

Diagnostic Electron Microscopy Strategy Document 2019

OVERVIEW

What is diagnostic electron microscopy?

The transmission electron microscope (TEM) is used as an important [diagnostic tool](#) to screen human tissues at the ultrastructural level, often in conjunction with other methods, particularly light microscopy and immunofluorescence/histochemical techniques. **Diagnostic electron microscopy is identified as a high complexity specialist service** in the recent document - [NHS Improvement pathology networking in England: the state of the nation](#).

Workload

Electron microscopy (EM) became an important diagnostic tool in the late 1970s and covered a range of specimens including renal, nerve and muscle diseases, virus and tumour identification and a number of other specialised disease including paediatric and metabolic disorders. In recent years, although the number of virology and tumour specimens has declined sharply, the remaining diagnostic EM workload has remained fairly stable with some of the rare diseases becoming commissioned services. It is difficult to put a figure on it but informal discussion shows that there is little or no capacity in the existing units for new work. Indeed, one of the UKs larger units - Queen Elizabeth Hospital, Birmingham is about to send out a backlog of work due to shortage of staff.

Number of diagnostic EM units in England & Wales

In 2010 there were 56 diagnostic electron microscopy units in England and Wales. In 2018 that number had dropped to 26 and out of those only 19 have their own electron microscope. While this consolidation may in part be good, it is being done in a completely unplanned way **with individual trusts taking decisions on an ad hoc basis**. Rather than a reduction in workload, this severe reduction in the number of units is due to smaller units closing (staff retirement and aging microscopes) and the work being transferred to larger units.

Work covered

Electron microscopy is an essential part of the diagnostic pathway for several diseases:

- The overwhelming majority of the workload consists of renal work
- A smaller proportion of nerve and muscle specimens
- A number of directly commissioned services:
 - Primary Ciliary Dyskinesia (PCD; Leicester Royal Infirmary; Royal Brompton, London; Southampton General Hospital)
 - Elhers-Danlos (Royal Hallamshire Hospital, Sheffield)
 - Epidermylosis Bullosa (Guy's & St Thomas', London)
 - Ophthalmic pathology (Royal Hallamshire, Sheffield & Manchester Royal Infirmary)
- Other specimens include hair (by scanning electron microscopy), lung, cardiac, blood, GI tract, CNS, parasites, CADASIL & eye and cases of [x-ray microanalysis](#).

Training

There is no formal training in diagnostic EM. New staff are either trained in in-house when they join a unit or they are attracted over from the University sector and then hone their skills on the job. Some units have developed in-house training programmes.

The Future

Some of the most experienced electron microscopists in the country (the world?) are due to retire in the next two or three years and there is no guarantee they will be replaced. Furthermore many units are getting by with very old equipment (microscopes, ultramicrotomes etc) – 30 years old and more, making their position precarious to say the least. Once closed electron microscopy units rarely, if ever reopen. This concern **that diagnostic EM is on the brink of a crisis is shared by clinicians and patient groups and there is agreement that there is desperate need for a long term strategy which would safeguard what is an essential pathology service.**

PROPOSED STRATEGY

Diagnostic electron microscopy becomes a commissioned service

It is clear that there is no structure or organisation to the way diagnostic EM is carried out at a national level. The Association of Clinical Electron Microscopists (ACEM) has played some coordinating role but each hospital makes its own decision as to the need and viability of such a service without reference to the national agenda. To safeguard the service going forward **we propose that the whole of diagnostic electron microscopy become a directly commissioned service** as parts of it are already (Elhers-Danlos, epidermylosis bullosa, primary ciliary dyskinesia).

The advantages of this strategy are clear

A directly commissioned service will deliver:

- A sustainable service delivered by specialist teams of health professionals who have the necessary skills and experience.
- A unified training platform for all EM staff across the country at all levels.
- A unified sustainable career structure tailored to this highly specialist diagnostic service.
- The provision of adequate state of the art equipment.
- The ability to collaborate with research organisations to drive innovation (building on existing collaborations with the Francis Crick Institute and several Universities – examples include microwave processing, correlative light & electron microscopy, 3D microscopy).
- The ability to review the entire service, to see where things can be improved, ensure services are keeping up with best practice and ensure equity of access to treatments and services.
- An opportunity to improve the coordination of specialised EM services, publish national standards to ensure patients get high quality care.
- Establish a world-class external quality assessment system building on the newly established NEQAS [TEM scheme](#) to drive improvement (an example of this is [European Respiratory Society Guidelines](#) for PCD).
- Engage with user groups to provide the best service for patients

