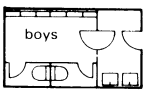
General guidelines

Secondary schools (with no 6th form)

e.g. 2 or 3 classes per year	
10 (12) or 15 (18) classrooms	each 65–70 m²
1 extra-large classroom (can be divided)	85 m²
3 classrooms for special courses	40–45 m²
Science rooms	
1 or 2 for demonstrations & practicals, or	each 70–75 m²
1 for physics demonstrations & practicals	70–75 m²
1 for chemistry and biology demonstrations & practicals, or	70–75 m²
1 for chemistry demonstrations & practicals	70–75 m²
1 for biology demonstrations & practicals	70–75 m²
1 or 2 preparation rooms, plus rooms for collections and materials,or	each 40 m²
1 preparation room for physics and chemistry (also used for collections and materials),or	30–35 m²
1 physics preparation room	30–35 m²
1 chemistry preparation room	20 m²
1 biology preparation room	30–35 m²
1 or 2 science rooms	each 30–35 m²
1 room for photography	20–25 m²
Domestic science	
1 kitchen	70–75 m²
1 classroom/dining room	30–40 m²
rooms for provisions, materials and household appliances	30–40 m²
1 washroom/changing room	15–20 m²
Art, crafts and textiles	
1 drawing studio (arts and crafts)	
1 or 2 rooms for technical crafts	
1 or 2 rooms for materials	
1 washroom/changing room total of approx.	180–220 m²
1 room for textile design	70–75 m²
3 rooms for teaching materials	each 10–15 m²
1 music room	65–70 m²
1 storeroom (instruments, music, stands)	15–20 m²
Language lab	
1 room for language teaching system	80–85 m²
1 room for materials and equipment	10–15 m²
1 room for library and magazines	60–65 m² or 70–75 m²
1 room for pupils' committee	15–20 m²
1 recreation room (to accommodate a maximum of half the total no. of pupils at 1 m²/pupil)	
Administration	
1 staffroom (meeting room)	80–85 m²
1 staff study (staff library) (or can be combined)	100–105 m²
1 office for headteacher	20/25 m²
1 office for deputy head	20–25 m²
1 office	15–20 m²
1 room for meeting parents, doubles as sickroom	20–25 m²
1 caretaker's room (also for milk distribution)	20–25 m²
Sport	
Gymnasium (per 10–15 classes)	
1 exercise area of 15 × 27 m	
Sports grounds according to requirements	

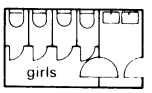
Secondary school (with 6th form)

e.g. 2 classes per year	
18 classrooms:	
12 classrooms	65–70 m²
6 classrooms (upper level)	50 m²
5 classrooms:	
2 supplementary classrooms	65–70 m²
3 supplementary classrooms	50 m²
1 extra-large classroom (history, geography)	
1 room for social sciences	50 m²
Science rooms	
Physics and biology	
1 classroom	each 55–60 m²
1 room each for collections and materials	30–35 m²
1 room each for preparation	30–35 m²
1 room each for demonstrations & practicals	70–75 m²
Chemistry	
1 room for theory and practical work	80–85 m²
1 room for preparation	30–35 m²
1 room for collections and materials	30–35 m²
2 rooms for science groups	each 30–35 m²
1 room for photography	20–25 m²
Domestic science	
1 kitchen	70–75 m²
1 classroom/dining room	30–40 m²
Rooms for provisions, materials and household appliances	30–40 m²
1 washroom/changing room	15–20 m²
Art	
1 drawing studio	80–85 m²
2 rooms for crafts	60–65 m²
2 rooms for materials	each 20–25 m²
1 washroom/changing room	15–20 m²
1 room for textile design	70–75 m²
1 music room	65–70 m²
1 storeroom	15–20 m²
Language lab	
1 room for language teaching system	80–85 m²
1 room for materials and equipment	10–15 m²
3 rooms for teaching materials	each 10–15 m²
1 room for school library	70–75 m²
1 room for pupils' committee	15–20 m²
1 recreation room to accommodate a maximum of half the total no. of pupils at 1 m²/pupil)	
Administration	
1 staffroom (meeting room)	80–85 m²
1 staff study (staff library) (or can be combined)	100–105 m²
1 office for headteacher	20–25 m²
1 office for deputy head	20–25 m²
1 office	15–20 m²
1 room for meeting parents (doubles as sickroom)	20–25 m²
1 caretaker's room (also for milk distribution)	20–25 m²
Sport	
Gymnasium (per 10–15 classes or part of)	
1 exercise area of 15 × 27 m	
Sports ground according to requirements	



