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A core syllabus in anatomy for medical students - Adding common sense to need to know

The Education Committee of the Anatomical Society of Great Britain and Ireland

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Summary

A satisfactory knowledge of topographical anatomy is one of the key foundations of safe and effective medical practice. Existing curriculum guidelines in the UK and Ireland from bodies including the General Medical Council, the Medical Council of Ireland and Scottish Doctors do not provide detailed guidance on curriculum content in respect of individual subjects. This paper describes a core syllabus in anatomy developed by the Anatomical Society of Great Britain and Ireland detailing the level of knowledge that we believe should be the minimum expected of a recently-qualified medical graduate in the UK and Ireland about to embark upon their two year Foundation training.

Key words: Medical education – Anatomy – Curriculum

Introduction

Anatomical knowledge remains one of the cornerstones of modern medical practice and for healthcare and allied professions including, dentistry and dental care professions, physiotherapy, radiography and human communication sciences. Knowledge of topographical anatomy is essential for those performing clinical examinations, is crucial for developing working diagnoses and is also required for carrying out many clinical procedures safely and effectively (Fig. 3). The advent of sophisticated imaging techniques has only served to

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increase the importance of anatomical knowledge (Fig. 2). This is because many of these techniques require a thorough understanding of structure for a full interpretation and exploitation of the information they contain (Fig. 1). Consequently, anatomy is now of increasing importance for a wider range of clinical practice than previously and therefore is still a key subject in professional medical, dental and healthcare education.

It has been argued that in the past students were overloaded with facts, but were not adequately prepared for effective communication with patients. This has been addressed in many Medical Schools by the introduction of problem-based, self-directed and patient-centered learning which at the same time shifts learning away from factual recall towards a broader range of activities including clinical skills. However, common sense dictates that there must be a necessary minimum of factual knowledge in basic medical disciplines to allow a medical practitioner to examine their patients effectively and to undertake simple procedures safely. It follows that this core knowledge should be the same, whatever teaching approaches are adopted within a curriculum.

Figure 1. Transverse section of the thorax of an embalmed cadaver at vertebral level T4. The section is viewed in the same way as CT scans are viewed i.e. from below.

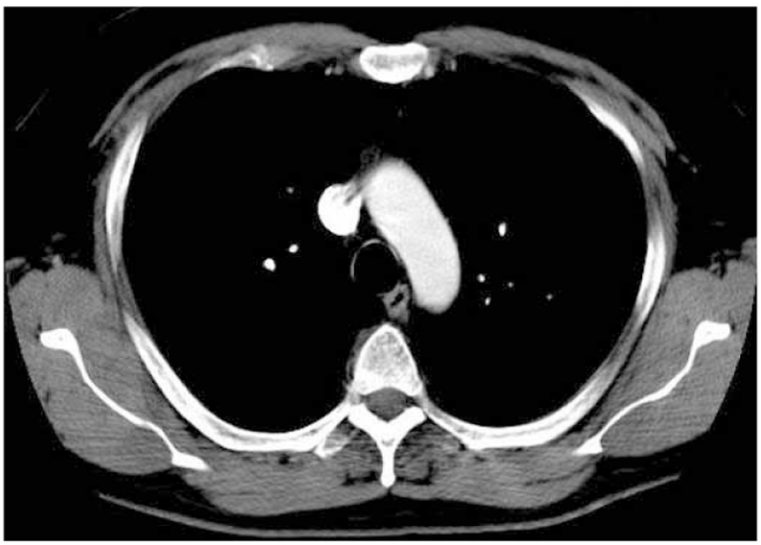

Figure 2. CT Scan of the thorax at vertebral level T4.

Figure 3. Teaching surface anatomy and clinical skills at the Bute Medical School, St Andrews.

Increased emphasis on preventative medicine has meant that, for example, public health, epidemiology, care in the community and communication skills have assumed more importance in medical practice. Emerging disciplines such as genetics and molecular biology also command a place in curricula. Consequently, medical curricula have been redesigned to accommodate these subjects. At the same time concerns have been widely-expressed that medical curricula are over-burdened with content with one consequence of this over-loading being that it limits the scope for creative and enquiry-based activities. Medical undergraduate courses have not changed substantially in length in the last century. Therefore, as the content of the curriculum has grown by addition of new topics without a compensatory change in the overall length of the course, changes have had to be made elsewhere. In many cases this has been achieved by reductions in number of hours available for basic sciences in general, and anatomy in particular, leading to reduction in anatomical content of curricula. Anatomy is often particularly targeted for reduction because it has been frequently depicted as the mere rote learning of excessive detail and it cannot be denied that in the past too little thought has been given to which facts were required for safe and effective practice. Anatomy is therefore an attractive target for those who depict older medical curricula as being over-burdened with an undue emphasis placed upon learning content. Morley (2003) has described this older approach to designing professional curricula as imparting knowledge to students 'just in case' it might be needed even though much of it is unlikely to be deployed by them in their future careers.

It could be argued that the reduction in the anatomy taught during undergraduate training and the Foundation years may not matter if the teaching of additional anatomy is deferred to a later stage of training and only for those who require the extra necessary detail. However, concerns continue to be articulated about the consequences that reductions in anatomy in the initial phases of training are having upon understanding of the subject. The first concern is pedagogic. Anatomy is a sequential subject in which basic knowledge acquired early is subsequently elaborated upon. Consequently, without the secure foundation that is derived from gaining a three dimensional understanding of the general functional organisation of the body, it can be difficult, even in a spiral curriculum where knowledge is revisited during the course, to appreciate the whole. Furthermore, the fragmentation of basic science, including anatomy, that can accompany the adoption of an enquiry-based curriculum may hinder a full understanding of the subject (Weatherall, 2000, 2006). The second concern derives from those engaged in postgraduate education, who perceive that the anatomical knowledge of those entering postgraduate training has been substantially reduced. This means that trainees do not have a sufficient foundation on which to develop to the standard expected at postgraduate level. Thirdly, there are a number of reports documented in the literature of increases in medical errors arising from inadequate knowledge of anatomy (Ellis, 2002; Goodwin, 2000; Monkhouse and Farrell, 2002). These errors are frequently made at junior level and are associated with significant morbidity and mortality leading to a rise in litigation. Finally, students themselves are often acutely aware of problems with their own anatomical knowledge. Prince et al. (2003, 2005) reported that in a sample of students from the Netherlands, the students' confidence in their own levels of anatomical knowledge varied significantly and this could be related to the amount of anatomy teaching they had received.

