Appendix A

Syllabus for Diagnostic Neuropathology

This syllabus is an adjunct to the curriculum and is to guide aspects of learning expected to be covered during diagnostic neuropathology training. The syllabus is not designed to be prescriptive or comprehensive as content may quickly become out of date. However, a solid grasp of knowledge and skills in the listed areas should provide a very strong platform for completing all the required training assessments and for excelling. The document is a guide for trainees and trainers.

Compared to the 2012 curriculum document there is a greater emphasis on the importance of molecular characteristics and techniques, particularly in the context of establishing an integrated (histological and molecular) diagnosis in the setting of primary brain tumours and in the investigation of genetic diseases / syndromes more generally. There is an acknowledgement of more recently described diagnostic applications, notably methylation profiling for primary brain tumours. Equally, the assessment of skin biopsies for intraepidermal nerve fibre densities is a recently established diagnostic tool and the basic principles should be familiar to trainees. Finally, the use of digital pathology is likely to expand further, and trainees should be familiar with this subject and with the relevant basic guidelines for validation. It is already the case that a lot of relevant training material (including the interpretative Diagnostic Neuropathology EQA) is available in a digital format only. The basic histopathology competencies are no longer included as they are covered within Integrated Cellular Pathology Training (ICPT), which forms a prerequisite for entry into diagnostic neuropathology for all trainees.

The skills, knowledge and competencies expected of a consultant neuropathologist are implicit in the structure of the Part 2 examination for FRCPath in Diagnostic Neuropathology. The following areas are assessed as part of the FRCPath examination in diagnostic neuropathology*:*

- Autopsy
- Brain cut (dissection, macroscopic examination and sampling for histology)
- Interpretation of brain macroscopic pathology (interpretation of archived brain tissue or digital brain macroscopic pathology images)
- Autopsy neurohistology long cases with histological slides and preparations of multiple neuroanatomical areas
- Biopsy long cases requiring interpretation of additional preparations and data, including neuromuscular pathology
- Neurosurgical biopsies, including muscle and nerve
- Intra-operative diagnosis using wet smears and/or frozen sections
- Cerebrospinal fluid (CSF) cytology
- Professional knowledge and application of knowledge (including the ability to apply appropriate regulations and deal with professional and clinical situations).

Candidates may also be examined on areas of overlap, which include basic aspects of:

- ocular pathology
- skin
- bone and soft tissue pathology
- haematopathology.

Examiners require evidence of competence in the following areas:
Knowledge

- Full spectrum of adult systemic gross pathology

- Expert knowledge of external and internal gross anatomy of the brain, including:
    - blood supply
    - afferent and efferent projection pathways of major cortical areas and subcortical, brainstem and cerebellar nuclei
- Gross pathology of the spinal cord and its coverings, including the vertebral column
- Clinical-anatomical correlation
- Sampling protocols according to clinical problem
- Surgical neuropathology
    - Use of H&E-stained sections to provide:
        - reasonably narrow differential diagnosis
        - distinguish between a reactive process and neoplasm
        - distinguish between a tumour that is benign (low grade) or malignant (high grade)
- Judicious use of immunohistochemical preparations to assist neuropathological differential diagnosis
- Judicious use of other molecular techniques (e.g. PCR, in situ hybridisation, sequencing, methylation profiling) to assist neuropathological differential diagnosis
- Judicious use of electron microscopy to assist neuropathological differential diagnosis (e.g. peripheral nerve and muscle pathology)
- Relevant legislation, regulations and current guidelines related to clinical practice
- Relevant safety and risk management.

Skills

- Performance of adult general autopsy (whole body)
- Examination of skull and intracranial contents, including dural venous sinuses, pituitary gland, cranial nerves, middle ear cavities and sinuses of the skull
- Examination and dissection of the arterial circle of Willis
- Removal of the brain
- Examination of the spine and removal of spinal cord and dorsal root ganglia
- Exposure and removal of the vertebral artery along its entire course
- Basic principles of further specialist neuropathology procedures as indicated (e.g. exposure and sampling of sympathetic chain, nerve plexus, orbital contents)
- Dissection, examination and sampling of the fixed brain (in coronal and/or horizontal plane) and spinal cord
- Observational skills (must not miss macroscopic neuropathology)
- Diagnostic interpretation of neurosurgical biopsies including intra-operative assessment and molecular investigations
- Diagnostic interpretation of cytological preparations of CSF
- Diagnostic interpretation of skeletal muscle biopsies
- Diagnostic interpretation of peripheral nerve biopsies
- Integration of multiple modalities of information (e.g. clinical, histology, molecular) to produce a diagnostic opinion and final integrated diagnosis
- Ability to correlate anatomical and pathological (histological and relevant molecular) features of the lesion(s) to the clinical details of the case
- Ability to write comprehensive and clear reports for users, indicating the degree of confidence with which an opinion is expressed
- Ability to make oneself understood to lay persons and to professionals at all levels.

The table below is a non-exhaustive list of further syllabus information.

