Blood science: what is it and where is it going?

Blood Science is the next step on the road to a fully integrated pathology service. Core disciplines of haematology and biochemistry are merged, but many also see the inclusion of immunology in this new super-discipline. Its development is driven by the need for cost reductions, commonality in laboratory processing and by roles in clinical diagnosis and management. The new discipline will demand a new breed of scientist, as Andrew Blann, Ian Jennings and Nessar Ahmed explain.

Historically, pathology has evolved into distinct disciplines, and training and practice has reflected this. The past decade has seen the birth and slow development of a new branch of pathology – blood science – which merges aspects of haematology, biochemistry and immunology. A further aspect of blood science may be molecular science and genetics, but this is far from being a well-developed and independent discipline. This change is being driven, in part, by the demands of routine NHS pathology laboratories. Now that the majority of blood-based work is increasingly becoming automated, there is an efficiency-led move towards merging those departments most amenable to automation (ie haematology and biochemistry). Indeed, the greater part (if not all) of the work of these departments is based on closed-tube systems. There is often an overlap of knowledge and particularly of methodology and techniques, and, with the increased use of automation and the development of common automated methods, the pooling of resources is inevitable in driving down costs. The Department of Health, in its *Modernising Scientific Careers* document, recognises three strands that flow from what it terms Life Science.[1] These are Blood Science, Infection Science (a modern view of microbiology encompassing infection control, epidemiology, bacteriology and virology) and Cell Science (into which histopathology, cytology and cellular pathology are evolving).

It follows that a new breed of scientist will be needed to take an overview of the previously separate disciplines outlined above. Taking this one step further sees the integration of haematology and biochemistry into blood science, together also with immunology, as the latter can be considered a branch of haematology. While many blood transfusion units may have a separate identity and staff (although rotations of junior staff are common), it is naturally at home with haematology, and is almost always physically linked. Indeed, we are witnessing the growing development of combined departments of blood science in hospitals. In parallel, many forward-looking universities, especially those already offering biomedical science degrees, are now developing undergraduate and professional courses in blood sciences that combine these two subjects.

> 'The past decade has seen the birth and slow development of blood science, which merges aspects of haematology, biochemistry and immunology'

The final piece of the jigsaw is the development of a new professional staff grade (ie the blood scientist). At present, scientists become qualified in any one of the main disciplines (haematology, blood transfusion, immunology or biochemistry): it is the rare individual who can boast dual qualifications. To this end, the Institute of Biomedical Science[2] is in the process of writing discussion documents and developing a joint list of skills appropriate to the new practitioner. But what should these skills comprise?

Sample reception

Many pathology units now have a centralised sample or specimen reception area. Here, blood samples and other specimens are booked in by reception staff, and are then processed to one of the laboratories where the analysis is performed. It follows that no high-tech laboratory skills are required in sample reception, but skills in computer processing are at a premium, and staff are required to be aware of health and safety issues. Consequently, highly skilled scientists are rarely found in sample reception, except perhaps to clarify a problem. However, sample reception staff members do carry the responsibility of ensuring sample details are recorded correctly (inevitably on a computer) and that specimens are directed towards the appropriate laboratory. In addition, some expertise is required in identifying and screening inappropriate samples.

Haematology and blood transfusion

A list (not exhaustive) of haematology and blood transfusion tests is given in Table 1.[3] The full blood count, providing information on red blood cells, white blood cells and platelets, is performed on a single closed sample tube, from which the erythrocyte sedimentation rate (ESR) may also be derived.
In some laboratories, however, ESR determination requires a separate tube. Tests of coagulation require plasma, haematinic tests (ie vitamins, iron) require serum; hence, both demand centrifugation of the sample tube and in some cases separation of the plasma/serum to a second vehicle. Collection of the samples into specific and different anticoagulants is required for these tests. The blood transfusion laboratory also demands blood samples centrifuged for the separate analysis of red blood cells and plasma.
Key processes in this unit are the determination of blood groups, the matching of blood from a patient with that from a donor,[4] and identification of antibodies.

Biochemistry

A major difference between haematology and biochemistry is that the latter focuses on the measurement of atoms, ions and molecules in serum, requiring blood to be allowed to clot, and then the separation of that clot from the serum by centrifugation.[5] Perhaps the main exception to this is the measurement of blood glucose, which calls for blood to be anticoagulated. As in haematology, most biochemistry tests can also be grouped together, examples of which include urea and electrolytes, and liver function tests (Table 2).

