Guidance on Layout and Space Standards for Biomedical Laboratory Buildings

1 General Considerations

1.01 This section offers guidance on the matters that will need to be considered when developing a proposal for refurbishing or constructing a biomedical research building.

1.02 The various aspects of the design of laboratory buildings are discussed from the viewpoint of the scientists, that is the users of the proposed research facilities, who have the responsibility for preparing an application to the Joint Infrastructure Fund (JIF) and for explaining the needs of users to the architects and other professional consultants who will design the building and supervise its construction.

1.03 It is essential that the design of a laboratory building should be developed as a collaboration between the scientific users of the building, the buildings officer (or other appropriate official) of the institution concerned, and appropriate external consultants (architects, consulting engineers, quantity surveyors, etc.). It is highly desirable that the design team should regularly feed information back to and hear the views of the whole body of potential users, and not rely solely on consultation with a few representatives.

1.04 No two research laboratories will be identical. Not only will site constraints influence design, but the preferences and detailed needs of the users will vary. There are, however, many broad commonalties, particularly of building layout, space standards and services, which are applicable to most biomedical laboratories. These criteria should not be regarded as specific rules, but rather as aids to planning. They also help to identify proposals, or aspects of them, where the user requirements are significantly different from those which would normally be expected and so may require special justification.

1.05 Unusual provisions, in services, space or layout may also limit future flexibility in the use of the building. The lifetime of a research building will normally be much longer than that of the project(s) for which it was originally designed. It can be expected to house a number of different projects, once the initial ones have been completed. It is thus important that the basic design of a building allows sufficient flexibility that, in the future, new research projects in the same general field can be accommodated without the need for major alterations, and that, when alterations are necessary, they can be readily accomplished.

1.06 The architect, John Weeks, whose experience of laboratory design is extensive, sums up the need for flexibility as follows:

> "The most enduring requirement for an architect in the design of research facilities is the maintenance of the ability of the users to use the facility in an ill-defined way. All programs for research facilities are out of date when the facility is brought into use. All work patterns will have changed to some degree or another. All briefs are wrong, to a greater or lesser extent. All laboratories have to be furnished in such a way that they may be stripped out, altered or marginally changed at the will of the users. All equipment used in laboratories is obsolescent and will soon be changed. Nothing should be built into the structure, because the structure has a different life span to all the functions which occur within it. The working laboratory is an environment of clutter; that is the characteristic appearance of laboratory work and an architect interferes, with his obsession for visually neat order, at his peril and the peril of his clients."

2. Accommodation Required

2.01 Once the decision has been taken to provide either refurbished laboratories or a new building, the first step is to decide what accommodation is required. This will depend, in turn, on the nature of the scientific work and the number of people to be accommodated.

2.02 The useable areas of biomedical laboratories may be classified under the headings of primary, secondary and tertiary space. This classification reflects the type of use of the different areas and its relationship to the main scientific work of the project(s). Therefore, it reflects the relative proximities which the layout should provide (see Section 4).

2.03 Primary areas are those in which the scientific researchers perform their principal tasks. They may be divided into primary laboratory space and other primary areas, principally offices and writing spaces. The two types of primary area will differ in their service requirements. The primary laboratory space will contain the work stations designated as the 'base' for individual research workers, including research workers who also have the use of an office. There may also be additional workstations, for example, associated with a piece of equipment or an experimental procedure, which are not the principal work location of a particular person, but may be used by one or more persons from time to time. The primary laboratory space will require a full range of electrical, data/telecom and piped (water, gas, etc.) services. The other primary space consists of writing areas for research workers, the offices of senior research staff and their secretaries and offices for members of the research team, such as computer operators, who do not use a laboratory workstation. These offices and writing spaces will not normally require piped service outlets, and, depending on the layout of the building, may not need to be covered by the main distribution network for piped services.

2.04 Secondary areas (sometimes referred to as 'ancillary areas' or 'slave spaces') include all areas which accommodate functions directly related to the operations carried out in the primary areas. They comprise spaces such as specialist laboratories (e.g. electron microscopy laboratories, tissue culture laboratories, containment suites for genetic modification or pathogen work), equipment rooms, instrument rooms, machine rooms, cold rooms, constant temperature rooms, preparation areas, washing-up and sterilizing areas. Computer rooms

used by systems support staff, rather than research staff, are classed as secondary space. Secondary areas contain few dedicated workstations. Exceptions include preparation and wash-up areas and computer rooms used by computer support staff.