General competencies in tissue-based pathology

Areas of learning	Knowledge	Skills
Basic knowledge (CiPs: 1, 2, 3, 4, 5, 9, 11)	Demonstrates sufficient general clinical knowledge including major changes in trends of diagnosis and treatment Possesses sufficient knowledge of normal anatomy, physiology and pathophysiology	Develops the ability to solve complex clinical and research (when applicable) problems by applying sound knowledge of basic principles without the requirement always to rely on 'pattern matching'
Surgical cut-up (CiPs: 9, 11)	Understands principles of specimen dissection, macroscopic description and block selection in neoplastic and non-neoplastic disease	Possesses sufficient manual dexterity to perform dissection safely and accurately, without damage to tissues
Laboratory processes (CiPs: 1, 2, 3, 4, 7, 8, 9, 11)	Understands the principles of laboratory processing within surgical pathology and cytopathology	Gains experience of laboratory processing including section cutting at the start of training
Surgical reporting (CiPs: 7, 9, 11)	Understands the principles of microscopy Demonstrates knowledge of the microscopic features of the range of normality within tissues as well as the major common pathological processes and patterns of disease	Demonstrates the ability to set up a microscope with ergonomic safety and operate it effectively Demonstrates the ability to recognise the microscopic features of tissue structure in normal and diseased tissues
Special techniques (CiPs: 7, 9, 11)	Understands principles of 'special' histochemical and immunohistochemical methods Understands principles of common molecular pathology techniques Understand principles of electron microscopy Demonstrates understanding of the origins and consequences of germ-line variation and somatic mutations, including DNA methylation and gene expression changes	Understands when to resort to special techniques Demonstrates the ability to recognise histological features of histochemical and immunohistochemical stains in normal and diseased tissues
Fundamentals of molecular biology (CiPs: 1, 2, 7, 9, 11)	Demonstrates knowledge of basic molecular databases Demonstrates knowledge of how histological samples are taken prepared and of how nucleic acids are extracted from them Demonstrates understanding of the principles of the most up-to-date	Demonstrates the ability to understand origins of, and justifications for, molecular tests Demonstrates the ability to retrieve relevant data from public sources Demonstrates the ability to undertake the appropriate sample

	molecular methods Demonstrates knowledge of molecular tests currently performed on histological samples, including the limitations of those tests, and of tests that are anticipated in the near future	collection, retrieval and preparation for the common molecular tests, whether performed on extracted nucleic acid or in situ Demonstrates knowledge of sequencing, PCR, microarrays (DNA and RNA), in situ hybridisation, mutation detection Demonstrates the ability to assess the demand for molecular tests and the modes of supply
Autopsies (CiPs: 2, 7, 9, 10, 11)	Demonstrates broad knowledge of the pathological basis of disease and the macroscopic/microscopic pathology of various types of death Possesses knowledge of anatomy, macroscopic features of major disease processes and common tissue dissection techniques relevant to autopsy practice Demonstrates knowledge of the main side effects of common treatments and the major complications of most surgical procedures Demonstrates some understanding of the training undertaken by anatomical pathology technologists (APTs) and the role that they can appropriately play within all aspects of mortuary practice Demonstrates understanding of the use of clinical information and the health record in autopsy examination Is conversant with current policy in relation to consent for autopsies and for tissue or organ retention Is conversant with current policy in relation to tissue or organ donation Understands the legal basis of consent to autopsy examination and the circumstances in which consent	Demonstrates the ability to obtain consent and/or advise other medical practitioners taking consent for autopsies and for further investigation of tissue or whole organs Demonstrates manual dexterity sufficient to perform autopsies safely and demonstrate the major abnormalities Acquires the ability to demonstrate findings to clinicians and medical students, with clear clinicopathological correlation Liaises with the APTs to maximise the autopsy learning opportunities Demonstrates the ability to interrogate the clinical and laboratory records and understand the utility and limitations associated with various types of investigation including imaging, microbiology and biochemistry Demonstrates the ability to identify issues to be addressed by the autopsy examination

	is not required Demonstrates awareness of the value of the autopsy as a teaching aid	

Areas of learning	**Knowledge**	**Skills**
(CiPs 1, 2, 3, 7, 9, 11) Diagnosis, both intra-operative and histology of a: • mass lesion or lytic lesion in bones of skull or vertebrae • mass lesion arising from the meningeal coverings of the brain or spinal cord • mass lesion in the region of the sella turcica • mass lesion in the region of the pineal gland • mass lesion within the brain or spinal cord	Demonstrates knowledge of: • microscopic features of mass and lytic lesions • relevant molecular features of mass and lytic lesions Demonstrates understanding of clinical features of conditions, including: • age • anatomical site • natural history • imaging features of conditions	Demonstrates preparation and interpretation of intra-operative biopsy Demonstrates preparation and interpretation of neurosurgical biopsy Demonstrates preparation and interpretation of CT and MR-guided bone needle biopsy Demonstrates the ability to communicate the diagnosis clearly Demonstrates the ability to advise on the likely biological behaviour of the lesion Demonstrates the ability to write comprehensive and clear reports for users, indicating the degree of confidence with which an opinion is expressed Demonstrates dissection, preparation and examination of neurosurgical lobectomy Demonstrates the ability to apply current WHO classifications and grade to a tumour Demonstrates the ability to accurately integrate histological, molecular and any other relevant findings to provide an integrated diagnosis
• mass lesion arising from nerve root or from the trunk of a cranial or peripheral nerve	Demonstrates knowledge of molecular characteristics of brain tumours, not limited to: • entity-defining characteristics for integrated histological and	Demonstrates interpretation of neurosurgical biopsy (meningeal, cerebral cortex and white matter biopsy)