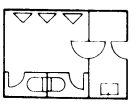
(e.g. for 100 boys, 15 m²)

① **Lesson-time WCs**



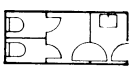
(e.g. for 100 girls, 15 m²)

② **Lesson-time WCs**



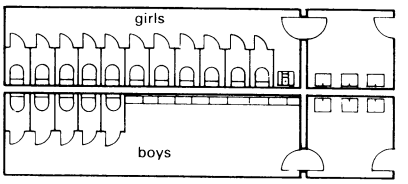
(e.g. for 30 teachers, 15 m²)

④ **WCs for male staff**



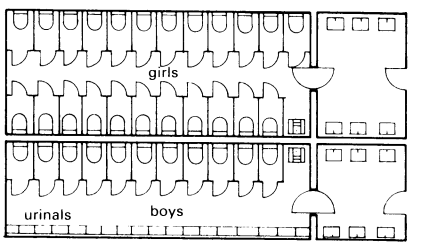
(e.g. for 20 teachers, 10 m²)

⑤ **WCs for female staff**



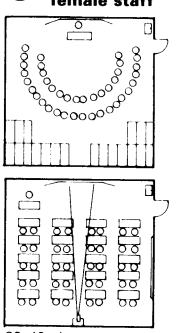
(e.g. for 250 girls, 40 m² and 250 boys, 40 m²)

③ **Break-time WC facilities**

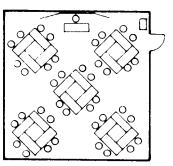


(Note: for larger complexes decentralised facilities should be provided.)

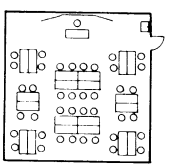
⑥ **Double-range facilities for 500 girls, 65 m²; for 500 boys, 40 m²**

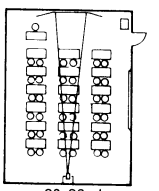


32–40 places



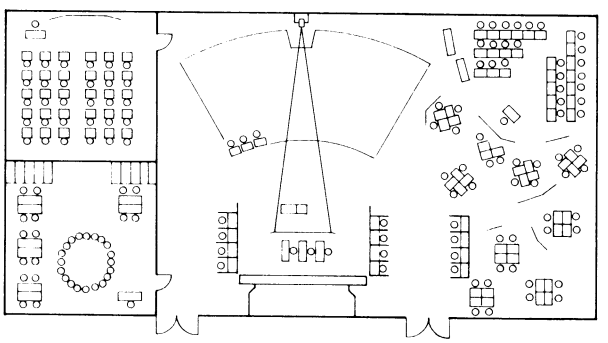
standard classroom
square or rectangular 65 m²
with furniture in rows
and freely arranged furniture





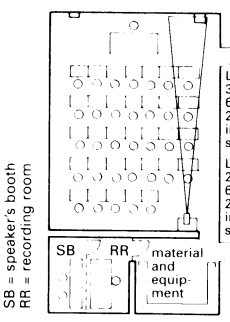
30–36 places

⑦ **Rooms and areas for general-purpose teaching**



option: either divided into 6 standard classrooms and staffroom or as open-plan teaching space

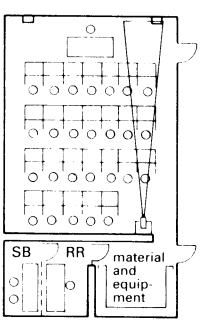
⑧ **Teaching area with desks for 180 pupils 550 m²**



(LT = listen and talk)

LT lab · ⑨
33 pupils at desks, 65 m² (approx. 2.0 m²/place) including ancillary spaces 95 m².