In its document "Tomorrow's Doctors" (1993) revised in 2002, the General Medical Council (GMC) set out the principles upon which medical curricula are designed and against which they are accredited. The recommendations in their document set out a framework for course design to achieve the required objectives and are, "by design less precise in their detail than some of their predecessors". These documents from the GMC are outcomes- and competency-based and one of the key recommendations is that the "burden of factual information in undergraduate medical curricula be substantially reduced". Some time after the publication of these GMC documents, the Quality Assurance Agency for Higher Education in the UK whose function is to assure the quality of Higher Education within the whole of the UK also set out a series of benchmarks for medical education. The difficulty with both these approaches is that they lay out syllabus content in all sub-

jects including anatomy, only in the most general of terms, with insufficient detail for curriculum planning. At the same time there has been "a more general trend to view professional knowledge as unstable, more disposable, transferable and delivered just in time" moving away from the view that "professional knowledge was something acquired early in a career for later deployment" (Morley, 2003). The consequence of these pressures has been to reduce the time devoted to many subjects in the curriculum without adequate consideration being given to the effects this might have on the understanding of the subject of anatomy as a whole.

Whilst recognising that it may be hard to obtain universal agreement on the details of the core knowledge required, we here attempt to establish a necessary minimum of anatomical knowledge for all future newly-qualified medical practitioners. All doctors (and medical students at the stage appropriate to the course they are following) should have the expertise outlined below. In our view it would be inappropriate to allow someone without such knowledge and understanding to work independently with patients. There have been a number of recent reviews describing the increase in litigation in surgical practice resulting from a lack of appropriate anatomical knowledge (Ellis, 2002; Goodwin, 2000; Monkhouse and Farrell, 2002). In addition it has often been observed in litigation cases that problems can arise consequent upon a practitioner's failure to explain to patients the full risks of a procedure because of their own lack of understanding and appreciation of the possible complications. This has led to litigation on the basis of a failure to obtain properly informed (Kahan et al, 2001; Kidder, 2002; Lynn-McCrae et al., 2004). Clearly, effective communication requires not only communication skills, but also the possession of the appropriate knowledge and understanding to inform that communication.

There have been a number of previous attempts to define a core syllabus in anatomy in the USA and Europe (Educational Affairs Committee, American Association of Anatomists, 1996; Griffioen et al., 1999; Kilroy and Driscoll, 2006). However, the syllabi defined by these documents are highly detailed either because they are aimed at a different level or targeted upon a more specialised audience for a more particular purpose. In our view, it is not realistic or necessary to expect that such syllabi, valuable as they are, could ever be adopted into an undergraduate medical curriculum in their present format. Therefore, the Anatomical Society of Great Britain and Ireland through its Education Committee, has initiated this project to design an anatomical syllabus defining the minimum knowledge outcome expected in topographical anatomy, (excluding histology or embryology), in a graduating medical student in the UK and Ireland.

The Royal College of Surgeons of England organised a meeting, in March 2007, to discuss the effects that reductions in anatomy teaching within the undergraduate curriculum were having upon the medical profession. One of the key consensus points to arise from that meeting was the need to define a core undergraduate syllabus in anatomy for all doctors. It is timely, therefore, that this project has reached its completion shortly after that meeting and we offer this document as a contribution to that debate.

Methodology

This syllabus was drafted by the authors, the majority of whom are members of the Education Committee of Anatomical Society of Great Britain and Ireland. The authors are practising teachers of anatomy with experience of a wide range of curricula, involved in curriculum design in their own institutions and with extensive cumulative experience of other curricula through external examining. The Education Committee of ASGBI includes members of the British Association of Clinical Anatomists.

An initial version of this document was posted on the Anatomical Society's website for comment and we thank all those who responded. The present document has been circulated for consultation and comment amongst the members of the Anatomical Society of Great Britain and Ireland. An earlier version of the document was approved at a meeting of the Council of the Society in 2006.

The document is laid out in broad regional terms. It starts with a broad general statement which includes surface anatomy, the interpretation of standard clinical images, and the

importance of the knowledge for understanding of common pathologies. This is followed by a more detailed specification of the topographical knowledge required to meet these general aims.

After qualification, most doctors will experience anatomy either as surface anatomy (Fig. 3) or clinical images (Figs. 1 and 2), though advances in computing mean that, increasingly, the latter can be rendered as 3-D reconstructions. By the use of the term 'standard clinical images' in the subsequent text we imply the following: standard P-A and lateral radiographs of all parts of the body with special views of clinically critical areas (e.g. open-mouth view of odontoid process); contrast radiographs of the vascular, alimentary, pancreato-biliary, urinary and female reproductive systems; axial CT and MRI series through the head and trunk, midline sagittal images of the head, spine and pelvis, and coronal and sagittal views of shoulder, hip, knee and ankle; nuclear images of the skeleton and thyroid; ultrasound images of pregnancies, kidney, gall bladder, liver, and heart; and endoscopic views of the tracheo-bronchial tree, the alimentary tract, and the knee joint.

Summary of the core Syllabus

We present here a summary of the detailed syllabus that follows to provide curriculum planners with a more concise form of words than the full syllabus allows.

Language

In order to communicate effectively with colleagues, graduates must understand and use accepted anatomical language to describe the normal structure of the body.

Vertebral column

Medical graduates should be able to recognise characteristic features of vertebrae from the five regions of the vertebral column, understand how the spine as a whole moves and how its normal curvatures develop and are stabilised. They should be able to interpret relevant clinical images to distinguish deviations from normal. They should understand the organisation of the contents of the vertebral canal i.e. the meninges, spinal cord, spinal nerve roots, spinal nerves and their particular relationships to the vertebrae and the intervertebral joints. This knowledge forms the basis for the understanding of common spinal pathologies e.g. back pain, prolapse of an intervertebral disc, injuries to the spinal cord, nerve, and whiplash injuries and their consequences for the remainder of the body. It is also necessary for the safe performance of procedures such as lumbar puncture, regional and epidural anaesthesia. Medical graduates should have sufficient knowledge of surface features and muscle groups to perform an examination of the back. They should have a working knowledge of dermatomes and peripheral nerve distribution, the functions of major muscle groups and their innervation in order to perform a basic neurological examination of the limbs and trunk.

