quiz 7

**Identify 1:** superior vena cava; left atrium; right ventricle; left ventricle; right atrium; **inferior vena cava**;

**Identify 2:** superior vena cava; left atrium; right ventricle; left ventricle; right atrium; inferior vena cava;

**Identify 3:** superior vena cava; left atrium; right ventricle; left ventricle; right atrium; inferior vena cava;

**Identify 4:** superior vena cava; **left atrium**; right ventricle; left ventricle; right atrium; inferior vena cava;

**Identify 5:** superior vena cava; left atrium; right ventricle; **left ventricle**; right atrium; inferior vena cava;

**Identify 6:** superior vena cava; left atrium; **right ventricle**; left ventricle; right atrium; inferior vena cava;
Illustration 39: Image from Thorax Practical 4: Quiz 8

**Identify 1:** right coronary artery; interventricular branch of the right coronary artery; marginal branch of the right coronary artery; *ascending aorta*

**Identify 2:** *right coronary artery*; interventricular branch of the right coronary artery; marginal branch of the right coronary artery; *ascending aorta*

**Identify 3:** right coronary artery; interventricular branch of the right coronary artery; *marginal branch of the right coronary artery*; ascending aorta

**Identify 4:** right coronary artery; *interventricular branch of the right coronary artery*; marginal branch of the right coronary artery; ascending aorta
4.3.18 Thorax Practical 4: Quiz 9

Illustration 40: Image from Thorax Practical 4: Quiz 9

**Identify 1:** origin of the left coronary artery; circumflex branch of the left coronary artery; anterior interventricular branch of the left coronary artery; ascending aorta

**Identify 2:** origin of the left coronary artery; circumflex branch of the left coronary artery; anterior interventricular branch of the left coronary artery; ascending aorta

**Identify 3:** origin of the left coronary artery; circumflex branch of the left coronary artery; anterior interventricular branch of the left coronary artery; ascending aorta

**Identify 4:** origin of the left coronary artery; circumflex branch of the left coronary artery; anterior interventricular branch of the left coronary artery; ascending aorta
Illustration 41: Image from Thorax Practical 4: Quiz 10

**Identify 1**: middle cardiac vein; small cardiac vein; great cardiac vein; coronary sinus

**Identify 2**: middle cardiac vein; small cardiac vein; great cardiac vein; coronary sinus

**Identify 3**: middle cardiac vein; small cardiac vein; **great cardiac vein**; coronary sinus

**Identify 4**: middle cardiac vein; **small cardiac vein**; great cardiac vein; coronary sinus
4.3.20 Thorax Practical 5: Quiz 1

Illustration 42: Image from Thorax Practical 5: Quiz 1

Identify 1: pulmonary trunk; right atrium; left ventricle; left atrial appendage; inferior vena cava; superior vena cava; left atrium; right ventricle; right atrial appendage; ascending aorta.

Identify 2: pulmonary trunk; right atrium; left ventricle; left atrial appendage; inferior vena cava; superior vena cava; left atrium; right ventricle; right atrial appendage; ascending aorta.

Identify 3: pulmonary trunk; right atrium; left ventricle; left atrial appendage; inferior vena cava; superior vena cava; left atrium; right ventricle; right atrial appendage; ascending aorta.
Identify 4: pulmonary trunk; right atrium; left ventricle, left atrial appendage, inferior vena cava; superior vena cava; left atrium; right ventricle; right atrial appendage, ascending aorta.

Identify 5: pulmonary trunk; right atrium; left ventricle; left atrial appendage; inferior vena cava; superior vena cava; left atrium; right ventricle; right atrial appendage, ascending aorta.

Identify 6: pulmonary trunk; right atrium; left ventricle; left atrial appendage, inferior vena cava; superior vena cava; left atrium; right ventricle; right atrial appendage, ascending aorta.

Identify 7: pulmonary trunk; right atrium; left ventricle, left atrial appendage; inferior vena cava; superior vena cava; left atrium; right ventricle; right atrial appendage, ascending aorta.

Identify 8: pulmonary trunk; right atrium; left ventricle, left atrial appendage; inferior vena cava; superior vena cava; left atrium; right ventricle; right atrial appendage, ascending aorta.

Identify 9: pulmonary trunk; right atrium; left ventricle, left atrial appendage; inferior vena cava; superior vena cava; left atrium; right ventricle; right atrial appendage, ascending aorta.

Identify 10: pulmonary trunk; right atrium; left ventricle, left atrial appendage; inferior vena cava; superior vena cava; left atrium; right ventricle; right atrial appendage, ascending aorta.
4.3.21 Thorax Practical 5: Quiz 2

Illustration 43: Image from Thorax Practical 5: Quiz 2

**Identify 1:** pectinate muscle; opening of coronary sinus; anterior cusp; chordae tendinae; interatrial septum; posterior cusp; septal cusp; fossa ovalis; crista terminalis.