LTR lab · ⑩
23 places in booths, 65 m² (approx. 2.8 m²/place) including ancillary spaces 95 m²



(LTR = listen, talk, record)

⑨ **Language lab**

⑩ **Language lab**

Cloakroom facilities can be decentralised by allocating space outside the classrooms but directly linked to them. The number of toilets, urinals and wash-basins required, based on total number of pupils and separated according to sex, should be as set out in the local school building guidelines (e.g. → ⑪). Sanitary installations with direct daylight and ventilation are preferable, and there must be separate entrances for boys and girls. Examples of different toilet facilities for schools are shown in ① - ⑥.

Horizontal and vertical circulation usually doubles as an emergency escape route. Escape routes must have a clear width of min. 1 m/150 people, but min. width of corridors in classroom areas is 2.00 m or 1.25 m for less than 180 people. Stairs in classroom areas must be 1.25 m, other escape routes 1.00 m. Max. length of escape routes: 25 m measured in a straight line from the stairwell door to the furthest workplace, or 30 m in an indirect line to the centre of the room. Capacity of stairs is dependent on number of users, average occupancy, etc. Width of stairs: 0.80 m/100 people (minimum 1.25 m, max. 2.50 m). Alternatively: 0.10 m/15 people. (Only the top floor is calculated at 100% occupancy, remaining floors at 50%.)

General-purpose teaching area includes standard classrooms, supplementary classrooms, extra-large classrooms, rooms for special courses, rooms for teaching languages and social studies, language labs, rooms for teaching material, maps and other ancillary rooms.

Space requirements: classroom for traditional teaching 2.00 m²/pupil; for teaching in sets 3.00 m²/pupil, for open plan teaching 4.50 m²/place including ancillary areas needed for each subject.

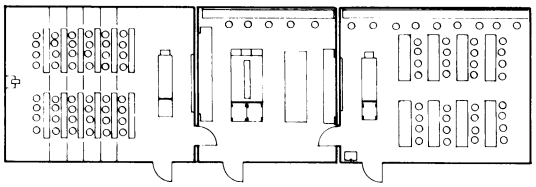
Standard room shape: rectangular or square (12×20, 12×16, 12×12, 12×10); with a max. room depth of 7.20 m it is possible to have windows on one side only. → ⑦

Floor areas are: traditional classroom, 1.80–2.00 m²/pupil; open plan 3.00–5.00 m²/pupil. The clear height should be 2.70–3.40 m.

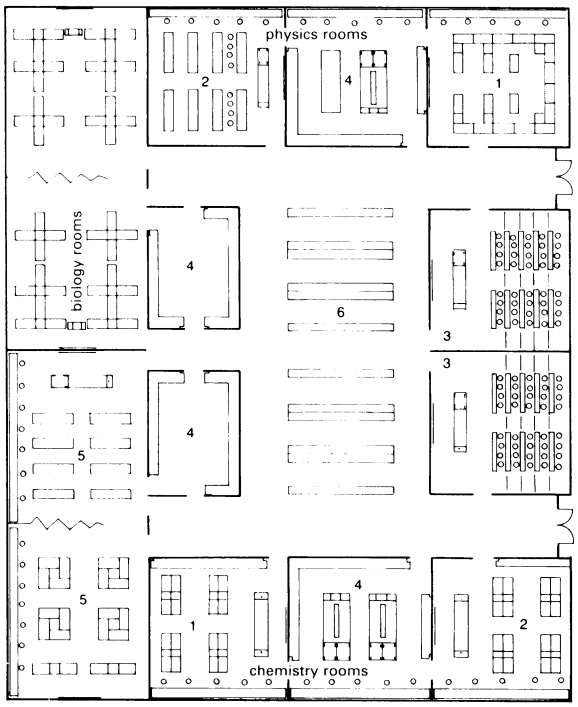
Language labs should be within or directly related to the general-purpose teaching area, and close to media centre and library. Approximately 30 language lab. places per 1000 pupils will be needed → ⑨ - ⑪. The size of LT (listen/talk) and LSR (listen/talk/record) labs is approx. 80 m²: booths 1×2 m, number of places/lab. 24–30, i.e. 48–60 m², plus ancillary spaces (e.g. studio, recording room, archive for teachers' and pupils' tapes). Artificially-lit internal language labs with an environmental control system are also possible.