2.05 Tertiary areas are those whose functions support the research work, but do not always need to be close to the primary and secondary areas. They include such disparate functions as administration, meetings rooms, incoming and outgoing goods areas, central stores (including external stores for solvents, gases, waste, etc.), maintenance workshops and so on. Tertiary areas may also include a reading room or library and a staff common room or canteen, **but funding will not be provided for areas of these types.**

2.06 As well as the functions, number and size of the various rooms required, the working relationships between different rooms form the key to the layout of the building. It is, therefore, important for users to consider relationships between rooms as well as their types and sizes.

2.07 One useful way to begin to define the accommodation required, the relationships between different elements and the size of each room, is to undertake a careful appraisal of the accommodation in which the research work is currently being carried out, bringing out both positive and negative features.

2.08 The gross internal area includes everything within the external envelope of the building. In addition to the useable areas – the primary, secondary and tertiary areas – it includes the so-called balance areas. The balance areas include horizontal and vertical circulation – corridors, stairs and lifts – lavatories, ducts, plant rooms, cleaners' stores, the reception area and so on. The area required for plant rooms is particularly difficult to pin down at the early stages of design and so it makes for more useful data to use the gross internal area excluding plant rooms as the basis for comparison. A separate figure will need to be assessed for area of the plant spaces.

2.09 The next Section (Section 3) gives standards for the area of primary laboratory space per laboratory worker and the relationships between this area, the areas of other types of useable space and the gross internal area of the building. It also gives standards for the dimensions of laboratory benches, aisles and corridors. The standards are based on consideration of a large number of buildings designed for biomedical research. They are given as ranges, rather than precise figures, to allow some scope to accommodate the detailed requirements, priorities and design constraints of individual projects. Experience has shown that, below the minimum standards quoted, a scheme either would not provide adequate accommodation in the first instance or would be so closely tailored to the first users' requirements that it would be inherently inflexible. Conversely, figures significantly in excess of the maximum of the ranges either suggest that the scheme has unusual requirements which need special justification or may bring into question the efficiency of the planning.

2.10 The standards may be used to obtain an initial estimate of the floor area required to accommodate a research project and so of the cost of the building (or conversion) needed to house it. The number of research workers and other staff to be accommodated, taken with the standards in Section 3, can be used to calculate the areas of laboratories and other useable areas required. The total

useable area can in turn give an estimate of the gross area. A knowledge of the current cost, in £ per square metre, of building or converting laboratories for biomedical research of a similar type, with suitable allowances for any special features as well as for professional fees, VAT (if applicable), contingencies etc., allows a first estimate of the cost of the project to be obtained. With proper care, initial estimates calculated in this way can give a good approximation to the final size and cost. Nevertheless, the estimates will need to be refined as details of the accommodation are worked out and the design of the building is progressed.

3. Space Standards

3.01 Table of average areas per person

	m^2
Primary laboratory area per laboratory worker	6–10[1]
Total primary space per researcher	10–16
Primary plus secondary space per researcher	15–25
Gross internal area (excluding plant rooms) per member of total staff	20–30

[1]Add 2–3 square metres (m^2) when a writing place is included in the laboratory area.

3.02 Table of relative areas
(Percentages are given relative to the gross internal area *excluding* plant room area).

Type of space	**%**
Primary laboratory area (or space)	20–25
Other primary space (offices/writing spaces)	15–20
Total primary space	35–45
Secondary space	18–25
Total primary plus secondary space	55–65[2]
Tertiary space	10–20
Total net useable area	70–80
Gross internal area (excluding plant rooms)	100

[2]The ratio of secondary to primary space is in the range 40—70%. It will depend, among other things, on the disposition of equipment between laboratory space and special instrument rooms (secondary space).