Immunology

Immunology can be viewed as the interface between haematology and microbiology, and this discipline studies the response of an individual to a foreign agent.[6] The foreign agent may be a bacterium, a virus, or tissue from another individual (ie a transplant) or, indeed, the individual themselves (ie autoimmunity). As in the other disciplines, immunology tests can be grouped together – immunologists assess antibodies, defined proteins, and the functions and subset tests of white blood cells (Table 3). The former can be measured in stored serum or plasma, but cell biology tests must be performed on whole blood and in real time.

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Staffing in pathology

In the past, a common hierarchy for staff in pathology subunits such as haematology or biochemistry saw a

TABLE 1. MAJOR ASPECTS OF HAEMATOLOGY AND BLOOD TRANSFUSION.

Full blood count:	Haemoglobin
	Red blood cell count
	White blood cell count
	Platelet count
	Mean cell volume
	Mean cell haemoglobin
	Mean cell haemoglobin concentration
	White blood cell differential
Coagulation	Prothrombin time / International normalised ratio
	Activated partial thromboplastin time
	Fibrinogen assay
	D-dimer
Erythrocyte sedimentation rate	
Haematinics	Iron studies
	Vitamin B_{12}, folate
Blood group determination	
	ABO
	Rh
Crossmatching	
Antibody detection	
Blood products	Platelets
	Fresh frozen plasma
	Cryoprecipitate
	Defined coagulation molecules (eg FVII, FVIII)
	Albumin

This list is not intended to be exhaustive.

TABLE 2. MAJOR ASPECTS OF BIOCHEMISTRY.

Urea and electrolytes	Urea
	Creatinine
	Sodium
	Potassium
Liver function tests	Bilirubin
	Alkaline phosphatase
	Gamma glutamyl-transferase
	Alanine aminotransferase
	Aspartate aminotransferase
Bone panel	Calcium
	Phosphate
	Parathyroid hormone
	Albumin
Endocrinology	Thyroid stimulating hormone
	Tetra-iodothyronin (T4– thyroxine)
	Tri-iodothyronine (T3)
Atherosclerosis and its risk factors	
	Glucose
	HbA1c
	Oral glucose tolerance test
	Total cholesterol
	HDL-cholesterol
	Triglycerides
	Creatine kinase
	Creatine kinase–MB
	Troponin

This list is not intended to be exhaustive.

chief scientist with overall responsibility for each department, and a senior chief scientist running the entire unit (Table 7). Perhaps two or three senior scientists would be responsible for different areas within each department (eg coagulation or endocrinology), and in turn each senior scientist would be likely to have the support of a number of basic-grade scientists. The staff establishment would likely be complemented by those in training grades. All of these staff members would have been expected to carry appropriate qualification in their particular disciplines, and senior staff may well have had higher qualifications (including management qualifications). Ancillary staff may also have had access to the laboratory, with essentially non-scientific duties.

TABLE 3. MAJOR ASPECTS OF IMMUNOLOGY.

Autoantibodies	Rheumatoid factor
	Antinuclear antibodies
	Acetylcholine receptor
	Adrenal antibodies
	Antineutrophil cytoplasmic antibodies
	C3-nephritic factor
	Cardiolipin antibodies
	Centromere antibodies
	Endomysial antibodies
	Extractable nuclear antibodies
	Gastric parietal cell antibodies
	Intrinsic factor antibodies
	Myeloperoxidase antibodies
	Smooth muscle antibodies
	Thyroid peroxidise antibodies
Defined proteins	β2-microglobulin
	C1 Inhibitor
	CH-50
	Complement components C3 and C4
	Immunoglobulins (total and subclass [eg IgE])
	Functional antibodies (eg to *H. influenzae*, tetanus toxoid)
	Paraproteins (serum and urine for Bence-Jones protein)
Precipitins	*Aspergillus*
	Avian
Cell biology	Lymphocyte subsets (eg CD4:CD8 ratio)
	Lymphocyte function (eg mixed lymphocyte reaction)
	Neutrophil function (eg phagocytosis, respiratory burst)

This list is not intended to be exhaustive.

TABLE 4. ASPECTS OF A PRACTITIONER TRAINING PATHWAY.