**Identify 2:** pectinate muscle; opening of coronary sinus; anterior cusp; chordae tendinae; interatrial septum; posterior cusp; septal cusp; fossa ovalis; crista terminalis

**Identify 3:** pectinate muscle; opening of coronary sinus; anterior cusp; chordae tendinae; interatrial septum; posterior cusp; septal cusp; fossa ovalis; crista terminalis
Identify 4: pectinate muscle; opening of coronary sinus; anterior cusp; chordae tendinae; interatrial septum; posterior cusp; septal cusp; fossa ovalis; crista terminalis

Identify 5: pectinate muscle; opening of coronary sinus; anterior cusp; chordae tendinae; interatrial septum; posterior cusp; septal cusp; fossa ovalis; crista terminalis

Identify 6: pectinate muscle; opening of coronary sinus; anterior cusp; chordae tendinae; interatrial septum; posterior cusp; septal cusp; fossa ovalis; crista terminalis

Identify 7: pectinate muscle; opening of coronary sinus; anterior cusp; chordae tendinae; interatrial septum; posterior cusp; septal cusp; fossa ovalis; crista terminalis

Identify 8: pectinate muscle; opening of coronary sinus; anterior cusp; chordae tendinae; interatrial septum; posterior cusp; septal cusp; fossa ovalis; crista terminalis

Identify 9: pectinate muscle; opening of coronary sinus; anterior cusp; chordae tendinae; interatrial septum; posterior cusp; septal cusp; fossa ovalis; crista terminalis
4.3.22 Thorax Practical 5: Quiz 3

Illustration 44: Image (a) from Thorax Practical 5: Quiz 3

Illustration 45: Image (b) from Thorax Practical 5: Quiz 3
Identify 1: posterior cusp; chordae tendinae; interventricular septum; anterior cusp of the semi-lunar valve; posterior cusp of the semi-lunar valve; right cusp of the semi-lunar valve; moderator band; septal cusp; anterior cusp; papillary muscle

Identify 2: posterior cusp; chordae tendinae; interventricular septum; anterior cusp of the semi-lunar valve; posterior cusp of the semi-lunar valve; right cusp of the semi-lunar valve; moderator band; septal cusp; anterior cusp; papillary muscle

Identify 3: posterior cusp; chordae tendinae; interventricular septum; anterior cusp of the semi-lunar valve; posterior cusp of the semi-lunar valve; right cusp of the semi-lunar valve; moderator band; septal cusp; anterior cusp; papillary muscle

Identify 4: posterior cusp; chordae tendinae; interventricular septum; anterior cusp of the semi-lunar valve; posterior cusp of the semi-lunar valve; right cusp of the semi-lunar valve; moderator band; septal cusp; anterior cusp; papillary muscle

Identify 5: posterior cusp; chordae tendinae; interventricular septum; anterior cusp of the semi-lunar valve; posterior cusp of the semi-lunar valve; right cusp of the semi-lunar valve; moderator band; septal cusp; anterior cusp; papillary muscle

Identify 6: posterior cusp; chordae tendinae; interventricular septum; anterior cusp of the semi-lunar valve; posterior cusp of the semi-lunar valve; right cusp of the semi-lunar valve; moderator band; septal cusp; anterior cusp; papillary muscle
Identify 7: posterior cusp; chordae tendinae; interventricular septum; anterior cusp of the semi-lunar valve; posterior cusp of the semi-lunar valve; right cusp of the semi-lunar valve; moderator band; septal cusp; anterior cusp; papillary muscle

Identify 8: posterior cusp; chordae tendinae; interventricular septum; anterior cusp of the semi-lunar valve; posterior cusp of the semi-lunar valve; right cusp of the semi-lunar valve; moderator band; septal cusp; anterior cusp; papillary muscle

Identify 9: posterior cusp; chordae tendinae; interventricular septum; anterior cusp of the semi-lunar valve; posterior cusp of the semi-lunar valve; right cusp of the semi-lunar valve; moderator band; septal cusp; anterior cusp; papillary muscle

Identify 10: posterior cusp; chordae tendinae; interventricular septum; anterior cusp of the semi-lunar valve; posterior cusp of the semi-lunar valve; right cusp of the semi-lunar valve; moderator band; septal cusp; anterior cusp; papillary muscle
4.3.23 Thorax Practical 5: Quiz 4

Illustration 46: Image (a) from Thorax Practical 5: Quiz 4

Illustration 47: Image (b) from Thorax Practical 5: Quiz 4
Identify 1: anterior cusp of the bicuspid valve; papillary muscle; non-coronary cusp of the aortic valve; right cusp of the aortic valve; left cusp of the aortic valve; chordae tendinae; posterior cusp of the bicuspid valve; interventricular septum.

Identify 2: anterior cusp of the bicuspid valve; papillary muscle; non-coronary cusp of the aortic valve; right cusp of the aortic valve; left cusp of the aortic valve; chordae tendinae; posterior cusp of the bicuspid valve; interventricular septum.

Identify 3: anterior cusp of the bicuspid valve; papillary muscle; non-coronary cusp of the aortic valve; right cusp of the aortic valve; left cusp of the aortic valve; chordae tendinae; posterior cusp of the bicuspid valve; interventricular septum.

Identify 4: anterior cusp of the bicuspid valve; papillary muscle; non-coronary cusp of the aortic valve; right cusp of the aortic valve; left cusp of the aortic valve; chordae tendinae; posterior cusp of the bicuspid valve; interventricular septum.