	molecular diagnosis (e.g. IDH status, 1p/19q status, histone mutations, molecular classification of medulloblastomas) • characteristics helpful for diagnosis, prognosis and prediction with response to therapy (e.g. BRAF status, MGMT, methylation profile) • role of more detailed molecular characterisation (e.g. whole genome sequencing in paediatric brain tumours)	Demonstrates the ability to interpret skin biopsy (CADASIL – electron microscopy) Demonstrates the ability to write comprehensive and clear reports for users, indicating the degree of confidence with which an opinion is expressed
• lesion causing intractable temporal lobe epilepsy	Demonstrates the ability to determine the specific nature of a structural lesion causing epilepsy Demonstrates the ability to distinguish between infective and non-infective inflammatory lesions causing epilepsy Demonstrates the ability to identify mesial temporal sclerosis	Demonstrates interpretation of neurosurgical biopsy (meningeal, cerebral cortex and white matter biopsy) Demonstrates the ability to write comprehensive and clear reports for users, indicating the degree of confidence with which an opinion is expressed
Diagnosis of a case of neurodegeneration	Demonstrates understanding of microscopic features of conditions causing cognitive decline and dementia Demonstrates understanding of relevant genetic features of conditions causing cognitive decline and dementia Demonstrates understanding of clinical features of conditions, including: • age • genetic predisposition • anatomical distribution • natural history Demonstrates understanding of the imaging of features of conditions	
Diagnosis, both intra-operative and histology, of focal or diffuse cerebral white matter abnormality	Demonstrates understanding of microscopic features of white matter pathology Demonstrates understanding of relevant genetic features of diseases involving white matter	

Diagnosis, both intra-operative and histology, of focal or diffuse, meningeal or cerebral lesions in immunosuppressed patients	Demonstrates understanding of microscopic features of pathology seen in immunosuppressed patients	
Areas of learning	**Knowledge**	**Skills**
(CiPs 1, 2, 3, 7, 9, 11) Diagnosis of muscle weakness, muscle pain or muscle wasting	Demonstrates understanding of microscopic features of major groups of muscle disorders Demonstrates understanding of relevant genetic features of major groups of muscle disorders Demonstrates understanding of clinical features of conditions listed above, including: • age • genetic predisposition • anatomical distribution • natural history	Demonstrates interpretation of: • skeletal muscle biopsy • peripheral nerve biopsy • fat and/or rectal biopsy (for amyloid) Demonstrates the ability to write comprehensive and clear reports for users, indicating the degree of confidence with which an opinion is expressed
Investigation of progressive ptosis and/or ophthalmoplegia	Demonstrates understanding of microscopical features of conditions causing ptosis and/or ophthalmoplegia Demonstrates understanding of relevant genetic features of conditions causing ptosis and/or ophthalmoplegia	Demonstrates interpretation of skeletal muscle biopsy (mitochondrial cytopathy, muscular dystrophy including specific features of myotonic dystrophy and oculopharyngeal muscular dystrophy, and the spectrum of changes in facioscapulohumeral muscular dystrophy) Demonstrates the ability to write comprehensive and clear reports for users, indicating the degree of confidence with which an opinion is expressed
Areas of learning	**Knowledge**	**Skills**
(CiPs 1, 2, 3, 7, 9, 11) Biopsy to investigate peripheral neuropathy	Demonstrates knowledge of microscopical features of peripheral neuropathies Demonstrates knowledge of basic genetic features of peripheral	Demonstrates interpretation of: • resin sections stained with thionin and acridine orange or methylene blue, azure II and basic fuchsin (trichrome preparation)

	neuropathies Demonstrates understanding of the principles of assessing skin biopsies for intraepidermal nerve fibre density in the investigation of suspected small fibre neuropathies	• teased nerve fibre preparation Demonstrates electron microscopy to assist identification of: • axonal degeneration and regeneration • Schwann cell abnormalities • myelin abnormalities • extracellular proteinaceous deposits and basal lamina abnormalities • cellular infiltration • micro-organisms • perineurial abnormalities • abnormalities of endoneurial blood vessels • histochemistry to identify the nature of any abnormal storage material within Schwann cells Demonstrates immunohistochemistry to: • assist morphology, with antibodies against neurofilament proteins, epithelial membrane antigen and S100 protein • characterise inflammatory cellular infiltrate • identify immunoglobulin light chain deposition • identify specific types of inherited amyloidosis Demonstrates the ability to write comprehensive and clear reports for users, indicating the degree of confidence with which an opinion is expressed
Biopsy, both intra-operative and histology, to investigate peripheral nerve tumour	Demonstrates knowledge of microscopic features of peripheral nerve tumours Demonstrates knowledge of relevant genetic features of peripheral nerve tumours	Demonstrates preparation of intra-operative wet smear preparation stained with toluidine blue or haematoxylin and eosin Demonstrates preparation of a frozen section stained with haematoxylin and eosin
Areas of learning	**Knowledge**	**Skills**
(CiPs 1, 2, 3, 7, 9, 11)		