Biochemistry	
Automated biochemistry	Blood gases
Glucose meter	Immunoassay analyser
Osmolality	HbA1c
Urine dipsticks	Faecal occult blood
Haematology	
Full blood count	Erythrocyte sedimentation rate
Coagulation screen	Blood film morphology
Infectious mononucleosis	Malaria
POCT for haemoglobin	Sickle cell screen
Blood transfusion	
Blood group and antibody screen	Simple antibody identification
Red cell phenotype	Serological cross match / electronic issue
Selection and issue of blood components/products	Kleihauer
Immunology	
Protein electrophoresis and myeloma screening	ELISA
Immunofluoresence	Allergy testing

This structure has evolved over the past couple of decades with the appearance of the medical laboratory assistant (MLA) grade. These staff members are not expected to have scientific qualifications, and work alongside scientific staff in supporting roles such as the centrifugation of blood samples and separation of serum or plasma. However, it is very likely the roles of these and other staff will evolve very rapidly in the coming years and are also likely to be trained to perform certain defined scientific tasks. Following parallel changes in the nursing profession, itself allied to *Agenda for Change*,[7] many laboratory staff now finding themselves described as 'practitioners', and MLAs now 'associate practitioners'.

A good example of the benefit of a blood scientist is in on-call work. At present, haematologists do not do biochemistry, and vice versa, requiring both types of staff member to be available on call. It may well be that either specialist can be trained to perform the other's task, thus saving the present requirement for one of each. This is a clear step forward in people management and provides much-needed flexibility. But is it achievable?

At present, different models exist for blood science laboratories. The drive for increased efficiency, coupled with increased automation and the potential deskilling of laboratories has already seen the formation of blood science departments in hospitals. In some cases, these are essentially shared laboratory space, with specialist scientific staff overseeing their discipline-specific areas, and the only multidisciplinary service provided by MLA staff in sample reception areas. In other cases, multidisciplinary biomedical scientists and clinical scientists staff the laboratory, and provide a multidisciplinary on-call service. At present, there is no specific guidance on the optimal set-up for these laboratories; however, there is

'Lines of accountability naturally must be both transparent and robust, and there will also need to be considerable communication between stakeholders with diverse interests'

TABLE 5. BLOOD SCIENCE ROUTE MAP FOR A SCIENTIST SEEKING A HIGHER DEGREE.

Year 1 Foundation	Year 2 Specialism	Year 3 Specialism
Healthcare science	*Biochemistry* Clinical disorders of the major organs and cancer, endocrinology and diabetes	Nutrition, drug investigation, pregnancy, neonatal and paediatrics
Introduction to blood sciences	*Haematology and transfusion* Haematology Transfusion	Haemostasis, oncology, transfusion
	Immunology Immunity: implications for infection, for cancer, and for pregnancy, autoimmunity	Hypersensitivity and allergy, immunodeficiency and immunotherapy, transplantation
	Genetics Genetics of learning disorders, genetics of neuromuscular disorders	Infertility and disorders of sexual differentiation, population and screening, cancer
	All disciplines Research methods, research project	*All disciplines* Research project

Modified from reference 9.

'Undoubtedly, many traditionalists will resist change, whereas others will view it as an opportunity to develop and continue the evolution of biomedical science'

undoubtedly a need for specialist knowledge at the higher career grades, although in some cases even managerial posts may require multidisciplinary expertise, or expertise in cross-discipline automation.

What is needed?

The ball is already rolling with the *Modernising Scientific Careers* documents produced by the Department of Health,[1] although blood science is only one facet of this initiative as it deals with all life scientists (eg those involved in lung disease). These documents certainly offer an overview of a hoped-for career structure, but at the practical level individual hospital pathology laboratories will need to find their own way. For example, at the bench it may be relatively easy to train a haematologist to perform some biochemistry methods, but which training organisation will validate the 'syllabus', and which manager will sign off an individual as competent?

TABLE 6. STAKEHOLDERS IN THE DEVELOPMENT OF BLOOD SCIENCE.

The Department of Health via the Chief Scientific Officer

- Provide guidance on training and career structure (Modernising Scientific Careers) for practitioners and scientists.