Identify 5: anterior cusp of the bicuspid valve; papillary muscle; non-coronary cusp of the aortic valve; right cusp of the aortic valve; left cusp of the aortic valve; chordae tendinae; posterior cusp of the bicuspid valve; interventricular septum.

Identify 6: anterior cusp of the bicuspid valve; papillary muscle; non-coronary cusp of the aortic valve; right cusp of the aortic valve; left cusp of the aortic valve; chordae tendinae; posterior cusp of the bicuspid valve; interventricular septum.
Identify 7: anterior cusp of the bicuspid valve; papillary muscle; non-coronary cusp of the aortic valve; right cusp of the aortic valve; \textit{left cusp of the aortic valve}; chordae tendinae; posterior cusp of the bicuspid valve; interventricular septum.

Identify 8: anterior cusp of the bicuspid valve; papillary muscle; non-coronary cusp of the aortic valve; \textit{right cusp of the aortic valve}; left cusp of the aortic valve; chordae tendinae; posterior cusp of the bicuspid valve; interventricular septum.
4.3.24 Thorax Practical 6: Quiz 1

Illustration 48: Image (a) from Thorax Practical 6: Quiz 1

Illustration 49: Image (b) from Thorax Practical 6: Quiz 1

Illustration 50: Image (d) from Thorax Practical 6: Quiz 1
**Identify 1:** upper lobe; base; middle lobe; lower lobe; anterior surface; medial surface; lateral surface; posterior surface; oblique fissure; horizontal fissure; lower lobe; apex.

**Identify 2:** upper lobe; base; middle lobe; lower lobe; anterior surface; medial surface; lateral surface; posterior surface; oblique fissure; horizontal fissure; lower lobe; apex

**Identify 3:** upper lobe; base; middle lobe; **lower lobe**; anterior surface; medial surface; lateral surface; posterior surface; oblique fissure; horizontal fissure; lower lobe; apex.

**Identify 4:** upper lobe; base; middle lobe; lower lobe; anterior surface; medial surface; lateral surface; posterior surface; oblique fissure; horizontal fissure; lower lobe; apex.

**Identify 5:** upper lobe; base; middle lobe; lower lobe; anterior surface; medial surface; lateral surface; posterior surface; oblique fissure; **horizontal fissure**; lower lobe; apex.

**Identify 6:** upper lobe; base; **middle lobe**; lower lobe; anterior surface; medial surface; lateral surface; posterior surface; oblique fissure; horizontal fissure; lower lobe; apex.

**Identify 7:** upper lobe; base; middle lobe; lower lobe; anterior surface; medial surface; lateral surface; posterior surface; **oblique fissure**; horizontal fissure; lower lobe; apex.

**Identify 8:** upper lobe; base; middle lobe; **lower lobe**; anterior surface; medial surface; lateral surface; posterior surface; oblique fissure; horizontal fissure; lower lobe; apex.
**Identify 9** upper lobe; base; middle lobe; lower lobe; anterior surface; medial surface; lateral surface; **posterior surface**; oblique fissure; horizontal fissure; lower lobe; apex.

**Identify 10**: upper lobe; base; middle lobe; lower lobe; **anterior surface**; medial surface; lateral surface; posterior surface; oblique fissure; horizontal fissure; lower lobe; apex.

**Identify 11**: upper lobe; base; middle lobe; lower lobe; anterior surface; medial surface; **lateral surface**; posterior surface; oblique fissure; horizontal fissure; lower lobe; apex.

**Identify 12**: upper lobe; base; middle lobe; lower lobe; anterior surface; medial surface; lateral surface; posterior surface; oblique fissure; horizontal fissure; lower lobe; apex.
4.2.25 Thorax Practical 6: Quiz 2

Illustration 51: Image (a) from Thorax Practical 6: Quiz 2

Illustration 52: Image (b) from Thorax Practical 6: Quiz 2

Illustration 53: Image (c) from Thorax Practical 6: Quiz 2
Identify 1: upper lobe; lower lobe; horizontal fissure; cardiac impression; right main bronchus; pulmonary veins; pulmonary artery; oesophageal impression; root of the lung; oblique fissure; middle lobe; apex.

Identify 2: upper lobe; lower lobe; horizontal fissure; cardiac impression; right main bronchus; pulmonary veins; pulmonary artery; oesophageal impression; root of the lung; oblique fissure; middle lobe; apex.

Identify 3: upper lobe; lower lobe; horizontal fissure; cardiac impression; right main bronchus; pulmonary veins; pulmonary artery; oesophageal impression; root of the lung; oblique fissure; middle lobe; apex.

Identify 4: upper lobe; lower lobe; horizontal fissure; cardiac impression; right main bronchus; pulmonary veins; pulmonary artery; oesophageal impression; root of the lung; oblique fissure; middle lobe; apex.

Identify 5: upper lobe; lower lobe; horizontal fissure; cardiac impression; right main bronchus; pulmonary veins; pulmonary artery; oesophageal impression; root of the lung; oblique fissure; middle lobe; apex.