3.03 Table of recommended laboratory working space dimensions
(All dimensions are in millimetres)

Length of bench per researcher	1800–2000 (2400 exceptionally)[3]
Bench depth for normal requirements	600–800[4]
Width of services upstand (or spine)	150–300
Clear distance between benches	1500–1600 (1800 exceptionally)[5]
Typical laboratory module	3200–3900[6,7]

[3]Suitable length will depend upon the amount of bench-mounted equipment 2000mm is a good median figure.

[4]Certain operations and pieces of equipment may require a greater bench depth. These need to be identified early in the design process, since they may be difficult to fit in at a later stage.

[5]Where a bench backs onto a wall, rather than another bench, a clear distance of 1200–1400mm will be required.

[6]The module is made up as follows:

2 × half partitions between modules	100 mm
2 × service upstands (spines)	400 mm
2 × 600 or 800 mm bench surfaces	1200–1600 mm
Minimum clear space between benches	1500 mm
	3200–3600 mm

A clear distance of 1800 mm between benches would give a module of 3500–3900 mm.

[7]The length of the bench module will depend on the unit size of the chosen laboratory furniture, usually 1000 mm for UK furniture manufacturers and 900 or 1200mm for other European manufacturers. Allowance should also be made for knee-hole spaces and underbench equipment, such as refrigerators and freezers.

3.04 Aisles and corridors

Aisles running along the ends of benches providing circulation within a laboratory	1200–1500mm[8]
Similar aisles, where there is no separate corridor for general circulation outside the laboratory	1800–2000mm[8]
General circulation corridors	1500–2000mm[9]

[8]These figures are for the clear width. Allowance must be made when the aisle may be partially obstructed, for example by staff using bench-end sinks, by doors opening into the aisle, by equipment, and by fume cupboards and safety cabinets.

[9]Where possible, and particularly when corridors are relatively long, a width of 1800–2000mm is preferable, for both functional and aesthetic reasons.

4. Building Layout – Working Areas

4.01 This section of the report is concerned with the locational relationship of useable areas.

4.02 Immediate adjacency is clearly essential between a laboratory and the other primary spaces which relate to it. Indeed, writing spaces may sometimes be located within the laboratory bench runs themselves, beside the workstations. There is a risk with that arrangement that writing surfaces tend to become used as overspill bench space, and their intended purpose is compromised.

4.03 Writing areas may be grouped in enclosed or partially enclosed areas in a number of ways. Each group of laboratory bench workstations may have its own set of writing spaces in a block at the end of the benches; or writing spaces for the staff of a whole laboratory may be located together in one room; or writing rooms serving several laboratories may be provided. The appropriate layout must be determined in the context of the users' requirements, the overriding criterion being ease of access between laboratory workstation and the associated writing area.

4.04 Primary and secondary areas need to be closely related physically to one another, as the movement between them of staff, equipment and materials is likely to be frequent. Some functions will appear a number of times, as each laboratory or group of laboratories will be likely to require certain secondary uses immediately adjacent. Other functions, such as media preparation and washing up, may be centrally located to serve the entire building.

4.05 The sizes of work groups may very well undergo changes during the lifetime of the project being undertaken by the first users; and when that project has been completed, further changes in the use patterns of the building may be expected. To facilitate change, the primary and secondary spaces should be laid out on a regular module with fixed elements such as structural columns located so as to cause the minimum interference to the ability to expand and contract the sizes of individual laboratories. The relationships between the primary and secondary spaces should have regard to the need to allow for flexibility in laboratory sizes, and also to the fact that the amount of secondary space directly serving each laboratory, or each group of laboratories, should be able to be altered to match changing needs.

4.06 In addition to allowing flexibility for change, the grouping of the primary plus secondary spaces, together with the adoption of a regular layout module, facilitates the design of services. The ability to minimize the number of services ducts and to keep their routes simple and direct is cost effective. This is particularly true in the case of bulky services elements such as ventilation and extraction ducts, the efficiency of which is directly affected by changes of direction and changes of cross section.

4.07 The need for proximity between the tertiary areas and the primary plus secondary areas will vary according to the tertiary function concerned. Meetings rooms, for example, may not need to be co-located with the laboratories.