The profession, for example:

- The Institute of Biomedical Sciences represents the vast majority of biomedical scientists. In the absence of a dedicated professional body representing clinical scientists, the IBMS is also likely to speak for this group. It will validate university courses in blood science as currently in biomedical science
- The Association for Clinical Biochemistry clearly speaks for those scientists with a role in biochemistry. Similarly, the British Toxicological Society is a stakeholder
- The Royal College of Pathologists: a membership once open only to those with a medical qualification, it currently has many clinical scientists as members and is finalising a route for biomedical scientists.

The Health Professions Council

- Concerned with registration and competence.

Universities

- Offer validated and non-validated undergraduate, postgraduate and refresher courses and training in blood science.

Given the current disparity in approach to the organisation of blood science laboratories, it seems likely that this will be something carried out on a local basis only.

Of course, a card-carrying haematologist, not a biochemist, will train junior haematologists, and vice-versa, but who can point to an appropriate and validated university course in blood science that will serve as the benchmark and will give the trainer the required licence? With no national view of what constitutes the required level of knowledge and training in blood science, these and other questions will be very hard to answer.

However, draft documents giving direction are now being published. One such document describes a practitioner training pathway,[8] highlighting sections of each segment of the blood science umbrella believed to be important at undergraduate level (Table 4). The full practitioner training pathway is a sizeable document listing all the major skills. Similarly, a second large document of 99 pages[9] points to key aspects of postgraduate training in blood science at MSc level (Table 5). There is also MLA/associate practitioner

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TABLE 7. PATHOLOGY STAFF STRUCTURES.

Past		Present		Future?
Senior Chief Scientist		Pathology Manager		Pathology Manager
Haematology chief scientist	Biochemistry chief scientist	Haematology manager (AfC 8)	Biochemistry manager (AfC 8)	Blood science chief scientist
Two or three senior scientists, each specialising in a defined area (eg coagulation, immunology)	Two or three senior scientists, each specialising in a defined area (eg endocrinology)	Two or three senior scientists, each specialising in a defined area (eg coagulation, (AfC 7)	Two or three senior scientists, each specialising in a defined area (eg endocrinology) (AfC 7)	Three or four senior scientists, each specialising in a defined area (eg haematology, immunology or biochemistry)
Basic grade scientists rotating around all sections of the laboratory	Basic grade scientists rotating around all sections of the laboratory	Basic grade scientists rotating around all sections of the laboratory (AfC 6)	Basic grade scientists rotating around all sections of the laboratory (AfC 6)	Basic grade scientists, perhaps some specialising in biochemistry or haematology: others with a joint qualification
Junior B scientists rotating around all sections of the laboratory	Junior B scientists rotating around all sections of the laboratory	Trainee scientists rotating around all sections of the laboratory (AfC 5)	Trainee scientists rotating around all sections of the laboratory (AfC 5)	Trainee scientists rotating around all sections of the blood science laboratory
Junior A scientists rotating around all sections of the pathology department		Medical laboratory aide / associate practitioner / assistant in the laboratory and in a unified sample reception area (AfC 3 and 4)		Associate practitioners in the laboratory and in a unified sample reception area
Ancilliary staff				

AfC: *Agenda for Change* banding.

training to allow career progression which may arise from a multidisciplinary core. Furthermore, the *Modernising Scientific Careers* Practitioner Training Programme allows training to graduate level in blood sciences, so is there also a role for professional bodies to provide postgraduate qualifications in blood sciences (eg specialist portfolio and higher specialist diplomas)?

Notably, several aspects of these documents can be traced back to National Occupation Standards,[10] and therefore provide a perspective for the breadth and depth of knowledge and skills required in order to be a competent worker in the field. It is clear, therefore, that these two documents[8,9] also provide a syllabus that must be met not only by training managers in hospitals, but also indicate the direction for universities. In many cases, however, effective training managers and universities will already be providing this training, so setting up a blood science programme will (hopefully) become an extended rebranding exercise.

The Health Professions Council, with which all scientists must be registered, may represent a hurdle, and there may also be legislative issues to address. Lines of accountability naturally must be both transparent and robust, and there will also need to be considerable communication between stakeholders with diverse interests (Table 6). As in any birth, there will be some pain and possibly some blood loss. Undoubtedly, many traditionalists with entrenched views will resist change, whereas others will view it as an opportunity to develop and continue the evolution of biomedical science. P

> 'At present, there is no specific guidance on the optimal set-up for blood science laboratories'

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