Identify 6: upper lobe; lower lobe; horizontal fissure; cardiac impression; right main bronchus; pulmonary veins; pulmonary artery; oesophageal impression; root of the lung; oblique fissure; middle lobe; apex.
Identify 7: upper lobe; lower lobe; horizontal fissure; cardiac impression; right main bronchus; pulmonary veins; pulmonary artery; oesophageal impression; root of the lung; oblique fissure; middle lobe; apex.

Identify 8: upper lobe; lower lobe; horizontal fissure; cardiac impression; right main bronchus; pulmonary veins; pulmonary artery; oesophageal impression; root of the lung; oblique fissure; middle lobe; apex.

Identify 9: upper lobe; lower lobe; horizontal fissure; cardiac impression; right main bronchus; pulmonary veins; pulmonary artery; oesophageal impression; root of the lung; oblique fissure; middle lobe; apex.

Identify 10: upper lobe; lower lobe; horizontal fissure; cardiac impression; right main bronchus; pulmonary veins; pulmonary artery; oesophageal impression; root of the lung; oblique fissure; middle lobe; apex.

Identify 11: upper lobe; lower lobe; horizontal fissure; cardiac impression; right main bronchus; pulmonary veins; pulmonary artery; oesophageal impression; root of the lung; oblique fissure; middle lobe; apex.

Identify 12: upper lobe; lower lobe; horizontal fissure; cardiac impression; right main bronchus; pulmonary veins; pulmonary artery; oesophageal impression; root of the lung; oblique fissure; middle lobe; apex.
4.3.26 Thorax Practical 6: Quiz 3

Illustration 54: Image (a) from Thorax Practical 6: Quiz 3

Illustration 55: Image (b) from Thorax Practical 6: Quiz 3

Illustration 56: Image (c) from Thorax Practical 6: Quiz 3
**Identify 1:** groove for the first rib and the subclavian blood vessels; cardiac notch; diaphragmatic surface; lower lobe; anterior surface; lateral surface; medial surface; posterior surface; oblique fissure; lingula; upper lobe; apex

**Identify 2:** groove for the first rib and the subclavian blood vessels; cardiac notch; diaphragmatic surface; lower lobe; anterior surface; lateral surface; medial surface; posterior surface; oblique fissure; lingula; upper lobe; apex

**Identify 3:** groove for the first rib and the subclavian blood vessels; cardiac notch; diaphragmatic surface; lower lobe; anterior surface; lateral surface; medial surface; posterior surface; oblique fissure; lingula; upper lobe; apex

**Identify 4:** groove for the first rib and the subclavian blood vessels; cardiac notch; diaphragmatic surface; lower lobe; anterior surface; lateral surface; medial surface; posterior surface; oblique fissure; lingula; upper lobe; apex

**Identify 5:** groove for the first rib and the subclavian blood vessels; cardiac notch; diaphragmatic surface; lower lobe; anterior surface; lateral surface; medial surface; posterior surface; oblique fissure; lingula; upper lobe; apex

**Identify 6:** groove for the first rib and the subclavian blood vessels; cardiac notch; diaphragmatic surface; lower lobe; anterior surface; lateral surface; medial surface; posterior surface; oblique fissure; lingula; upper lobe; apex
**Identify 7:** groove for the first rib and the subclavian blood vessels; cardiac notch; diaphragmatic surface; lower lobe; anterior surface; lateral surface; medial surface; posterior surface; oblique fissure; lingula; upper lobe; apex

**Identify 8:** groove for the first rib and the subclavian blood vessels; cardiac notch; diaphragmatic surface; lower lobe; anterior surface; lateral surface; medial surface; posterior surface; oblique fissure; lingula; upper lobe; apex

**Identify 9:** groove for the first rib and the subclavian blood vessels; cardiac notch; diaphragmatic surface; lower lobe; anterior surface; lateral surface; medial surface; posterior surface; oblique fissure; lingula; upper lobe; apex

**Identify 10:** groove for the first rib and the subclavian blood vessels; cardiac notch; diaphragmatic surface; lower lobe; anterior surface; lateral surface; medial surface; posterior surface; oblique fissure; lingula; upper lobe; apex

**Identify 11:** groove for the first rib and the subclavian blood vessels; cardiac notch; diaphragmatic surface; lower lobe; anterior surface; lateral surface; medial surface; posterior surface; oblique fissure; lingula; upper lobe; apex

**Identify 12:** groove for the first rib and the subclavian blood vessels; cardiac notch; diaphragmatic surface; lower lobe; anterior surface; lateral surface; medial surface; posterior surface; oblique fissure; lingula; upper lobe; apex

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4.3.27 Thorax Practical 6: Quiz 4

Illustration 57: Image (a) from Thorax Practical 6: Quiz 4

Illustration 58: Image (b) from Thorax Practical 6: Quiz 4
Identify 1: Impression of the arch of the aorta; upper lobe; impression of the aorta; lower lobe; lingula; pulmonary artery; pulmonary veins; left main bronchus; diaphragmatic surface; cardiac notch; cardiac impression; root of the lung; oblique fissure; apex

Identify 2: Impression of the arch of the aorta; upper lobe; impression of the aorta; lower lobe; lingula; pulmonary artery; pulmonary veins; left main bronchus; diaphragmatic surface; cardiac notch; cardiac impression; root of the lung; oblique fissure; apex