Upper limb

Medical graduates should be able to recognise the major palpable and imaging features of the bones of the upper limb, be aware of the sites of common fractures (clavicle, humerus, distal radius and scaphoid) and the complications that might result from them. They should be aware of the factors that influence the stability of the shoulder, elbow, wrist and interphalangeal joints and understand the nature and consequences of common injuries (e.g. shoulder, elbow and finger dislocation).

In order to perform clinical procedures safely and effectively, graduates should be able to demonstrate the course, key relations and distribution of the main neurovascular structures of the upper limb, be able to demonstrate major pulse points (e.g. subclavian, brachial and radial), the position of major veins (for venous access) and know the common sites of peripheral nerve injury and their likely functional effects (brachial plexus lesions, axillary, radial, ulnar and median nerve lesions). They should be able to explain the anatomical basis of common conditions of the upper limb (e.g. rotator cuff injuries, carpal tunnel syndrome) and how infection might spread in the limb. They should be able to describe the organisation of the axillary lymph nodes and the lymphatic drainage of the breast and explain their significance in relation to metastatic spread of breast cancer and melanoma.

Thorax

Medical graduates should be able to demonstrate the major palpable and radiological features of the thoracic wall, and describe the anatomy of the intercostal spaces, the diaphragm and the functional anatomy of ventilation. They should know the extent of the

pleural cavities and the anatomy of the lungs (including their lymphatic drainage and its role in the metastatic spread of lung cancer), the main divisions of the mediastinum and their contents and the anatomy of the heart and great vessels of the thorax, including their surface projections. They should be aware of the anatomical basis of common congenital cardiac abnormalities, heart murmurs and their effects. They should understand the function and arrangement of the coronary arteries and the position and function of the heart valves. They should know the course of major structures passing between the neck and thorax and those which pass through the diaphragm between the thorax and the abdomen. This knowledge forms the basis of understanding pneumothorax, lung and pleural disease, coronary artery and valve surgery and in referred pain from the distribution of the phrenic and intercostal nerves. They should have a working knowledge of surface anatomy of the thorax, be able to undertake an examination of the heart and lungs and interpret standard diagnostic images. They should be aware of the possible complications when inserting central venous lines and where to place a chest drain for simple and tension pneuomothorax and for cardiac tamponade.

Abdomen

Medical graduates should be familiar with the anatomy of the anterior and posterior abdominal walls and the inguinal region, the extent of the peritoneal cavity and the anatomy and key relationships of the oesophagus, stomach, small and large intestines including the appendix, liver, gall bladder, pancreas, spleen, kidneys, ureters and adrenal and suprarenal glands. They should understand the arterial supply and venous drainage to the intestine in relation to arterial occlusion, strangulation, intestinal surgery, the portal circulation and the effects of portal hypertension, and the lymphatic drainage and innervation of the abdominal organs in relation to metastatic spread of cancer and abdominal pain. This knowledge forms the basis of understanding of surgical incisions, referred pain from the abdominal viscera (especially the gall bladder and appendix) and how the sub-hepatic and sub-phrenic spaces may be implicated in the spread of infection. They should have a working knowledge of surface anatomy and be able to undertake an examination of the abdomen and of the inguinal canal for hernias. They should be able to interpret standard diagnostic images of the alimentary, pancreato-biliary and urinary tracts.

Pelvis

Medical graduates should be familiar with the anatomy and positions of the ureters, bladder, urethra, rectum and anal canal, the structure of the pelvic floor, and the anatomy of continence, the anatomy of the external and internal genitalia in males (scrotum, testis, vas deferens, seminal vesicles, prostate, penis) and females (ovaries, uterine tubes, uterus, cervix, vagina, labia, clitoris). They should be able to describe the peritoneal relationships, and supports of the pelvic viscera to understand ectopic pregnancy, prolapse and suprapubic catheterisation. They should understand the arterial supply, venous drainage and the lymphatic drainage and innervation of the pelvic organs in relation to metastatic spread of cancer. Graduates should be able to interpret relevant standard diagnostic images and have sufficient anatomical knowledge to be able to perform rectal and vaginal examinations, urinary catheterisation in both males and females, and obtain a cervical smear in females.

Lower limb

Medical graduates should be able to recognise the major palpable and imaging features of the bones of the lower limb, be aware of the sites of common fractures (neck and shaft of femur, tibia and fibula) and the complications that might result from them. They should be able to explain the factors that influence the stability of the hip, knee and ankle joints, the common ligamentous injuries and be able to test for ligament integrity. In order to perform clinical procedures safely and effectively, graduates should be able to describe the course and distribution of the main neurovascular structures in the lower limb (e.g. to avoid damage to the sciatic nerve when making an intramuscular injection,), be able to demonstrate major pulse points (e.g. femoral, for arterial blood sampling, popliteal, posterior tibial and dorsalis pedis), the position of major veins (for venepuncture, venous access by 'cut down' and assessment of varicose veins) and the common sites of peripheral nerve injury and the possible functional effects of such damage (e.g. sciatic and common peroneal nerve at neck of fibula). They should have a working knowledge of surface anatomy, dermatomes and peripheral nerve distribution, the functions of major muscle

groups and their innervation in order to perform a basic neurological examination of the lower limb. Graduates should understand the organisation of inguinal lymph nodes and how they relate to the lymphatic drainage of the limb, trunk skin and perineum. They should be aware of the organisation of the deep fascia of the lower limb and its relevance to compartment syndromes, how blood is returned to the heart from the legs and how failure of this mechanism may cause the development of varicosities, deep vein thromboses and embolism.