4.08 In general, administrative areas may be located away from the laboratories: but senior laboratory-based personnel often combine research and administrative functions. It is important to identify such circumstances early in the briefing process – but it is equally important not to allow the building layout to become so oriented to the needs of the first users that different users could not readily be accommodated in the future.

4.09 In determining the relative locations of primary and secondary spaces, the need will arise to determine priorities in relation to daylight – or, more accurately, proximity to windows, as unassisted natural light is rarely adequate for scientific work, and it is the opportunity for staff to be in visual contact with the outside world that is the real factor under consideration.

4.10 The provision of an efficient layout is highly unlikely to allow all areas to have outside windows. Whilst the majority of secondary spaces are perfectly satisfactory as internal spaces, it is highly desirable that areas such as media preparation and wash-up, which are the primary workstations for the relevant staff, should have views to the outside.

4.11 Where writing areas are grouped together in sufficient numbers to serve all the staff in a laboratory, or even in several laboratories, it may well be possible to locate them in rooms with outside windows. However, where writing areas are located in small groups, immediately adjacent to the laboratory workstations they serve, they may be located in internal space. This is not particularly disadvantageous, as they are used for concentrated work over relatively shorter periods than are spent in the laboratories. Alternatively, writing areas may be located by the external wall, leaving the laboratory areas in internal, or semi-internal space.

4.12 Where the plan form is based on a central block of secondary space in the core of the building, flanked by laboratory areas, locating writing areas against the external wall has the significant advantage of minimizing the travel distance between the laboratories and the secondary areas that serve them; and the writing areas are located where there is least disturbance from people moving around.

4.13 The decision whether or not to have separate corridors between the laboratory modules on the perimeter of the building and the secondary space in the core will depend on the particular needs of the researchers. Using the end aisle of the laboratory modules to double as the main circulation increases the proximity of the primary to the secondary accommodation, but may result in more disturbance to the researchers. The choice has some effect on the ratio of net to gross internal area, which is one of the many reasons why, when relative areas are considered, the 'typical' ratios have to be stated as ranges, rather than finite figures.

5. Building Layout – Circulation and Amenity Provisions

5.01 The circulation routes – corridors, stairs and lifts – need to have regard both to ease of movement and avoidance of conflict. In particular, the provisions for circulation must take account of the need to accommodate trolley movements to and from media preparation and wash-up areas.

5.02 Whilst it is logical to have a passenger lift opening on to the main reception area, this is unlikely to be wholly satisfactory if the same lift has to double as a service lift for trolleys. Lift provision being expensive, there may well have to be some compromises; if they are unavoidable, they should be biased in favour of the scientific operations.

5.03 Circulation provision should allow for the need to get bulky equipment in and out of the building and, from time to time, to relocate it within the building.

5.04 Lavatory provision relates directly to the numbers of males and females who can be accommodated in a building of a given type. It is therefore important to provide sufficient facilities for the maximum numbers who may reasonably be

expected to be accommodated, even if the first users' occupancy is below that level.

5.05 Determining with any degree of accuracy the relative proportions of males and females who will occupy the building at any given time during its life is not possible. There are two basic ways to deal with this – firstly to overprovide, by assessing the maximum occupancy level and allocating lavatory accommodation on the basis of 75% male and 75% female staff and, secondly, to construct lavatories with adaptable partitions between them so that the proportions of male and females provision can be varied relatively easily.

6. Heights

6.01 The adequacy of the floor to ceiling heights is relevant to amenity (user comfort) and to the installation of equipment.

6.02 Amenity is concerned with the visual qualities of rooms. Whilst this is a subjective manner, ill proportioned rooms are less comfortable to use, particularly when ceilings feel too low relative to the size of the room.

6.03 Laboratories require a ceiling height of 2.7 metres to accommodate all normal equipment, including fume cupboards. Any special requirements for greater heights need to be determined at the start of the briefing process.

6.04 Smaller rooms, such as the offices of group leaders, secretaries and the like, would feel satisfactory with ceilings lower than 2.7 metres. However, where small rooms are interspersed with large rooms, it is not always practicable to vary the ceiling heights from room to room. It is invariably more satisfactory visually to have a somewhat high ceiling in a small room rather than an oppressively low one in a large room.