Identify 3: Impression of the arch of the aorta; upper lobe; impression of the aorta; lower lobe; lingula; pulmonary artery; pulmonary veins; left main bronchus; diaphragmatic surface; cardiac notch; cardiac impression; root of the lung; oblique fissure; apex

Identify 4: Impression of the arch of the aorta; upper lobe; impression of the aorta; lower lobe; lingula; pulmonary artery; pulmonary veins; left main bronchus; diaphragmatic surface; cardiac notch; cardiac impression; root of the lung; oblique fissure; apex

Identify 5: Impression of the arch of the aorta; upper lobe; impression of the aorta; lower lobe; lingula; pulmonary artery; pulmonary veins; left main bronchus; diaphragmatic surface; cardiac notch; cardiac impression; root of the lung; oblique fissure; apex

Identify 6: Impression of the arch of the aorta; upper lobe; impression of the aorta; lower lobe; lingula; pulmonary artery; pulmonary veins; left main bronchus; diaphragmatic surface; cardiac notch; cardiac impression; root of the lung; oblique fissure; apex
Identify 7: Impression of the arch of the aorta; upper lobe; impression of the aorta; lower lobe; lingula; pulmonary artery; pulmonary veins; left main bronchus; diaphragmatic surface; cardiac notch; cardiac impression; root of the lung; oblique fissure; apex

Identify 8: Impression of the arch of the aorta; upper lobe; impression of the aorta; lower lobe; lingula; pulmonary artery; pulmonary veins; left main bronchus; diaphragmatic surface; cardiac notch; cardiac impression; root of the lung; oblique fissure; apex

Identify 9: Impression of the arch of the aorta; upper lobe; impression of the aorta; lower lobe; lingula; pulmonary artery; pulmonary veins; left main bronchus; diaphragmatic surface; cardiac notch; cardiac impression; root of the lung; oblique fissure; apex

Identify 10: Impression of the arch of the aorta; upper lobe; impression of the aorta; lower lobe; lingula; pulmonary artery; pulmonary veins; left main bronchus; diaphragmatic surface; cardiac notch; cardiac impression; root of the lung; oblique fissure; apex

Identify 11: Impression of the arch of the aorta; upper lobe; impression of the aorta; lower lobe; lingula; pulmonary artery; pulmonary veins; left main bronchus; diaphragmatic surface; cardiac notch; cardiac impression; root of the lung; oblique fissure; apex

Identify 12: Impression of the arch of the aorta; upper lobe; impression of the aorta; lower lobe; lingula; pulmonary artery; pulmonary veins; left main bronchus; diaphragmatic surface; cardiac notch; cardiac impression; root of the lung; oblique fissure; apex
Identify 13: Impression of the arch of the aorta; upper lobe; impression of the aorta; lower lobe; lingula; pulmonary artery; pulmonary veins; left main bronchus; diaphragmatic surface; cardiac notch; cardiac impression; root of the lung; oblique fissure; apex

Identify 14: Impression of the arch of the aorta; upper lobe; impression of the aorta; lower lobe; lingula; pulmonary artery; pulmonary veins; left main bronchus; diaphragmatic surface; cardiac notch; cardiac impression; root of the lung; oblique fissure; apex
Illustration 59: Image from Thorax Practical 7: Quiz 1

**Identify 1:** muscular aspect of the right dome of the diaphragm; left dome of the diaphragm; tendinous aspect of the left dome of the diaphragm; orifice of the inferior vena cava; muscular aspect of the left dome of the diaphragm; tendinous aspect of the right dome of the diaphragm; **right dome of the diaphragm.**

**Identify 2:** **muscular aspect of the right dome of the diaphragm;** left dome of the diaphragm; tendinous aspect of the left dome of the diaphragm; orifice of the inferior vena cava; muscular aspect of the left dome of the diaphragm; tendinous aspect of the right dome of the diaphragm; **right dome of the diaphragm.**
Identify 3: muscular aspect of the right dome of the diaphragm; left dome of the diaphragm; tendinous aspect of the left dome of the diaphragm; orifice of the inferior vena cava; muscular aspect of the left dome of the diaphragm; tendinous aspect of the right dome of the diaphragm; right dome of the diaphragm.

Identify 4: muscular aspect of the right dome of the diaphragm; left dome of the diaphragm; tendinous aspect of the left dome of the diaphragm; orifice of the inferior vena cava; muscular aspect of the left dome of the diaphragm; tendinous aspect of the right dome of the diaphragm; right dome of the diaphragm.

Identify 5: muscular aspect of the right dome of the diaphragm; left dome of the diaphragm; tendinous aspect of the left dome of the diaphragm; orifice of the inferior vena cava; muscular aspect of the left dome of the diaphragm; tendinous aspect of the right dome of the diaphragm; right dome of the diaphragm.

Identify 6: muscular aspect of the right dome of the diaphragm; left dome of the diaphragm; tendinous aspect of the left dome of the diaphragm; orifice of the inferior vena cava; muscular aspect of the left dome of the diaphragm; tendinous aspect of the right dome of the diaphragm; right dome of the diaphragm.