Head and Neck

Medical graduates should be able to recognise the major palpable and imaging features of the skull and cervical spine in order to be able to interpret relevant medical images. To perform clinical examination of the head and neck graduates should be familiar with the position, key relationships, neurovascular supply, venous and lymphatic drainage of the following major structures: course and distribution of the cranial nerves, ear and pharyngotympanic (Eustachian) tube, eye, eyelids and conjunctivae, nasal cavity and paranasal air sinuses, oral cavity and tongue, tonsils, soft palate, pharynx, salivary glands, larynx and trachea, thyroid and parathyroid glands and the contents of the carotid sheath. Medical graduates should be able to describe the fascia and fascial spaces of the neck in relation to the spread of infection. This knowledge is necessary for understanding conductive and sensorineural deafness, otalgia and the likely sources of referred pain to the ear, facial nerve palsy, epistaxis, quinsy, dysphagia, upper airway obstruction, infantile stridor, sinusitis, vocal cord paralysis and hoarseness, cervical swellings, and salivary gland swellings. Medical graduates should have sufficient anatomical knowledge to be able to manage the airway, insert an endotracheal or nasogastric tube, and perform a tracheostomy and laryngotomy. They should have a working knowledge of surface anatomy, cranial nerve distribution, the functions of major muscles of the head and neck and their innervation in order to perform a basic neurological examination.

Neuroanatomy

Medical graduates should understand the blood supply and venous drainage of the brain and spinal cord, the arrangement of the meninges, the pattern of the major dural venous sinuses, subarachnoid space, ventricular system and the production, circulation and drainage of cerebrospinal fluid. They should understand the position, organisation, connections, vascular supply, venous drainage and key relations of the main parts of the brain and spinal cord including the cerebral cortex, internal capsule, cerebellum, basal ganglia, thalamus, hypothalamus and brainstem. They should be aware of the key relations and components of the white matter, including the main motor and sensory pathways of the brain and spinal cord. This knowledge is necessary for interpretation of standard diagnostic images, an understanding of stroke and recognition of the signs and symptoms of common neurological disorders and intracranial haemorrhages.

For all structures, the emphasis should be on those that are commonly damaged or involved in interventional procedures. For the musculoskeletal system, the emphasis should be on the principal palpable and radiological features of the bones, commonly damaged ligaments, functional muscle groups (avoiding unnecessary details of their attachments) and their innervation by segmental spinal nerves. For the cardiovascular system there should be a good knowledge of the heart and emphasis on pulse points and commonly damaged sites on arteries, access points on veins, and a sound understanding of the lymphatic drainage of tissues. For the peripheral nervous system the emphasis should be on supplies to areas of skin and muscle groups by both segmental spinal nerves and peripheral nerves.

<u>Anatomical Terms</u>

A medical graduate should be able to:

1. Define and demonstrate the following terms relative to the anatomical position: medial, lateral, proximal, distal, superior, inferior, deep, superficial, palmar, plantar, anterior/ventral, posterior/dorsal, rostral, caudal.
2. Describe the following anatomical planes: axial / transverse / horizontal, sagittal and coronal.
3. Define and demonstrate the terms used to describe the movements of the limbs and vertebral column: flexion, extension, lateral flexion, pronation, supination, abduction, adduction, medial and lateral rotation, inversion, eversion, plantarflexion, dorsiflexion, protraction, retraction and circumduction.

4. Define the terms somatic and visceral when used to describe parts and systems (e.g. somatic and visceral motor systems) of the body.

Vertebral Column

A medical graduate should be able to:

1. Describe the main anatomical features of a typical vertebra. Identify the atlas, axis, typical cervical, thoracic, lumbar vertebrae and sacrum and recognise their characteristic features.
2. Describe the structures, regions and functions of the vertebral column. Describe the range of movement of the entire vertebral column and its individual regions. Explain what makes spinal injuries stable and unstable.
3. Describe the anatomy of intervertebral facet joints and intervertebral discs. Explain the role of the discs in weight-bearing by the vertebral column and give examples of common disc lesions, and how they may impinge upon spinal nerve roots and / or the spinal cord.
4. Describe the anatomy of a spinal nerve (e.g. as exemplified by a thoracic spinal nerve, including its origin from dorsal and ventral spinal roots, its main motor and cutaneous branches and any autonomic component.
5. Identify the principal muscle groups and ligaments of the vertebral column and surface features in order to be able to perform an examination of the back, discuss their functional role in stability and movement of the vertebral column and describe the anatomical basis of back pain.
6. Describe the anatomical relationships of the meninges to the spinal cord and dorsal and ventral nerve roots, particularly in relation to root compression and the placement of epidural and spinal injections. Describe the anatomy of lumbar puncture.
7. Interpret standard diagnostic images of the vertebral column and be able to recognise common abnormalities.

Upper Limb

A medical graduate should be able to:

1. Describe and demonstrate the main anatomical landmarks of the clavicle, scapula, humerus, radius and ulna. Recognise the bones of the wrist and hand and their relative positions, identify those bones that are commonly damaged (scaphoid and lunate) and predict functional impairment following such damage.
2. Describe the close relations of the bones and joints (e.g. bursae, blood vessels, nerves ligaments and tendons), which may be injured by fractures or dislocation and predict what the functional effects of such damage might be.
3. Describe the fascial compartments delimiting the major muscle groups of the upper limb. Explain the functional importance of those compartments and their contents.
4. Describe the origin, course and distribution of the major arteries and their branches that supply the shoulder, arm and forearm in relation to common sites of injury. Explain the importance of anastomoses between branches of these arteries at the shoulder and in the upper limb.
5. Demonstrate the sites at which pulses in the brachial, radial and ulnar arteries may be located.
6. Describe the courses of the main veins of the upper limb; classify and contrast the functions of the deep and superficial veins. Identify the common sites of venous access and describe their key anatomical relations. Explain the relationship between venous and lymphatic drainage channels.
7. Describe the organisation of the brachial plexus, its origin in the neck and continuation to the axilla and upper limb.
8. Describe the origin, course and function of the axillary, radial, musculocutaneous, median and ulnar nerves in the arm, forearm, wrist and hand. Name the main muscles and muscle groups that these nerves supply as well as their sensory distribution. Predict the consequences of injury to these nerves and describe how to test their functional integrity.
9. Describe the boundaries of the axilla. List its contents, including the major vessels, parts of the brachial plexus and lymph node groups.
10. Describe the movements of the pectoral girdle; identify the muscles responsible for its movements and summarise their main attachments and somatic motor nerve supply.
11. Describe the factors that contribute to the stability of the shoulder joint and explain

the functional and possible pathological consequences of its dislocation.