Eligibility criteria for EM units

These would have to be established but might take into account:

- Number of specimens processed
- Availability of relevant pathologists/ specialist experts
- Capacity of the unit in terms of equipment
- Willingness and capacity to carry out training at different levels (see below)
- Whether a unit already carries out a commissioned service
- Willingness and ability of the host Trust to maintain all of the above
- Whether units have appropriate accreditation (currently UKAS ISO15189)

Training

Training is a key element of a sustainable service. Participating hospitals must embrace a full training programme or collaborate with others in such provision. Training should be at all levels based on the [model](#) outlined by Professor Sue Hill:

- Practitioner training programme including level 6 degree apprenticeships in Biomedical Sciences. Staff would employed at band 4 level and registered for an accredited part time degree in biomedical sciences. They would be given on the job training in their own unit and be sent to other units for additional training.
- Scientist Training Programme (STP) - Alongside existing specialisms in [Life Sciences](#), create another specialism in Diagnostic Electron Microscopy (appendix 2). They would be given on the job training in their own unit and be sent to other units for additional training.
- Higher Specialist Scientist Training (HSST) – Alongside existing specialisms in [Life Sciences](#), create another specialism in Diagnostic Electron Microscopy (appendix 3)
- A vital part of this training hierarchy, especially at the higher level, is the involvement of clinicians both in the provision and participation. It should also see an increase the EM content of ST1 training.

Appendix 1: Diagnostic Electron Microscopy Units in England & Wales in 2010 and 2018

City	Centre (existed in 2010)	Still exists in 2018?	Contact	Comments
BIRMINGHAM	Birmingham Children's Hospital (NHS)	Yes	Susan Cavanagh	Use TEM at QEH, Birmingham
	Birmingham Heartlands Hospital (NHS/HPA)	No		
	Queen Elizabeth Hospital (NHS)	Yes	Liz Curtis	
BRIGHTON	Royal Sussex Hospital NHS Trust	Yes	Joanna Browning?	
BRISTOL	Bristol (HPA)	No		Sent to Cardiff
	Bristol Royal Infirmary (NHS)	No		Sent to Cardiff
	Southmead Hospital (NHS)	No		Sent to Cardiff
	Frenchay Hospital (NHS)	No		Sent to Cardiff
CARDIFF	University Hospital of Wales, Cardiff	Yes	Ruth Scully	
CAMBRIDGE	Addenbrooke's Hospital (NHS)	Yes	Tom Willingham	
	Cambridge (HPA)	No		
DUDLEY	Russell Hall Hospital (NHS)	No		Sent to QEH, Birmingham?
EPSOM	Epsom & St Helier	No		Sent to GOS
EXETER	Royal Devon & Exeter	No		Sent to Southampton
LEEDS	Leeds (HPA)	No		
	St. James' Hospital Leeds (NHS)	No		Sent to Leicester
LEICESTER	Leicester Royal Infirmary (NHS)	Yes	Tracy de Haro	
LIVERPOOL	The Walton Centre NHS Foundation Trust	Yes	Amanda Williams	
LIVERPOOL	Royal Liverpool and Broadgreen University Hospitals	No		Sent to Newcastle
LONDON	Barts & The London Trust (NHS)	Yes	Graham McPhail	Use TEM at Queen Mary College
	CHPA Colindale (HPA)	No		
	London Dubowitz Neuromuscular Unit (NSCAG)	Yes		Use TEM at Institute of Neurology