Identify 7: muscular aspect of the right dome of the diaphragm; left dome of the diaphragm; tendinous aspect of the left dome of the diaphragm; orifice of the inferior vena cava; muscular aspect of the left dome of the diaphragm; tendinous aspect of the right dome of the diaphragm; right dome of the diaphragm.
Illustration 60: Image from Thorax Practical 7: Quiz 2

**Identify 1:** left common carotid; right subclavian; left brachiocephalic vein; ascending aorta; right phrenic nerve; azygos vein; left phrenic nerve; superior vena cava; right brachiocephalic vein; brachiocephalic trunk; left subclavian vein; right common carotid.

**Identify 2:** left common carotid; right subclavian; left brachiocephalic vein; ascending aorta; right phrenic nerve; azygos vein; left phrenic nerve; superior vena cava; right brachiocephalic vein; brachiocephalic trunk; left subclavian vein; right common carotid.

**Identify 3:** left common carotid; right subclavian artery; left brachiocephalic vein; ascending aorta; right phrenic nerve; azygos vein; left phrenic nerve; superior vena cava; right brachiocephalic vein; brachiocephalic trunk; left subclavian vein; right common carotid.

**Identify 4:** left common carotid; right subclavian artery; left brachiocephalic vein; ascending aorta; right phrenic nerve; azygos vein; left phrenic nerve; superior vena cava; right brachiocephalic vein; **brachiocephalic trunk**; left subclavian vein; right common carotid.
**Identify 5:** left common carotid; right subclavian artery; left brachiocephalic vein; ascending aorta; right phrenic nerve; azygos vein; left phrenic nerve; superior vena cava; right brachiocephalic vein; **brachiocephalic trunk**; left subclavian vein; right common carotid.

**Identify 6:** left common carotid; right subclavian artery; left brachiocephalic vein; ascending aorta; right phrenic nerve; azygos vein; left phrenic nerve; superior vena cava; right brachiocephalic vein; brachiocephalic trunk; left subclavian vein; right common carotid.

**Identify 7:** left common carotid; right subclavian artery; left brachiocephalic vein; ascending aorta; right phrenic nerve; azygos vein; left phrenic nerve; superior vena cava; **right brachiocephalic vein**; brachiocephalic trunk; left subclavian vein; right common carotid.

**Identify 8:** left common carotid; right subclavian artery; left brachiocephalic vein; **ascending aorta**; right phrenic nerve; azygos vein; left phrenic nerve; superior vena cava; right brachiocephalic vein; brachiocephalic trunk; left subclavian vein; right common carotid.

**Identify 9:** left common carotid; right subclavian artery; left brachiocephalic vein; ascending aorta; right phrenic nerve; azygos vein; left phrenic nerve; **superior vena cava**; right brachiocephalic vein; brachiocephalic trunk; left subclavian vein; right common carotid.

**Identify 10:** left common carotid; right subclavian artery; left brachiocephalic vein; ascending aorta; **right phrenic nerve**; azygos vein; left phrenic nerve; superior vena cava; right brachiocephalic vein; brachiocephalic trunk; left subclavian vein; right common carotid.
Identify 11: left common carotid; right subclavian artery; left brachiocephalic vein; ascending aorta; right phrenic nerve; azygos vein; left phrenic nerve; superior vena cava; right brachiocephalic vein; brachiocephalic trunk; left subclavian vein; right common carotid.

Identify 12: left common carotid; right subclavian; left brachiocephalic vein; ascending aorta; right phrenic nerve; azygos vein; left phrenic nerve; superior vena cava; right brachiocephalic vein; brachiocephalic trunk; left subclavian vein; right common carotid.
**4.3.30 Thorax Practical 7: Quiz 3**

*Illustration 61: Image from Thorax Practical 7: Quiz 3*

**Identify 1:** Oesophageal plexus; greater splanchnic nerves; left vagus nerve; left recurrent laryngeal nerve; accessory hemiazygos vein; oesophagus; right vagus nerve.

**Identify 2:** Oesophageal plexus; greater splanchnic nerves; left vagus nerve; left recurrent laryngeal nerve; accessory hemiazygos vein; oesophagus; right vagus nerve.

**Identify 3:** Oesophageal plexus; greater splanchnic nerves; left vagus nerve; left recurrent laryngeal nerve; accessory hemiazygos vein; oesophagus; right vagus nerve.

**Identify 4:** Oesophageal plexus; greater splanchnic nerves; left vagus nerve; left recurrent laryngeal nerve; accessory hemiazygos vein; oesophagus; right vagus nerve.
**Identify 5:** Oesophageal plexus; greater splanchnic nerves; left vagus nerve; left recurrent laryngeal nerve; accessory hemiazygos vein; oesophagus; right vagus nerve.

**Identify 6:** Oesophageal plexus; greater splanchnic nerves; left vagus nerve; left recurrent laryngeal nerve; accessory hemiazygos vein; oesophagus; right vagus nerve.

**Identify 7:** Oesophageal plexus; greater splanchnic nerves; left vagus nerve; left recurrent laryngeal nerve; accessory hemiazygos vein; oesophagus; right vagus nerve
4.3.31 Thorax Practical 7: Quiz 4

Illustration 62: Images from Thorax Practical 7: Quiz 4

**Identify 1**: right main bronchus; carina; arch of aorta; descending aorta; accessory hemiazygos vein; left main bronchus, *trachea*.