12. Describe the anatomy of the elbow joint. Demonstrate the movements of flexion and extension, identify the muscles responsible for these movements and summarise their main attachments and somatic motor nerve supply.
13. Describe the anatomy of the superior and inferior radio-ulnar joints. Explain the movements of supination and pronation; identify the muscles responsible for these movements and summarise their main attachments and somatic motor nerve supply.
14. Describe the anatomy of the wrist. Describe and demonstrate movements at these joints and name and identify the muscle groups responsible for the movements. Describe the relative positions of the tendons, vessels and nerves at the wrist in relation to injuries.
15. Name and demonstrate the movements of the fingers and thumb. Describe the position, function and nerve supply of the muscles and tendons involved in these movements, differentiating between those in the forearm and those intrinsic to the hand.
16. Explain the main types of grip (power, precision and hook) and the role of the muscles and nerves involved in executing them.
17. Describe the position and function of the retinacula of the wrist and the tendon sheaths of the wrist and hand. Explain carpal tunnel syndrome and the spread of infection in tendon sheaths.
18. Explain why and describe where the axillary, musculocutaneous, radial, median and ulnar nerves are commonly injured and be able to describe the functional consequences of these injuries.
19. Explain the loss of function resulting from injuries to the different parts of the brachial plexus.
20. Demonstrate how to test for motor and sensory nerve function. Describe the anatomical basis of: the assessment of cutaneous sensation in the dermatomes of the upper limb, tendon jerk testing of biceps and triceps and comparative strength tests.
21. Describe the anatomy of the axillary lymph nodes and explain their importance in the lymphatic drainage of the breast and the skin of the trunk and upper limb and in the spread of tumours.
22. Interpret standard diagnostic images of the upper limb and be able to recognise common abnormalities.

Thorax

A medical graduate should be able to:

1. Demonstrate the main anatomical landmarks of the thoracic vertebrae, ribs and sternum.
2. Describe the anatomy of the joints between the ribs and vertebral column, the ribs and costal cartilages and the costal cartilages and sternum. Explain the movements made at those joints during ventilation and the differences between ventilatory movements in the upper and lower chest.
3. Describe how the boundaries of the thoracic inlet and outlet are formed by the vertebrae, ribs, costal cartilages and sternum.
4. Describe the surface projection, attachments and relationships of the diaphragm and the structures that pass through it. Explain the movements it makes during ventilation and the motor and sensory nerve supply to it and its pleural and peritoneal coverings.
5. Explain the anatomy of the intercostal muscles. Describe a neurovascular bundle in a typical intercostal space and outline the structures its components supply.
6. Explain the movements involved in normal, vigorous and forced ventilation and describe the muscles responsible for these movements.
7. Demonstrate the surface markings of the heart and great vessels, the margins of the pleura and the lobes and fissures of the lungs.
8. Summarise the anatomy of the bronchial tree and bronchopulmonary segments; explain their functional significance in relation to inhalation injury.
9. Describe the blood and nerve supply and lymph drainage of the lungs. Describe the structures in the hilum and the mediastinal relations of each lung.
10. Describe the arrangement and contents of the superior, anterior, middle and posterior parts of the mediastinum.
11. Identify the major anatomical features of each chamber of the heart and explain their functional significance.

12. Describe the structure and position of the atrio-ventricular, pulmonary and aortic valves and describe their role in the prevention of reflux of blood.
13. Describe the origin, course and main branches of the left and right coronary arteries and discuss the functional consequences of their obstruction.
14. Understand the anatomical course of the spread of excitation through the chambers of the heart and describe the placement of ECG electrodes for its clinical assessment.
15. Demonstrate the arrangement of the fibrous and serous layers of the pericardium in relation to cardiac tamponade.
16. Describe the course of the ascending aorta, the arch of the aorta and the descending thoracic aorta. Name their major branches and the structures they supply.
17. Describe the origins, course and relationships of the brachiocephalic veins, inferior and superior venae cavae and the azygos venous system.
18. Describe the origin, course and distribution of the vagus nerve and its branches and the phrenic nerves on both the right and left sides of the thorax. Explain the mechanism of referred pain and where pain is referred from thoracic organs.
19. Describe the composition and function of the sympathetic chains and splanchnic nerves. Describe their composition and function.
20. Describe the course and major relations of the oesophagus within the thorax.
21. Describe the course and major relations of the thoracic duct and the other lymph systems within the thorax, and explain their medical significance.
22. Demonstrate the surface markings of the heart and the position and site of auscultation of the four major valves
23. Demonstrate the surface projections of the margins of the pleura and the lobes and fissures of the lungs.
24. Identify major thoracic structures on standard diagnostic images and be able to recognise common abnormalities.

Abdomen

A medical graduate should be able to:

1. Demonstrate the bony and cartilaginous landmarks visible or palpable on abdominal examination.
2. Demonstrate the descriptive regions of the abdomen and common incision sites. Demonstrate the surface projections of the abdominal organs.
3. Describe the anatomy, innervation and functions of the muscles of the anterior and posterior abdominal walls. Discuss their functional relationship with the diaphragm and roles in posture, ventilation and voiding of abdominal / thoracic contents.
4. In relation to direct and indirect inguinal hernias, demonstrate the anatomy of the attachments of the inguinal ligament; the anatomy of the superficial and deep inguinal rings and how the anterior abdominal wall muscles form the inguinal canal. Describe the contents of the inguinal canal in both males and females.
5. Describe the relationship between the femoral canal and the inguinal ligament and the anatomy of femoral hernias.
6. Demonstrate the positions of the liver, pancreas, spleen, kidneys, stomach, duodenum, jejunum and ileum of the small intestine, caecum, appendix, ascending, transverse, descending and sigmoid parts of the colon and the rectum.
7. Describe the organisation of the parietal and visceral peritoneum; its lesser and greater sacs, mesenteries and peritoneal 'ligaments'. Explain the significance of the variable attachment of the ascending and descending colon to the posterior abdominal wall.
8. Summarise the functional anatomy of the small bowel mesentery; its structure, location and vascular, lymphatic and neural content.
9. Explain the nerve supply of the parietal and visceral peritoneum and the role of the visceral peritoneum in referred pain.
10. Describe the functional anatomy of the stomach, its position, parts, sphincters, blood and nerve supply and key relations to other abdominal organs.
11. Describe the duodenum, its parts, position, secondary retroperitoneal attachment, blood supply and key relations with other abdominal organs and their significance in relation to peptic ulcer disease.
12. Describe the regions of the small and large intestine, including the anatomy of the appendix. Describe the anatomical variations in the position of the appendix and

explain their significance in relation to appendicitis.