	Great Ormond Street Hospital For Children (NHS)	Yes	Glenn Anderson	
	Great Ormond Street Hospital For Children, Virology (NHS)	No		
	Guys & St Thomas (KCL/NHS)	Yes	??	Use TEM at Kings College
	Guys & St Thomas, Virology (NHS)	No		
	Hammersmith Hospitals Trust (NHS)	Yes	Jill Moss	
	Institute of Neurology (Univ)	Yes	Kerry Venner	
	Kings College Hospital (NHS)	Yes	Stephan Buk	
	Royal Brompton Hospital (NHS/UNIV/NSCAG)	Yes	Paul Griffin	
	Royal Free Hospital (Univ)	No		Sent to Leicester
	Royal Free Hospital, Paediatric Gastroenterology (NHS)	No		
	Royal Free Hospital, Clinical Neurosciences (NHS)	No		
	Royal Free Hospital, Virology (NHS)	No		
	Royal Marsden Hospital (NHS)	No		
	St Georges Hospital Medical School (UNIV)	Yes	Maria McGlynn	
	St John's Institute of Dermatology (NSCAG)	Yes	??	Use TEM at Kings College
	St Mary's Virology Department Windeyer Institute	No		
MANCHESTER	Christie Hospital (NHS)	No		
	Manchester Royal Infirmary (NHS)	Yes	Lee Crompton	
	Royal Manchester Children's Hospital (NHS)	Yes		Use TEM at Manchester Royal Infirmary
NEWCASTLE	Newcastle Upon Tyne NHS Trust (NHS)	Yes	Lynn Tindale??	
NOTTINGHAM	Nottingham University Hospital (NCH / NHS)	No		Sent to Leicester
	Nottingham University Hospital (GMC) (NHS/UNIV)	No		Sent to Leicester
NORTH STAFFORDSHIRE	University Hospital of North Staffordshire	No		Sent to Southampton
OWESTRY	Robert Jones & Agnes Hunt Orthopaedic Hospital (NHS)	No		Sent to QEH, Birmingham

OXFORD	John Radcliffe's Hospital (NHS/UNIV)	No		Sent to Southampton
PLYMOUTH	Derriford Hospital (NHS)	Yes		
	University of Plymouth (UNIV)	No		
PORTON DOWN	CMRA (HPA)	Yes	Howard Tolly??	
PRESTON	Royal Preston Hospital (NHS)	Yes	Christine Thomas	
SALFORD	Hope Hospital (NHS)	Yes	Richard Mathias	
SHEFFIELD	Royal Hallamshire Hospital (NHS)	Yes	Bart Wagner	
SHREWSBURY	Royal Shrewsbury Hospital (NHS)	No		Sent to QEH, Birmingham
SOUTHAMPTON	Southampton General Hospital (NHS/ UNIV / HPA)	Yes	Anton Page	
WOLVERHAMPTON	Royal Wolverhampton & New Cross Hospital	No		Sent to QEH, Birmingham

Total number of diagnostic electron microscopy units in England & Wales:

2010 56

2018 26

With their own TEM 19

Diagnostic Electron Microscopy Units in Scotland in 2010 and 2018

City	Centre (existed in 2010)	Still exists in 2018?	Contact	Comments
ABERDEEN (NHS Grampian Health Board)	Aberdeen Royal Infirmary	Yes	Karen Sibley (tbc)	Use Aberdeen University Microscope for imaging
DUNDEE (NHS Tayside Health Board)	Ninewells Hospital	Yes	David Allen	Includes Renal Service from NHS Fife HB
EDINBURGH (NHS Lothian Health Board)	Western General Hospital	Yes	Fiona Young	Includes Neuropathology service from NHS Grampian and Tayside HB
GLASGOW (NHS Greater Glasgow & Clyde Health Board)	Queen Elizabeth University Hospital & Royal Hospital for Children	Yes	Alison Lupton	Includes Renal and Neuropathology Services from Ayrshire & Arran HB, Lanarkshire HB, Dumfries & Galloway HB , Highland HB. Also PCD Service
	Royal Hospital for Sick Children	No		Sent to QEUH
	Southern General Hospital	No		Sent to QEUH
	Western Royal Infirmary	No		Sent to QEUH
INVERNESS (NHS Highland Health Board)	Raigmore Hospital	No		Sent to QEUH

Total number of diagnostic electron microscopy units in Scotland:

2010 8

2018 4

Appendix 2: Diagnostic Electron Microscopy Specialism in the Scientist Training Programme (STP)

Need

EM is a key element in the diagnostic pathway. It is a highly specialised field but is a fundamental tool in the diagnosis of many diseases. The Association of Clinical Electron Microscopists (ACEM) surveyed the provision of diagnostic EM units in Great Britain in 2013 and the main findings were as follows:

- Many of the EM units are run by just one or two staff.
- Although there is a fairly good age distribution of unit staff there is a marked lack of expertise in the younger age cohorts.
- There is little or no formal training in diagnostic EM. A few external bodies, IBMS and Royal Microscopical Society, provide some general EM training but in-depth diagnostic courses do not exist.
- Most respondents felt that a lack of formal training was detrimental to both the service and their personal development.
- Staff with high level experience in diagnostic EM are close to retirement and these skills are only being passed on in an ad hoc way. (some units have adopted a structured approach)

It is now recognised that there is a critical shortage of trained diagnostic electron microscopists and, in the next few years, this will have a severe impact on the national EM service and several specially commissioned services (e.g., Ehlers-Danlos, epidermolysis bullosa, primary ciliary dyskinesia). Staff trained in histology are not equipped with the skills to carry out EM or have appropriate secondment time in EM units.