Cytological examination of CSF to detect inflammatory disorders of the CNS and its coverings Cytological examination of CSF to detect neoplastic disorders of the CNS and its coverings	Demonstrates knowledge of the features of cells normally present within the CSF, including: • lymphocytes and macrophages • meningothelial cells and cells from the choroid plexus • ependymal cells and corpora amylacea (in ventricular fluid) • chondrocytes (in lumbar puncture-derived sample) Demonstrates knowledge of the features of a leukocytic reaction Demonstrates knowledge of the features of microorganisms: • viral cytopathic change; e.g. herpes simplex and cytomegalovirus • cryptococcus neoformans • toxoplasma gondii • hyphae of phycomycete • bacteria on Gram stain or, in the case of acid-fast bacilli, Ziehl Neelsen preparation Demonstrates knowledge of the features of neoplastic cells present within the CSF	Demonstrates the ability to: • distinguish between normal appearances, reactive pleocytosis and neoplastic pleocytosis • identify any microorganisms • select judiciously appropriate microbial and immunocytochemical preparations to assist differential diagnosis Demonstrates the ability to write clear and comprehensive reports for users, indicating the degree of confidence with which an opinion is expressed
Areas of learning	**Knowledge**	**Skills**

(CiPs 1, 2, 3, 7, 9, 11)
 	
Basic neuropathological autopsy to:
 	
• determine cause of death
• determine whether disease injury outside the nervous system contributed to neurological dysfunction
• determine whether disease or injury of the skull or meninges contributed to
	Demonstrates knowledge of the gross anatomy of the human body
	
	Demonstrates basic pathological processes:
	• inflammation, including abscess and caseation
	• granulation tissue and fibrosis
	• vascular pathology and infarction
	• neoplasia:
	  ○ benign vs malignant,
	  ○ primary vs secondary
	
	Demonstrates knowledge of the gross pathology of general body organs and systems in the adult
		Demonstrates removal and subsequent examination of the spinal cord
		
		Demonstrates examination and sampling of the orbit
		
		Demonstrates examination and sampling of the middle and inner ear
		
		Demonstrates removal and subsequent examination of dorsal root ganglia
		
		Demonstrates removal and subsequent examination of

neurological dysfunction • Identify pathological changes in the brain, spinal cord and adjacent tissues	Demonstrates knowledge of systemic histopathology (microscopic features) in the adult Demonstrates knowledge of the gross neuroanatomy of the: • skull • brain coverings • vascular supply to the brain • brain • clinico-anatomical correlates Demonstrates knowledge of the gross pathology of the skull, meninges and brain Demonstrates knowledge of microscopical pathology of the skull, meninges and brain Demonstrates knowledge of relevant genetic features Demonstrates fixation techniques for the brain	autonomic ganglia Demonstrates removal and subsequent examination of peripheral nerve plexuses Demonstrates removal and subsequent examination of peripheral nerve trunks Demonstrates removal of skeletal muscle samples Demonstrates the ability to correlate anatomical and pathological features of the lesion(s) to the clinical details of the case Demonstrates the ability to write clear and comprehensive reports for users, indicating the degree of confidence with which an opinion is expressed
Areas of learning	**Knowledge**	**Skills**
(CiPs 1, 2, 3, 7, 9, 11) Special procedure for autopsy in high-risk cases	Demonstrates risk stratification of infectious and transmissible disorders Demonstrates knowledge of the spectrum of clinical syndromes seen in prion disease (transmissible spongiform encephalopathies) Demonstrates understanding of guidelines for good practice when performing autopsies on high-risk cases including the handling, processing and storing of tissue in the laboratory Demonstrates knowledge of the guidelines set out in the *Guidelines For Good Practice: The Perinatal Autopsy,* prepared by the British Neuropathological Society	Demonstrates modification of autopsy in such a way as to ensure minimal contamination of the mortuary and to prevent disease transmission by accidental inoculation Demonstrates special considerations in decontamination of the mortuary working surfaces and instruments

Areas of learning	Knowledge	Skills
(CiPs 1, 2, 3, 7, 9, 11) Investigation of diseases causing cognitive decline, dementia and movement disorders	Demonstrates understanding of the microscopic features of conditions causing cognitive decline, dementia and movement disorders Demonstrates understanding of the relevant genetic features of conditions causing cognitive decline and dementia Demonstrates understanding of the clinical features of conditions, including: • age • genetic predisposition • anatomical distribution • natural history Demonstrates understanding of the imaging of features of conditions	Demonstrates the ability to sample and analyse a wide range of conditions (and the ability to apply up-to-date sampling and assessment protocols as appropriate) Demonstrates understanding of neurodegenerative diseases: • Alzheimer's disease • dementia with Lewy bodies • frontotemporal lobar degenerations • corticobasal degeneration • progressive supranuclear palsy • motor neuron disease • other (e.g. argyrophilic grain disease) Demonstrate understanding of other conditions causing cognitive decline, dementia and movement disorders: • amyloid angiopathy Cerebral vasculitis CADASIL • paraneoplastic/autoimmune encephalitides • Prion disease • AIDS and opportunistic infection • metabolic disease (leukodystrophy, lysosomal storage disease, mitochondrial disease, peroxisomal disorders etc.)
Areas of learning	**Knowledge**	**Skills**
(CiPs 1, 2, 3, 7, 9, 11) Investigate by autopsy the cause and manner of death in a case of head or spinal injury	Demonstrates knowledge of gross pathology of extradural/epidural, subdural and subarachnoid haemorrhage, and the changes that may date the injury	Demonstrates autopsy to assess the nature and extent of traumatic injury, especially to head, neck and spine Demonstrates external