13. Describe the position and form of the pancreas and its relationships to other abdominal organs. Discuss the significance of these relationships in relation to pancreatitis and biliary stone disease.
14. Describe the position and form of the liver, the lobes of the liver and their key anatomical relations. Explain the peritoneal reflections of the liver and its movement during respiration. Summarise the functional anatomy of the portal vein, the portal venous system and portal-systemic anastomosis and their significance in portal hypertension.
15. Describe the position and form of the gall bladder and biliary tree; their relations in the abdomen and the significance of these relations in relation to gall bladder inflammation and biliary stones.
16. Describe the position and form of the kidneys and ureters. Demonstrate their relationships to other abdominal and pelvic structures and discuss the significance of these relations in relation to urinary stones.
17. Describe the relations of the suprarenal (adrenal) glands and their functional anatomy.
18. Describe the position (in relation to the ribs) and form of the spleen in relation to its palpation through the abdominal wall and its key anatomical relationships with other abdominal structures. Explain the significance of these relationships in relation to trauma, chronic infections and disorders of the haematopoetic system.
19. Describe the origins, course and major branches of the abdominal aorta, coeliac axis, superior and inferior mesenteric arteries and their major branches, the renal and gonadal arteries. Explain the significance of the blood supply from the abdominal aorta to the spinal cord in relation to abdominal aneurysm repair. Demonstrate the origins, course and major tributaries of the inferior vena cava.
20. Describe the anatomy of the lymph nodes involved in lymph drainage of abdominal viscera and its significance in relation to spread of malignancy.
21. Interpret standard diagnostic images of the abdomen and recognise common abnormalities.

Pelvis

A medical graduate should be able to:

1. Describe the skeletal and ligamentous components of the pelvis, the anatomy of the pelvic inlet and outlet and recognise their normal orientation. Explain sex differences in pelvic skeletal anatomy and how these change during development.
2. Demonstrate the palpable anatomical landmarks of the iliac, ischial and pubic bones in the living and on the bones and identify them on medical images.
3. Demonstrate the points of attachment of the muscles of the abdominal wall and those of levator ani.
4. Describe the functional importance of the pelvic floor musculature, its midline raphé and the structures passing through it in males and females.
5. Describe the anatomy of the bladder, its base and ureteric openings. Explain how its position changes with filling and pregnancy and its relationship to the overlying peritoneum.
6. Describe the anatomy of the urethra; explain the anatomy of its different part in males and females in relationship to continence and catheterisation.
7. Describe the innervation of the bladder and its sphincters and the mechanism of micturition
8. Describe the anatomy of the scrotum, testis, epididymis and their normal features on clinical examination. Explain the significance of their arterial supply in relation to torsion, their venous drainage in relation to varicocoele and their lymphatic drainage in relation to tumour spread.
9. Describe the structure and course of the spermatic cord and vas deferens.
10. Describe the anatomy of the prostate gland, seminal vesicles and their anatomical relations. Describe the normal form of the prostate when examined per rectum and changes in relation to hypertrophy and malignancy.
11. Describe the position and form of the ovary, uterine tubes, uterus, cervix and vagina and their anatomical relationships, including any peritoneal coverings. Describe the changes that occur in the uterus and cervix with pregnancy.
12. Describe the origin, course and relations of the uterine, ovarian and testicular arteries.

13. Describe the origin, course and branches of the pudendal nerves and the sites of nerve block during childbirth.
14. Describe the innervation and mechanisms involved in erection of cavernous tissue in male and female and emission and ejaculation in the male.
15. Describe the anatomy of the sigmoid colon and rectum and their anatomical relationships including peritoneal. Explain the anatomy of the anal canal, the functional anatomy of the anal sphincters and their role in faecal continence.
16. Describe the blood supply and venous drainage of the distal bowel; the supply from the superior rectal (inferior mesenteric), middle rectal (internal iliac) and inferior rectal arteries (from pudendal to anal canal only), and portal-systemic venous anastomosis. Describe the vascular anal cushions and explain their role in continence.
17. Describe the anatomy of the ischio-anal fossa and explain its potential involvement in abscesses, anal glands and fissures.
18. Describe the structure of the penis, scrotum and its contents, the clitoris and vulva. Describe the arterial supply to and venous drainage from the penis. Explain the anatomy of the perineal membrane and superficial perineal pouch in relation to the accumulation of fluids in the male.
19. Describe the lymphatic drainage of the pelvis
20. Interpret standard diagnostic images of the pelvis and be able to recognise common abnormalities.

Lower Limb

A medical graduate should be able to:

1. Recognise the major features and surface landmarks of the pelvis, femur, tibia, fibula, ankle and foot. Demonstrate their palpable and imaging landmarks. Appreciate which bones and joints are vulnerable to damage and what the consequences of such damage could be.
2. Describe the close relations of the bones and joints (e.g. bursae, blood vessels, nerves ligaments and tendons), which may be injured in fractures or dislocations and predict what the functional effects of such damage would be.
3. Describe the fascial compartments enclosing the major muscle groups and explain the functional importance of these compartments and their contents in relation to compartment syndromes.
4. Demonstrate the origin, course and branches of the major arteries that supply the hip, gluteal region, thigh, leg, ankle and foot. Explain the functional significance of anastomoses between branches of these arteries at the hip and knee.
5. Demonstrate the locations at which the femoral, popliteal, dorsalis pedis and posterior tibial pulses can be felt.
6. Demonstrate the course of the principal veins of the lower limb. Explain the role of the perforator vein connections between the superficial and deep veins and the function of the 'muscle pump' for venous return to the heart. Describe the sites of venous access that can be used for 'cut-down' procedures in emergencies.
7. Outline the origin of the lumbosacral plexus and the formation of its major branches.
8. Describe the origin, course and function of the sciatic, femoral, obturator, common peroneal and tibial nerves, sural and saphenous nerves and summarise the muscles and muscle groups that each supplies as well as their sensory distribution.
9. Describe the structure and movements of the hip joint. Summarise the muscles responsible for these movements, their innervation and main attachments.
10. Describe the structures responsible for stability of the hip joint and their relative contribution to maintaining the lower limb in different positions.
11 Describe the structures at risk from a fracture of the femoral neck or dislocation of the hip and explain the functional consequences of these injuries.
12. Describe the boundaries of the femoral triangle and the anatomical relationships of the femoral nerve, artery, vein and lymph nodes to each other and to the inguinal ligament, with particular regard to arterial blood sampling and catheter placement.
13. Describe the anatomy of the gluteal (buttock) region and the course of the sciatic nerve within it. Explain how to avoid damage to the sciatic nerve when giving intramuscular injections.
14. Describe the structure and movements of the knee joint. Summarise the muscles responsible for these movements, their innervation and main attachments.