6.05 The depth of the ceiling void affects services, especially duct work for air handling, fume cupboards, etc. It is essential that the ceiling void gives sufficient space for the initial service requirements and for the future accommodation of any changed requirements that might reasonably be foreseen.

6.06 Air conditioning and fume extract ducts are particularly bulky services elements, and their operational efficiency is seriously impaired if the optimum cross sectional size and shape cannot be accommodated, or if there are changes of direction. It is thus very important that the clear depths of ceiling void provided by the architect's proposals - that is, the amount of space which is not compromised by the presence of downstand beams or other obstructions is adequate. It is, unfortunately, not uncommon for services design to be considered in any detail rather late in the design process. Laboratories are highly serviced buildings, and it is prudent to consider very early, and to show clearly even on the initial design proposals, the properly sized major duct routes.

6.07 A ceiling void of less than one metre will not normally be satisfactory in the long term, whereas voids of 1.5–2.0 metres facilitate the provision, maintenance and alteration of services, particularly where the building has a deep plan. Naturally ventilated buildings will, of course, be likely to require shallower ceiling voids than air conditioned buildings.

6.08 Floor to floor heights will be generally within the range of 4–5.5 metres, depending on the sizes of the main room, the levels of servicing required and the constructional system adopted.

7. Services and Equipment

7.01 There are certain fundamental aspects of services and equipment which need to be covered early in the design process, as they impact directly on spatial provisions, and the design of the building.

7.02 One element which has a major influence on the basic design of any building is the means of heating and ventilation. The decision whether to use air conditioning may be determined immediately by the building's location, if there is significant air or noise pollution. In a location where natural ventilation would otherwise be acceptable, air cooling or full air conditioning may be necessitated by the operations to be carried out, where more heat will be generated than could be dispersed by natural ventilation or where exceptionally clean air is necessary. Simple heat removal may be required for such areas as freezer rooms. Decisions on means of ventilation need to be made very early in the briefing process, as they relate directly to the depths of ceiling void needed and hence to the storey heights.

7.03 Energy conservation is becoming an ever more important consideration, and this applies not only to minimizing the energy required to heat a building but also to the energy required to remove excess heat. It is thus important to ensure that windows do not permit excessive solar gain. The capital cost of effective energy management can be a significant item in the construction cost, and it is therefore necessary to look at the likely payback periods, as well as the benefits to the users' working conditions.

7.04 Fume cupboards, safety cabinets and the like can draw substantial volumes of air from rooms, which needs to be replaced with air at a suitable temperature. This poses one of the services engineers' most intractable problems, as there is no alternative to designing the heating and ventilation on the basis of assumptions as to the frequency and nature of the usage of the fume cupboards in any particular room and, to be safe, those assumptions have to err on the high side. The problem can be mitigated by the selection of those types of fume cupboards which have devices which automatically change the rate of extraction according to the amount the access panel is open.

7.05 The incoming services to laboratories and other areas need to be identified at an early stage by the intended users. Where there is no demand for a service which might be expected to be generally found in biomedical laboratories, consideration should be given to the means of providing it in the future, as and when demands arise. The need to provide for future flexibility requires that service risers and ducts should be constructed initially with some spare capacity, and designed so that access for the addition of new services, as well as for maintenance and repair, is facilitated.

7.06 The provision to be made for information technology (IT) needs to be considered at an early stage in the design process. It can represent a substantial factor in the cost of a building and, in addition, time may be needed for

extensive discussion to ensure that the provision made is suitable for present needs and allows sufficient flexibility and room for expansion to accommodate technological advances and changing requirements in the future. In this area, consultation with users is especially important, as also is the employment of expert consultants who can assess how best to meet perceived needs and be aware of future trends. IT seems to be one aspect of a new building where generous provision for future expansion may well be justifiable.

7.07 Consideration needs to be given to the storage and disposal of materials which cannot be accepted by the local authority's normal refuse services or disposed of directly via the mains drainage. Such materials include those which are volatile, toxic or radioactive. The provision of dedicated sinks with drainage to a protected holding tank may be necessary.