	Demonstrates knowledge of the gross pathology of the brain and spinal cord (and their coverings) due to direct impact injury and whiplash injury, including: • cortical and gliding contusions • diffuse axonal injury • diffuse vascular injury • cerebral infarction • other hypoxic-ischaemic lesions • traumatic dissection of the vertebral and other cranio-cerebral blood vessels Demonstrates knowledge of the gross pathology of the brain resulting from raised intracranial pressure Demonstrates knowledge of the gross pathology of infection complicating head injury, including meningitis and brain abscess Demonstrates knowledge of the gross pathology of medical complications following trauma Demonstrates knowledge of the microscopical features of pathological causes of infarction and intracerebral haemorrhage	examination of the body and examination of internal anatomical structures and general body organs to determine the presence and extent of injury or disease outside the nervous system which: • may have caused death • may have contributed to neurological dysfunction
Areas of learning	**Knowledge**	**Skills**
(CiPs 1, 2, 3, 7, 9, 11) Investigation of strokes (cerebral infarction or haemorrhage)	Demonstrates knowledge of the clinical features of infarction and intracerebral haemorrhage	Demonstrates examination of scalp and skull Demonstrates removal of brain and meninges Demonstrates neuropathological examination of brain and meninges Demonstrates preparation and interpretation of neurohistological sections and sections of skeletal muscle

Areas of learning	Knowledge	Skills
(CiPs 1, 2, 3, 7, 9, 11) Investigation of developmental abnormalities of the nervous system in the foetus, neonate or child	Demonstrates knowledge of developmental abnormalities and other pathology in the foetus, neonate or child	Demonstrates the ability to remove the brain, under water or into a saturated salt solution if it is particularly soft, from a superior approach and collect it intact into formalin Demonstrates the ability to remove macerated brains within an intact dural sac in the case of stillborn foetuses

Assessment of the neurological component of pathology leading to death in the premature infant and sudden unexpected deaths in infancy and childhood	Demonstrates knowledge of microscopic features of:
	• cellular reactions in the developing CNS
	• malformations, including:
	  ○ toxic and metabolic CNS damage, including:
	  ○ kernicterus
	  ○ hypoglycaemia
	  ○ lysosomal disorders
	  ○ perioxisomal disorders
	  ○ mitochondrial disorders
	  ○ other inborn errors of intermediary metabolism
	  ○ hypoxic-ischaemic grey and white matter injury
	  ○ perinatal infections of the CNS and its coverings
	  ○ neurodegenerative diseases of childhood, including:
	  ○ spinal muscular and neurogenic atrophies
	  ○ neuroaxonal dystrophies
	  ○ leukodystrophies
	  ○ Alpers' syndrome and Rett's syndrome
	  ○ arthrogryposis multiplex congenita
	  ○ CNS tumours of childhood
	
	Demonstrates knowledge of relevant genetic features
	
	Demonstrates knowledge of the clinical features of conditions listed above, including:
	• genetic predisposition
	• anatomical distribution
	• natural history
		Demonstrates preparation and interpretation of neurohistological sections
		
		Demonstrates preparation and interpretation of sections of skeletal muscle and peripheral nerve
		
		Demonstrates the ability to relate findings to a cause or manner of death
		
		Demonstrates the ability to correlate anatomical and pathological features of a lesion to the clinical details of the case
		
		Demonstrates judicious selection of fresh or frozen tissue for biochemical and genetic analysis
		
		Demonstrates judicious selection of tissue samples for EM examination
		
		Demonstrates the ability to correlate anatomical and pathological features of lesion to the clinical details of the case
		
		Demonstrates the ability to write clear and comprehensive reports for users, indicating the degree of confidence with which an opinion is expressed

	• features on imaging of conditions listed above	

Competencies in Clinical Neuroscience

Competencies in clinical neuroscience must be acquired by trainees during the course of diagnostic neuropathology training. Whilst these are embedded in the diagnostic neuropathology curriculum as part of the need for clinicopathological correlation, it may be useful to list the competencies separately here. They are drawn from relevant aspects of specialty training in neurology and neurosurgery. The competencies consist mostly of the acquisition of knowledge rather than learned skills or behaviour. This is to be expected as the skills required of a neurologist and neurosurgeon are very different to those required of a neuropathologist, which are principally to use clinical information to inform neuropathological differential diagnosis, to aid in correct neuropathological diagnosis and in the provision of advice to clinicians and clinicopathological correlation in both biopsy and autopsy contexts.