15. Describe the close relations of the knee joint including major bursae and explain which structures may be injured by trauma (including fractures and dislocation) to the knee.
16. Identify the factors responsible for maintaining the stability of the knee joint. Describe the menisci, ligaments and the locking mechanism close to full extension. Explain the anatomical basis of tests which assess the integrity of the cruciate ligaments.
17. Describe the boundaries and contents of the popliteal fossa.
18. Describe the anatomy of the ankle joint. Explain the movements of flexion, extension, plantarflexion, dorsiflexion, inversion and eversion. Summarise the muscles responsible for these movements, their innervation and their main attachments.
19. Describe the factors responsible for stability of the ankle joint, especially the lateral ligaments, and explain the anatomical basis of "sprain" injuries.
20. Describe the arches of the foot and the bony, ligamentous and muscular factors that maintain them.
21. Describe the movements of inversion and eversion at the subtalar joint, the muscles responsible, their innervation and main attachments.
22. Describe the anatomical basis (nerve root or peripheral nerve) for loss of movements and reflexes at the knee and ankle resulting from spinal injuries, disc lesions and common peripheral nerve injuries. Describe the dermatomes of the lower limb and perineum used to assess spinal injuries
23. Describe the structures at risk to a fracture of the femoral neck or dislocation of the hip and describe the functional consequences of these conditions.
24. Describe the lymphatic drainage of the lower limb and its relationship to tumour spread.
25. Discuss the structures of the lower limb that may be used for autografts.
26. Interpret standard diagnostic images of the lower limb and be able to recognise common abnormalities.

Head and Neck

A medical graduate should be able to:

1. Demonstrate the position, palpable and imaging landmarks of the major bones of the skull, including the frontal, parietal, occipital, temporal, maxilla, zygoma, mandible, sphenoid, nasal and ethmoid bones. Demonstrate the palpable position of the hyoid bone, thyroid and cricoid cartilages, lateral mass of the atlas and the spine of C7. Demonstrate the major sutural joints and describe the fontanelles of the fetal skull.
2. Describe the boundaries, walls and floors of the cranial fossae.
3. Identify the external and internal features of the cranial foraminae and list the structures that each transmits.
4. Demonstrate the position of the anterior and posterior triangles of the neck defined by the sternum, clavicle, mandible, mastoid process, trapezius and sternocleidomastoid.
5. In the posterior triangle, demonstrate the position of the spinal accessory nerve, the roots and trunks of the brachial plexus, the external jugular vein and subclavian vessels in relation to penetrating neck trauma.
6. In the anterior triangle, demonstrate the position of the common, internal and external carotid arteries, the internal jugular vein and vagus nerve, the trachea, thyroid cartilage, larynx, thyroid and parathyroid glands. Explain their significance in relation to carotid insufficiency, central venous line insertion, emergency airway management and diagnosis of thyroid disease.
7. Describe the location and anatomical relations of the thyroid and parathyroid glands, their blood supply and the significance of the courses of the laryngeal nerves.
8. Demonstrate the origin, course and major branches of the common, internal and external carotid arteries and locate the carotid pulse.
9. Describe the courses of the accessory, vagus and phrenic nerves in the neck.
10. Identify the major structures passing between the neck and the thorax. Describe the courses and important relationships of the subclavian arteries and veins.
11. Describe the anatomy of the scalp, naming its individual layers. Describe the blood supply of the scalp and its significance in laceration injuries.
12. Demonstrate the extracranial course of the branches of the facial nerve. Summarise the muscles of facial expression supplied

by each branch and describe the consequences of injury to each branch.

13. Describe the intracranial and intrapetrous course of the facial nerve and the relationships of its major branches to the middle ear in relation to damage of the nerve within the facial canal.
14. Describe the anatomy of the temporomandibular joint. Explain the movements that occur during chewing and describe the muscles involved including their innervation. Explain what occurs in anterior joint dislocation and relocation.
15. Describe the origin, function and major branches of the sensory and motor components of the trigeminal nerve.
16. Describe the origins and summarise the courses and major branches of the facial and maxillary arteries, including the course and intracranial relations of the middle meningeal artery and its significance in extradural haemorrhage.
17. Describe the relationship of the termination of the facial vein (draining into the internal jugular vein) and the mandibular branch of the retromandibular vein (supplying facial muscles controlling the angle of the mouth) to the submandibular gland and related upper jugular lymph nodes in relation to exploration of this area.
18. Describe the key anatomical relations of the parotid, submandibular and sublingual salivary glands, the course of their ducts into the oral cavity and their autonomic secretomotor innervation. Appreciate the narrow points of the ducts in relation to salivary stone impaction.
19. Demonstrate the major features and boundaries of the oral cavity and summarise its sensory innervation.
20. Describe the functional anatomy of the tongue, including its motor and sensory innervation and the role of the extrinsic and intrinsic muscles. Explain the deviation of the tongue after hypoglossal nerve injuries.
21. Describe the anatomical arrangement and functional significance of the lymphoid tissue in the tonsils, pharyngeal, and posterior nasal walls.
22. Describe the muscles that compose the pharyngeal walls and move the soft palate; summarise their functions and nerve supply. Describe the components of the gag reflex.
23. Describe the hyoid bone and cartilages of the larynx. Explain how these structures are linked together by the thyrohyoid, cricothyroid, and quadrangular membranes.
24. Describe the intrinsic and extrinsic laryngeal muscles responsible for closing the laryngeal inlet, controlling vocal cord position and tension. Explain how these muscles function during phonation, laryngeal closure, the cough reflex and regulation of intrathoracic pressure.
25. Describe the origin, course and functions of the motor and sensory nerve supply of the larynx and the functional consequences of injury to them.
26. Describe the stages of swallowing and the functions of the muscles of the jaw, cheek, lips, tongue, soft palate, pharynx, larynx and oesophagus during swallowing.
27. Describe the location, actions and nerve supply of the intrinsic and extra-ocular muscles and apply this knowledge to explain the consequences of injury to the nerve supply of these muscles.
28. Describe the anatomy of the eyelids, conjunctiva and lacrimal glands. Explain their importance for the maintenance of corneal integrity.
29. Describe the functional anatomy of the external auditory meatus, tympanic membrane, ear ossicles and auditory tube, together with their major anatomical relations.
30. Describe the bones of the nasal cavity and the major features of the lateral wall of the nasal cavity. Describe the major arteries that supply the lateral wall and nasal septum in relation to nosebleeds.
31. Name the paranasal sinuses, describe their relationships to the nasal cavities and sites of drainage on its lateral wall and explain their innervation in relation to referred pain.
32. Describe the arrangement of the dura mater, and its main reflections within the cranial cavity and their relationship to the major venous sinuses and the brain itself.
33. Describe the arrangement of the venous sinuses of the cranial cavity; explain the entrance of cerebral veins into the superior sagittal sinus in relation to subdural haemorrhage, and how connections between sinuses and extracranial veins may permit intracranial infection
34. Describe the relationships between the brain and the anterior, middle and posterior cranial fossae.
35. Describe the anatomy of the motor and sensory nerves to the head and neck and