**Identify 2**: right main bronchus; carina; arch of aorta; descending aorta; accessory hemiazygos vein; left main bronchus, *trachea*.

**Identify 3**: right main bronchus; carina; arch of aorta; descending aorta; accessory hemiazygos vein; *left main bronchus*, *trachea*.

**Identify 4**: right main bronchus; *carina*; arch of aorta; descending aorta; accessory hemiazygos vein; left main bronchus, *trachea*.

**Identify 5**: right main bronchus; carina; arch of aorta; descending aorta; accessory hemiazygos vein; left main bronchus, *trachea*.

**Identify 6**: right main bronchus; carina; arch of aorta; descending aorta; accessory hemiazygos vein; left main bronchus, *trachea*.

**Identify 7**: right main bronchus; carina; arch of aorta; *descending aorta*; accessory hemiazygos vein; left main bronchus, *trachea*.
4.3.32 Thorax Practical 7: Quiz 5

Illustration 63: Images from Thorax Practical 7: Quiz 5

**Identify 1:** left brachiocephalic vein; superior vena cava; trachea; left main bronchus; carina; right main bronchus; azygos vein; left subclavian; right brachiocephalic

**Identify 2:** left brachiocephalic vein; superior vena cava; trachea; left main bronchus; carina; right main bronchus; azygos vein; left subclavian; right brachiocephalic

**Identify 3:** left brachiocephalic vein; superior vena cava; trachea; left main bronchus; carina; right main bronchus; azygos vein; left subclavian; right brachiocephalic

**Identify 4:** left brachiocephalic vein; superior vena cava; trachea; left main bronchus; carina; right main bronchus; azygos vein; left subclavian; right brachiocephalic

**Identify 5:** left brachiocephalic vein; superior vena cava; trachea; left main bronchus; carina; right main bronchus; azygos vein; left subclavian; right brachiocephalic
**Identify 6:** left brachiocephalic vein; superior vena cava; trachea; left main bronchus; carina; right main bronchus; azygos vein; left subclavian; right brachiocephalic

**Identify 7:** left brachiocephalic vein; superior vena cava; trachea; left main bronchus; carina; right main bronchus; azygos vein; left subclavian; right brachiocephalic

**Identify 8:** left brachiocephalic vein; superior vena cava; trachea; left main bronchus; carina; right main bronchus; azygos vein; left subclavian; right brachiocephalic

**Identify 9:** left brachiocephalic vein; superior vena cava; trachea; left main bronchus; carina; right main bronchus; azygos vein; left subclavian; right brachiocephalic
4.3.33 Thorax Practical 7: Quiz 6

Illustration 64: Images from Thorax Practical 7: Quiz 6

**Identify 1:** ascending aorta; left recurrent laryngeal; right common carotid, brachiocephalic vein, left common carotid; arch of the aorta, left vagus nerve; right vagus nerve

**Identify 2:** ascending aorta; left recurrent laryngeal; right common carotid, brachiocephalic vein, left common carotid; arch of the aorta, left vagus nerve; right vagus nerve
Identify 3: ascending aorta; left recurrent laryngeal; right common carotid, brachiocephalic vein, left common carotid; arch of the aorta, left vagus nerve; right vagus nerve

Identify 4: ascending aorta; left recurrent laryngeal; right common carotid, brachiocephalic vein, left common carotid; arch of the aorta, left vagus nerve; right vagus nerve

Identify 5: ascending aorta; left recurrent laryngeal; right common carotid, brachiocephalic vein, left common carotid; arch of the aorta, left vagus nerve; right vagus nerve

Identify 6: ascending aorta; left recurrent laryngeal; right common carotid, brachiocephalic vein, left common carotid; arch of the aorta, left vagus nerve; right vagus nerve

Identify 7: ascending aorta; left recurrent laryngeal; right common carotid, brachiocephalic vein, left common carotid; arch of the aorta, left vagus nerve; right vagus nerve

Identify 8: ascending aorta; left recurrent laryngeal; right common carotid, brachiocephalic vein, left common carotid; arch of the aorta, left vagus nerve; right vagus nerve
**4.3.34 Thorax Practical 7: Quiz 7**

*Illustration 65: Images from Thorax Practical 7: Quiz 7*

**Identify 1:** left phrenic nerve; oesophagus; thoracic duct; azygos vein; greater splanchnic nerve; descending aorta; oesophageal plexus; right vagus nerve; left vagus nerve

**Identify 2:** left phrenic nerve; oesophagus; thoracic duct; azygos vein; greater splanchnic nerve; descending aorta; oesophageal plexus; right vagus nerve; left vagus nerve
Identify 3: left phrenic nerve; oesophagus; thoracic duct; azygos vein; greater splanchnic nerve; descending aorta; oesophageal plexus; right vagus nerve; left vagus nerve

Identify 4: left phrenic nerve; oesophagus; thoracic duct; azygos vein; greater splanchnic nerve; descending aorta; oesophageal plexus; right vagus nerve; left vagus nerve