Areas of learning	**Knowledge**
Differential diagnosis, investigation and initial management	Demonstrates knowledge of the different presentations of common and less common neurological diseases Demonstrates understanding of the roles and usefulness of investigations including neuroimaging and neurophysiology Demonstrates the ability to formulate an appropriately ordered differential diagnosis based on an appreciation of the patient, their past history and current problems, and their likely causes (consideration is given for different racial, social and ethnic groups) Demonstrates the ability to formulate a focussed and relevant series of basic investigations
Clinical pharmacology of neurological disorders	Demonstrates knowledge of the principles of treatment, especially for vascular disease, migraine, epilepsy, pain, psychiatric disorders, movement disorders, multiple sclerosis, autoimmune disorders, infections, dementia and motor neuron disease
Head injury	Demonstrates knowledge of symptoms and signs of head injury and its complications Demonstrates knowledge of indications for investigations and medical interventions, ITU referral, and urgent and delayed neurosurgery
Disorders of consciousness	Demonstrates knowledge of anatomy and physiology of consciousness, and the pathophysiology of disorders of consciousness Demonstrates knowledge of the definitions, causes, pathophysiology, clinical features and prognosis of permanent vegetative state, locked in state and brainstem death Demonstrates an understanding of the legal issues relating to disorders of consciousness

Epilepsy and loss of consciousness	Demonstrates knowledge of the differential diagnosis of paroxysmal and transient events, the scope and limitations of investigations, the use of anti-epileptic drugs, treatment of refractory seizures, serial seizures and status epilepticus, and the role of epilepsy surgery Demonstrates awareness of issues related to women and pregnancy and sudden death Demonstrates knowledge and management of other causes of loss of consciousness including syncope, drop attacks and vaso-vagal episodes
Cerebrovascular disease	Demonstrates knowledge of the cerebral circulation and its determinants, and the pathophysiology of cerebral infarction, cerebral haemorrhage, subarachnoid haemorrhage, cerebral venous thrombosis and vascular dementia Demonstrates knowledge of the epidemiology, risk factors and their management, and features of stroke/transient ischaemic attack (TIA), intracranial haemorrhage and venous thrombosis Demonstrates knowledge of investigation and management of acute stroke (including thrombolysis) and TIA as medical emergencies, and the role of medical secondary prevention and surgical interventions (e.g. hemicraniectomy, endarterectomy) Demonstrates an understanding of the role and limitation of imaging Demonstrates knowledge of cerebral aneurysm and arteriovenous malformation (AVM), and interventional, surgical and radiotherapy treatment
Tumours of the nervous system, neurological complications of systemic cancer, and complications of cancer treatment	Demonstrates understanding of neuropathological classification of brain tumours and the clinical features of the common tumours of the nervous system including malignant meningitis Demonstrates understanding of the clinical features and immunology of paraneoplastic syndromes, the benefits and risks of therapies including surgery and radiotherapy, and neurological complications of chemotherapy and radiotherapy Demonstrates understanding of the role of the neuro-oncology multidisciplinary team
Infections of the nervous system	Demonstrates understanding of the principles of neurological infectious disease and the clinical features of these diseases and their causes (including meningitis, encephalitis, tuberculosis, HIV and neurosyphilis) Demonstrates understanding of diagnostic techniques and their

	appropriate use, anti-microbial therapies and their use, and the importance of liaison with infectious disease physicians, microbiologists, public health and occupational health medicine in relation to neurological infections Demonstrates knowledge of prion disorders and the wider implications, such as infection control risk
CSF disorders	Demonstrates knowledge of CSF composition and dynamics, anatomy and radiology of the ventricular system, genesis of hydrocephalus, biochemistry and immunology of CSF, the blood-brain barrier, and indications, techniques and contraindications of CSF examination Demonstrates understanding of methods of intracranial pressure monitoring, treatments of raised intracranial pressure, and management of shunts
Demyelination and vasculitis	Demonstrates knowledge of the biology of demyelination and vasculitis and the clinical features of multiple sclerosis (MS), related demyelinating disorders, and vasculitic and arteritic disorders Demonstrates knowledge of the management of specific impairments and disabilities arising in MS and the role of disease-modifying drugs, symptomatic treatments and therapies
Neurological complications of immunosuppression	Demonstrates knowledge of the principles of immune responses in relation to the nervous system, the immunological basis underlying autoimmune neurological diseases, the clinical features of these diseases, and diagnostic techniques and their appropriate use Demonstrates knowledge of immunosuppressive and immunomodulatory therapies and their actions, side effects and indications
Parkinsonism and movement disorders	Demonstrates knowledge of the clinical features and differential diagnosis of parkinsonism, chorea/athetosis, dystonia, tics and tremor, and the role of investigations in diagnosis Demonstrates knowledge of the treatment (and complications of treatment) of movement disorders, and the role of neurosurgical interventions
Motor neuron disease	Demonstrates knowledge of the clinical features and differential diagnosis of motor neuron syndromes, and disease-modifying and symptomatic treatments
Toxic and metabolic states	Demonstrates knowledge of the biochemistry and neuropathology of exposure to alcohol and other recreational drugs (cocaine, amphetamine, opiates), heavy metals, pesticides and therapeutic agents; clinical features of alcohol, cocaine, opiate, amphetamine neurotoxicity, and of heavy metal, CO, NO and organophosphate poisoning; and of therapeutic agent neurotoxicity (e.g. vincristine,