Proposal

Establish a new specialism of “Diagnostic Electron Microscopy” in the NHS Scientist Training [Programme](#) (graduate entry route to become a clinical scientist).

Course outline

Diagnostic electron microscopy would be established as a specialism within the Life Sciences pathway following the existing programme structure

- Year 1 – students complete four 12 week competencies
 - Histology (already established)
 - Genomics (already established)
 - Microbiology (already established)
 - Diagnostic electron microscopy - basic overview of light microscopy, x-ray microscopy, scanning electron microscopy and transmission electron microscopy.
- Years 2 & 3 – A general outline would be as follows:
 - General histology competencies
 - Understand why we use EMs.
 - Understand the rationale for chemical fixation of specimens for EM and be able to design fixation protocols to suit different specimens.
 - Have practical experience of specimen preparation, sectioning and use of the electron microscopes.
 - Understand how SEMs and TEMs work.
 - The above is covered in the IBMS Specialist portfolio
 -
 - Be able to capture, store and retrieve digital microscope images from a secure server.
 - Be able to recognize a wide range of cell structures (both normal and diseased) in electron micrographs.
 - Have experience and knowledge of a range of specimens and diseases for which electron microscopy is appropriate.
 - Be able to recognize and photograph diagnostic features relevant to each case.

- o Follow specimens from the patient, through histology and subsequent EM to give a full understanding of the part each plays in the overall diagnosis.
- o Understand the concepts of some of the advanced techniques in EM.
- o Be able to present EM data at multi-disciplinary team meetings
- o Understand immuno-labelling procedures and how to adapt them for particular applications.
- o Understand basic image enhancement and processing procedures.
- o Be able to prepare light and EM material for publication
- o Be able to carry out and report on a project
- MSC/ MRes – students would also enrol in a suitable MSc MRes course as part of the STP programme

Demand

Due to the highly specialised nature of the UK EM service it is envisaged that we would need to train two students per year or possibly two students every other year according to the need of the service.

Delivery

Students would be trained in their home unit but travel to other units as required. For example, we already run training courses in EM, advanced light microscopy and an annual training day in diagnostic EM. These courses could form the basis of the STP course. Training in particular aspects of the various diseases where EM is relevant would be covered by experts around the country (Glenn Anderson, Great Ormond Street – paediatric conditions; Bart Wagner, Sheffield – renal disease) Nerve / muscle / renal transplants? Clinical Scientist from NWLP willing to participate.

Career progression

A diagnostic EM STP specialism should lead directly into the Higher Specialist Scientific Training (HSST).

Appendix 3: Diagnostic Electron Microscopy Specialism in the Higher Specialist Scientific Training Programme (HSST)

Need

EM is a key element in the diagnostic pathway. It is a highly specialised field but is a fundamental tool in the diagnosis of many diseases. As with the STP (appendix 2) there is little or no formal high level training in this discipline. Electron microscopists and clinicians who trained to this level are few and far between in this country. Almost all of those that do exist are close to retirement.

Proposal

Establish a new specialism of “Diagnostic Electron Microscopy” in the existing HSST pathway.

Course outline

Diagnostic electron microscopy would be established as a specialism within the Life Sciences pathway following the existing [programme](#) structure

The Higher Specialist Scientist Training is a quality assured five-year workplace based training programme that provides opportunities for clinical scientists to train to become eligible to apply for available consultant clinical scientist posts. Formed of an underpinning academic doctoral programme and the requirement to gain fellowship of the RCPATH. Participants would gain skills including:

- Specialist scientific knowledge
- Clinical skills, values and behaviours
- Innovation in healthcare science
- Ability to provide highly developed and advanced clinical scientific expertise and interpretation
- Acquire scientific responsibilities at a level equivalent to that of a medical consultant
- Provide leadership and influence scientific, diagnostic and clinical areas/specialism
- Through transitional scientific research and education, bring strategic direction and innovation into practice

The curriculum needs to be developed, in association with Health Education England (HEE) and Manchester Academy for Healthcare Scientist Education (MAHSE) to include learning outcomes, competencies and assessments with and alternative pathway for PhD holders - direct entry or in service.