apply this to a basic neurological assessment of the cranial nerves and upper cervical spinal nerves.

36. Describe the sympathetic innervation of the head and neck and the features and casual lesions in Horner's syndrome.
37. Demonstrate the positions of the external and internal jugular veins and the surface landmarks that are used when inserting a central venous line.
38. Describe the arrangement of the lymphatic drainage of the head and neck, the major groups of lymph nodes and the potential routes for the spread of infection and malignant disease.
39. Interpret standard diagnostic images of the head and neck and be able to recognise common abnormalities.

Neuroanatomy

A medical graduate should be able to:

1. Define the terms rostral and caudal, anterior / ventral and posterior / dorsal in relation to the nervous system.
2. Define the terms grey and white matter, fasciculus, tract, commissure, pathway, chiasm, decussation, nucleus, ganglion, and cortex.
3. Identify the major divisions of the brain: the cerebral hemispheres, diencephalon (thalamus, hypothalamus and epithalamus), midbrain, pons, medulla oblongata and cerebellum.
4. Identify the major sulci and gyri of the cerebral hemispheres (lateral, central and post-calcarine) and summarise the position of the frontal, parietal, occipital and temporal lobes.
5. Describe the areas of cerebral cortex subserving major special functions; motor (including motor speech); sensory; visual; auditory (including sensory speech); memory and emotion (medial temporal – hippocampus, amygdala); decision making, social behaviour (orbitofrontal). Explain the manifestations of related disorders.
6. Summarise the position of the major commissure (corpus callosum) and ascending and descending tracts (internal capsule, cerebral peduncles, pyramids),
7. Describe the blood supply to the brain and explain the functional deficits occurring after 'stroke' involving individual cerebral arteries.
8. Describe the anatomy of the arachnoid and pia mater and ventricular system. Explain the formation, circulation and drainage cerebrospinal fluid.
9. Describe the origins, courses and functions of the cranial nerves.
10. Describe the neural pathways sub-serving the special senses.
11. Summarise the structure of the cerebellum, the connections and functions of the principal cerebellar inputs and outputs.
12. Summarise the locations, connections and functions of the basal ganglia (caudate, putamen, globus pallidus, subthalamic nucleus and substantia nigra). Explain the manifestations of related disorders.
13. Summarise the functions and connections of the thalamus.
14. Describe the anatomy and major functions (endocrine, autonomic) of the hypothalamus and pituitary gland. Explain the manifestations of related disorders.
15. Describe the principal components of the limbic system, hippocampus, amygdala, prefrontal cortex, nucleus accumbens), the pathways connecting them and their function.
16. Discuss the position and major functions of the ascending aminergic systems (noradrenaline, dopamine, and serotonin) and cholinergic systems.
17. Describe the positions within the spinal cord of the dorsal column, anterolateral (spinothalamic) and trigeminothalamic ascending tracts, the spinocerebellar and the corticospinal and extrapyramidal descending tracts. Describe the sites at which synapses occur in these pathways.
18. Explain the anatomical basis of neurological assessment.
19. Identify the major features of the brain on coronal, horizontal and sagittal sections and standard diagnostic image and be able to recognise common abnormalities.

Discussion and Conclusions

We have set out in this document a suggested core syllabus in anatomy for medical students in the UK and Ireland. It should be emphasised that we are trying to set standards not impose them. Existing guidelines from, for example, the GMC and Scottish Doctors are valuable for course designers who are trying to define "core" knowledge but are, in them-

selves, not sufficiently detailed to allow those who teach anatomy to set a syllabus. The purpose of this document is to suggest a core of anatomical knowledge that will equip students in the UK and Ireland for safe and effective clinical practice. Inevitably the suggestions reflect the background and understanding of its authors. Some will feel that there are other things that should be included and that some of suggestions ought to be excluded. We would welcome any such comments either to any of the authors or via the website of the Anatomical Society of Great Britain and Ireland as we view this syllabus as one which will evolve over time. The next stage of this project will be to validate our syllabus using a Delphi approach (Fischer, 1978) and that will be the subject of a future publication.

All those who design courses in UK and Irish medical schools, whether systems-based or integrated curricula, problem-based or scenario-led teaching, should ensure that their medical students learn in such a way that they become generally familiar with the anatomy summarised in this document. This knowledge base is necessary for safe and effective examination and diagnosis of a patient. The syllabus we have described defines the knowledge we would expect to see newly qualified medical graduates attain by the end of their course so that they can examine, diagnose and perform minor procedures safely and effectively. An important corollary of this is that such a standard of knowledge should be expected at the relevant level of examination, regardless of the teaching and learning methods used and the methods of assessment employed. This suggested minimum should serve as the benchmark for anatomical knowledge. We hope that colleagues will take up this syllabus and use it to inform the planning of this key foundation of medical practice within their undergraduate medical curricula. At the same time we would emphasise that more and different anatomical knowledge will be required when a qualified doctor moves into almost any specialised training. This approach can be summed up as 'what is needed, when it is needed' – our document only refers to that point which all aspiring doctors must pass; that of the initial qualification in medicine.

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