	lithium, radiation) Demonstrates knowledge of neurological presentations of renal and hepatic failure, nutritional deficiencies and porphyria Demonstrates knowledge of the role and value of blood and urine toxicology, imaging and neurophysiology, assessment of other organ damage, and the clinical features and management of hyper/hypo-thermia, sodium, potassium, calcium and acid base disorders
Disorders of the visual system	Demonstrates application of anatomy and physiology of the visual and oculomotor systems; clinical evaluation of the eye and adnexae, and vision (acuity, fields and higher function); and clinical features and conditions that may affect these systems
Disorders of cranial nerves	Demonstrates knowledge of the anatomy of the skull base, particularly the orbit, cavernous sinus, pituitary fossa, foramen magnum and jugular foramen; pathological processes involving cranial nerves and their central connections; and clinical features and clinical assessment of cranial nerve function
Disorders of spine, spinal cord, roots and spinal injury	Demonstrates knowledge of anatomy of the spine, spinal cord and roots; clinical features of spinal cord, root and cauda equina syndromes; indications for urgent investigation; and the potential and limitations of spinal CT, MRI, myelography and spinal angiograph Demonstrates knowledge of emergency management of the spinal cord or root compression and of spinal injury, and the management of neck and low back pain and sciatica
Disorders of peripheral nerves	Demonstrates knowledge of anatomy and pathology of peripheral nerves; clinical features and investigation of genetic and acquired axonal and demyelinating neuropathies, traumatic and entrapment neuropathies, plexopathies and mononeuritis multiplex Demonstrates knowledge of the management of Guillain-Barré syndrome and other severe paralysing neuropathies; and general management of acute neuromuscular paralysis
Disorders of muscle	Demonstrates knowledge of clinical features and investigation of genetic and acquired disorders of the neuromuscular junction and voluntary muscle including periodic disorders and disorders of energy metabolism (e.g. mitochondrial disorders)
Clinical neurophysiology	Demonstrates basic understanding of electroencephalography Demonstrates basic understanding of electromyography/nerve conduction studies/repetitive stimulation (the principles of the techniques); abnormalities in common nerve entrapments and peripheral neuropathies; motor neuron disease; disorders of neuromuscular junction; and muscle disease

	Demonstrates basic understanding of evoked potentials and common abnormalities in neurological diseases, particularly demyelination, and the role of intra-operative EP Demonstrates basic understanding of the role and practice of neurophysiological investigations in disorders of the nervous system, and the ability to interpret a neurophysiology report
Neuroendocrinology	Demonstrates knowledge of relationships with neurological disorders Demonstrates understanding of steroid therapy and its complications Demonstrates understanding of the principles of the NS in endocrine function and the neurological features of endocrine disorders, particularly pituitary disease
Neurogenetics	Demonstrates understanding of basic genetic principles including inheritance patterns and common diagnostic methods, and the roles of a detailed family history and of DNA-based diagnostic tests Demonstrates understanding of genetic contributions to multifactorial neurological diseases (e.g. stroke, multiple sclerosis, subarachnoid haemorrhage, epilepsy) Demonstrates knowledge of the clinical features of common genetic conditions (hereditary ataxias, Huntington's disease, hereditary neuropathies, muscle diseases and neurocutaneous syndromes) Demonstrates understanding of the role of bioinformatic databases of human disease Demonstrates understanding of principles of genetics as applied to neurological disorders, and the ability to interpret a genetics report
Neurointensive care	Demonstrates understanding of clinical features, causes, investigation and management of coma (including epilepsy and raised intracranial pressure), failure to regain consciousness and paralysis Demonstrates understanding of the diagnosis of and ability to define the vegetative state; management of status epilepticus; the principles of cardiovascular and respiratory support; and indications for and methods of artificial nutrition Demonstrates knowledge of the ITU neurological complications of major surgery, sepsis, drugs and medical disorders

	Demonstrates understanding of clinical, legal and ethical issues in brain death, coma and vegetative state
Neuropaediatrics	Demonstrates understanding of neurological disorders in intrauterine life and childhood, key stages of development and range of normality Demonstrates understanding of developmental disorders (including effects of intrauterine and perinatal factors on neural development), metabolic conditions, cerebral palsy, learning disability and autism Demonstrates knowledge of paediatric conditions that can present in adulthood
Neuropsychology	Demonstrates understanding of the neuroanatomical and neurophysiological basis of memory, attention, language and perception; understand the value and limitations of neuropsychological interventions such as cognitive behavioural therapy; and understand mini-mental state examination and basic neuropsychological tests employed by clinical psychologists
Neuroradiology	Demonstrates understanding of the principles of, and indications for, neuroradiological investigations (CT scan cranial/angiography, MR scan cranial/spinal/angiography, catheter angiography diagnostic/interventional, myelography, ultrasound carotid/transcranial/cardiac, and other special investigations, e.g. positron emission tomography, single photon emission computed tomography) Demonstrates the ability to evaluate neuroradiological investigations and reports, liaise effectively with the neuroradiologist, and understand the role, risks and limitations of common techniques
Neurosurgery	Demonstrates understanding of the role of neurosurgery in the management of head injury, raised intracranial pressure, intracranial haemorrhage and ischaemic stroke, aneurysm, vascular malformation and tumours, spinal cord and root disorder, and peripheral nerve lesions Demonstrates understanding of the purpose, limitations, process and complications of biopsy procedures (brain, muscle, nerve)
Embryology and maldevelopment	Demonstrates understanding of the principles of general and specific risks and complications of neurosurgical interventions Demonstrates knowledge of embryogenesis of the brain, spinal cord and supporting structures (skull and vertebral column), and common anatomical variations and developmental abnormalities
Anatomy of the skull	Demonstrates knowledge of the structure, blood supply, innervation, surface and three-dimensional relationships of the: • scalp • skull • meninges