7.08 It is important to ascertain at an early stage what scientific equipment is to be accommodated in the context of layout and space planning, and to ensure that adequate power is available and the heat outputs of the various items can be accounted for in designing the buildings heating and ventilation systems.

7.09 The full extent of the required plant room area will only be known at a relatively late stage in the design. In appraising preliminary designs, therefore, it is possible only to ensure that there will be space for the largest likely plant room – which may be as much as 20% of the gross internal area, but could be less than 10%. It is by reason of that uncertainty that comparative area figures related to the gross internal area should look at the latter excluding the plant room.

8. The Site

8.01 The site may be land for a new building or may be an existing building for adaptation and/or fitting out. The following matters, where applicable, need to be identified and considered:

(a) Tenure – freehold, ground lease or building lease. Assurance must be provided as to the security of tenure for whatever period is deemed to be necessary in the circumstances applying to the particular project under consideration.

(b) Covenants – any restrictive covenants which could impinge upon the building proposals or the operations to be carried out in the buildings (short and long term) need to be identified at the outset.

(c) Town planning – preliminary consultations should have been carried out with the local town planning authority to determine whether the proposals will, in principle, be acceptable. It may be advisable to submit a formal outline planning application at an early stage to try and secure a specific permission for development of the scale and nature envisaged.

(d) Possible height restrictions due to the proximity of an airfield need to be investigated.

(e) Flood risk, the possibility of contaminated land and potential instability (due, for example, to past, current or proposed mining operations) need to be investigated.

(f) The nature and condition of the subsoil should be investigated and any effect this may have on the foundations and structure of the building assessed.

(g) The appropriate bodies should be consulted to determine the likelihood of significant archaeological discoveries, the excavation of which could cause delays to the building construction programme.

(h) The neighbouring land uses should be investigated, to ensure they will not adversely affect the research work by fumes, noise or vibration. It is also necessary to discover whether any special steps would need to be taken to prevent nuisance to neighbours – noxious discharges from fume cupboard flues, noise from air conditioning or other equipment and so on.

(i) Security – if there are general security problems in the area, or if the research to be carried out is particularly sensitive or controversial, the site must be capable of being made secure, to a degree compatible with the perceived risks.

(j) Services – the availability of all services normally required by biomedical laboratories must be investigated (even if one or more may not be needed by the first users). This includes incoming services (power, water, gas, telecommunications) and outgoing (drainage).

8.02 *Access* – the access(es) to and from the site must be adequate for the nature and volume of traffic envisaged. The highway authority must be satisfied with the proposals. Failure to take full account of these matters at the earliest possible time can result later in significant problems and delays to the programme.

8.03 *Circulation on site* – appropriate separation needs to be achieved between incompatible types of traffic – private cars, delivery vehicles and refuse collection lorries. The routes for each should be easy to follow and potential conflict avoided, with suitable priorities given at junctions. Safe pedestrian routes should be provided.

8.04 Access to building(s) – consideration should be given to the location of building entrances so as to give adequate separation of entrances for staff and visitors from those for goods deliveries and refuse collection. Access points for goods delivery and refuse collection should be located so that their use does not disturb the building's occupants.

8.05 *Parking* – two factors influence the provisions for vehicle parking:

(a) the needs of the building's users;

(b) the requirements of the local planning authority.

In many cases, the local authority will stipulate the minimum level of provision that it requires, provisions in excess of the minimum requirement being perfectly acceptable. However, in certain urban areas, the local authorities endeavour to limit traffic movements by imposing maximum levels of parking for each type of building, or 'use class'. In such cases, it is important to endeavour to ensure that the local authority will allow sufficient parking provision to meet the essential needs of the users. It may be necessary to seek special agreements with the local authority if it is expected that staff will be working unusual hours and finishing work at times when public transport will not be available.

8.06 *Convenience and security* – considerations of convenience and security relate to such matters as signage, lighting and site perimeter walls, fences and gates. Whilst these may be relatively small proportions of the budget, security in particular may be found to be financially quite significant. It may be that the appropriate level of security demands such provisions as a manned gatehouse, television surveillance cameras and so on. The needs for site security relate to the proposed activities on the site or to the nature of the surrounding area, or to a combination of both.