Identify 5: left phrenic nerve; oesophagus; thoracic duct; azygos vein; greater splanchnic nerve; descending aorta; oesophageal plexus; right vagus nerve; left vagus nerve

Identify 6: left phrenic nerve; oesophagus; thoracic duct; azygos vein; greater splanchnic nerve; descending aorta; oesophageal plexus; right vagus nerve; left vagus nerve

Identify 7: left phrenic nerve; oesophagus; thoracic duct; azygos vein; greater splanchnic nerve; descending aorta; oesophageal plexus; right vagus nerve; left vagus nerve

Identify 8: left phrenic nerve; oesophagus; thoracic duct; azygos vein; greater splanchnic nerve; descending aorta; oesophageal plexus; right vagus nerve; left vagus nerve

Identify 9: left phrenic nerve; oesophagus; thoracic duct; azygos vein; greater splanchnic nerve; descending aorta; oesophageal plexus; right vagus nerve; left vagus nerve
Chapter 5: Discussion

An undergraduate project by Jamil Ahmad and Matthew Inwood developed an interactive, multimedia anatomy dissection guide (Inwood and Ahmad, 2005). In practice, however, the result was not ideal due to technical lighting, filming, audio and compression issues.

A close relationship between the Department of Anatomy at the RCSI and the Department of Electronic and Electrical Engineers of Trinity College Dublin had arisen and offered an opportunity to combine professional dissection with expert film processing. However, a professional studio with lighting and camera crew were not available.

The result was, with experimentation, jury rigged semi-professional equipment used by non professionals. Much was learned, but this involved significant time delays and constraints on the work that was done with the result that only the Thorax was completed. The Thorax Dissection Guide was used as an on-line support to undergraduate anatomy teaching in RCSI Dublin and Bahrain for two years, and is still in use as part of the DVD made available to the trainees of the College of Surgeons of East, Central and Southern Africa (COSECSA), consisting of nine countries in all: Ethiopia, Uganda, Rwanda, Tanzania, Kenya, Mozambique, Malawi, Zambia and Zimbabwe. Its contribution has never been formally quantified, but staff and students have reported that it greatly enhanced anatomy teaching and specifically aided in correct recognition of structures at practical examinations.
As the intermediate step in this three stage process, this project identified a number of pitfalls:

1. Understanding the technology

   From the anatomical perspective the auto-editing via content analysis, was not truly understood. We had assumed that once the software had been adapted to be able to track the pointer, the highlighting would be achieved. We did not comprehend that the process of cartoonisation would require further development. A simpler method would have been to use the audio to quickly edit the footage to the relevant sections and then use the simpler annotation software to highlight the structures required.

2. Duration

   The videos are too long. We had intended for the student to see the relevant anatomy in a clear and concise manner, but not something that was slow to get to the point. There were unnecessary pauses and excessively long views of dissection. The intention was to show that this was achievable by the student undertaking the dissection class, however, the on-screen result was that the videos were possibly twice as long and created larger files than needed.

3. Pathological specimen

   Unfortunately the heart of the cadaver that was used was pathological due to hypertrophy and so was not a good teaching aid for normal anatomy.

4. Image degradation

   The uploaded diagrams were fuzzy and more processing time would have rendered them crisper, or digital versions could have been obtained from the publisher.
What is apparent is that this was part of an evolutionary project. Building on the previous attempts (Ahmad and Inwood, 2005), the technical issues were identified and solutions experimented and finalised (Kheradmand, 2008) and the heart was later revisited (Morris, 2010). What was achieved was a format and method that could be expanded upon. As the delays caused by the encountered technical issues were apparent, an appropriate scaling back on the aims to complete the thorax alone was decided upon. From this perspective the aims have been achieved. The DVD format was abandoned when the adoption of the new RCSI virtual learning environment ‘Moodle’ made it possible to have these data accessible online.

When this project was commenced the plan was to have a DVD product, it skipped USB format and went to an online format on the RCSI in-house intranet student education portal Moodle. With the commonality of smart phones and tablets on the market it is conceivable that the quiz could be produced in an application format. Information technology and electronic education is now commonplace. Students and the young in general are growing up in an online world, they will expect to be educated in some fashion in online and electronic fashion. Anatomy, medicine and education in general are adapting to this reality and the Thorax Dissection Guide is a link in this evolutionary process. This thesis and accompanying DVD restcres this missing link.
Chapter 6: Conclusion

This project evolved over time and so did the aims. Temporal factors limited the achievements. So the aims and objectives were either achieved or achieved in part and were, in some cases, taken to the next evolutionary step.

1. Dissection Instructions were created for the Thorax.

2. Relevant and appropriate images were chosen and assigned the relevant and appropriate images from Cunningham's Manual of Practical Anatomy for the practical classes of the Thorax.

3. Cadaveric dissection was performed and Thorax filmed.

4. Each filmed practical was edited with computer-assisted content analysis to provide a concise short video of 5-10 minutes duration.

5. The important anatomical structures were identified and labeled.

6. A quiz was created for the medical students to self-test.

7. The quiz was interactive to allow for the students to score their performance.

8. To provide all of the above on a DVD, this was later uploaded on Moodle.
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