	• orbit • cranial fossae • cranial foraminae • cranial nerves
Anatomy of the brain	Demonstrates knowledge of cortical topography, projection and association tracts, organisation of the basal ganglia and the structure, organisation and connections of the cerebellum, pons and brainstem Demonstrates knowledge of the cranial nerves and their relationships, visual and auditory pathways, ventricular system and choroid plexus, subarachnoid space and cisterns, Circle of Willis and principle regional and segmental blood supply, venous drainage and dural sinuses
Anatomy of the spine	Demonstrates knowledge of the structure, blood supply, innervation, surface and three-dimensional relationships of the: • vertebral column • spinal cord (ascending and descending tracts) • spinal nerve roots • cauda equina
Anatomy of the autonomic and peripheral nervous system	Demonstrates knowledge of the sympathetic and parasympathetic pathways, and visceral and pelvic innervation (control of sphincter function, brachial plexus, lumbosacral plexus)
	Demonstrates knowledge of the course, distribution and innervation of the major peripheral nerves
Functional neurophysiology	Demonstrates knowledge of the structure and function of neurones and glial cells, synaptic function, action potentials and axonal conduction, and higher cerebral functions Demonstrates understanding of sleep and coma states, memory and disorders of the limbic system, control of motor function (ascending and descending pathways, basal ganglia and cerebellar function), the special senses, functions of the autonomic nervous system, and hypothalamic-pituitary function
Pathophysiology of intracranial disorders	Demonstrates knowledge of cerebral blood flow and metabolism, cerebral autoregulation and vasospasm, blood-brain barrier and cerebral oedema, intracranial pressure dynamics, cerebral ischaemia and neuroprotection, and CSF hydrodynamics (production and absorption)
General management of the head injured patient	Demonstrates knowledge of the pathophysiology of head injury and of multiple trauma including an understanding of: • cerebral perfusion and oxygenation • raised intracranial pressure • impaired intracranial compliance • intracranial herniation Demonstrates understanding of the medical management of

	acutely raised intracranial pressure and indications for operation intervention including the use of pressure monitoring Demonstrates understanding of the principles of diagnosis and confirmation of brain death, principles of intensive care of head injured patients, principles of spinal stabilisation and radiological assessment in head injured patients Demonstrates understanding of the natural history of recovery from head injury including neurological, cognitive and behavioural disability and post-traumatic epilepsy
Insertion of intracranial pressure (ICP) monitor	Demonstrates understanding of indications for ICP monitoring Demonstrates understanding of applied anatomy of the skull vault Demonstrates understanding of potential complications of the procedure
Burr hole evacuation of chronic subdural haematoma	Demonstrates understanding of the pathophysiology of chronic subdural haematomas, applied anatomy of the skull vault and subdural space, indications for surgery and surgical options, complications of surgery, and management of anti-platelet and anti-coagulant medication
General management of subarachnoid haemorrhage (SAH)	Demonstrates knowledge of the aetiology and pathophysiology of SAH, World Federation of Neurosurgical Societies (WFNS) grading of SAH, principles of management of post-haemorrhagic hydrocephalus, and indications for endovascular and surgical intervention Demonstrates interpretation of CT scans including assessment of intracranial blood load, haematomas and hydrocephalus Demonstrates basic interpretation of cerebral angiography
Management of delayed secondary ischaemia	Demonstrates knowledge of pathophysiology of delayed cerebral ischaemia including the impact of secondary insults Demonstrates knowledge of the principles governing the augmentation of cerebral blood flow
Management of post-haemorrhagic hydrocephalus	Demonstrates knowledge of the pathophysiology of hydrocephalus and applied anatomy of the skull vault, subdural space and ventricular system Demonstrates understanding of the indications for external ventricular and lumbar subarachnoid drainage, and complications of surgery
Adult hydrocephalus	Demonstrates understanding of the pathophysiology of CSF circulation and applied surgical anatomy of the ventricular system

	Demonstrates understanding of the indications for external ventricular drainage, ventriculoperitoneal shunting, lumbar CSF drainage and shunting and ventriculo-cisternostomy, and complications of surgery
Assessment and peri-operative management of patients with space-occupying intracranial tumours	Demonstrates understanding of the clinical presentations of intracranial tumours, indications for neuroimaging, management of raised intracranial pressure, principles of operative management, and detection and management of post-operative complications Demonstrates basic interpretation of CT and MRI scans
Image-guided biopsy of intracranial tumour	Demonstrates understanding of indications for biopsy of intracranial tumours, risks of biopsy, and the principles of image-guided surgery