Term	design	segregated boys/girls	position	use	miscellaneous
Class WC	sanitary inst. with lobby	no	next to a classroom	during lessons	for pre-school or kindergarten poss. 2 WCs and lobby
Lesson WC	sanitary installation	yes	accessible from corridor or lobby	several classes during lessons	from each classroom withouta WC the max. distance (incl staircase) from a lesson WC should be 40 m
Break WC	sanitary installation	yes	accessible from schoolyard or entrance lobby	for classes during breaks	WC at ground floor level, on perimeter of building, accessible from areas used during breaks
Staff WC	sanitary installation	segregated women/ men	part of the staff or office area	during breaks	possibly linked to staff cloakroom

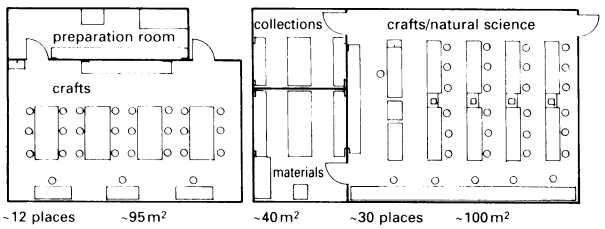
⑪ **Recommended WC facilities**



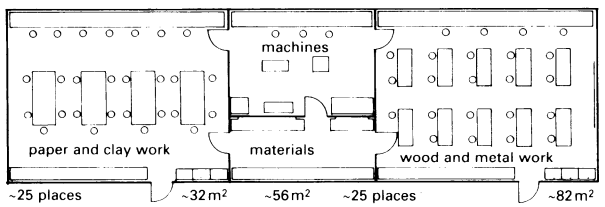
① **Rooms and areas for science teaching**



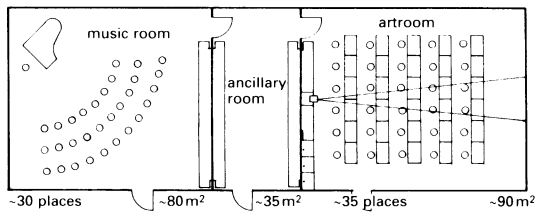
② **Science area with 400 places 1400 m²**



③ **Rooms and areas for technical subjects, economics, music and art** → ④ – ⑥



④ **Areas for technical subjects**



⑤ **Music and art**

Science area includes rooms for teaching of theory and practice, practicals, preparation and collections, photographic studios and labs. Classrooms for biology, physics and chemistry 2.50 m²/place. For lectures and demonstrations in practical work 4.50 m²/place including special-purpose ancillary space but not including ancillary rooms.

Room sizes for demonstrations and practicals in chemistry and biology, physics, or combinations should be 70–80 m² → ①. Ideally, for physics, biology and chemistry lectures (possibly including demonstrations) 60 m² is needed, with fixed raked seating. Second entrance/exit. Possibility of internal classroom with artificial lighting.

Room for practical work, group work in biology and physics and as well as interdisciplinary work, space divisible into smaller units. 80 m² per individual room or space.

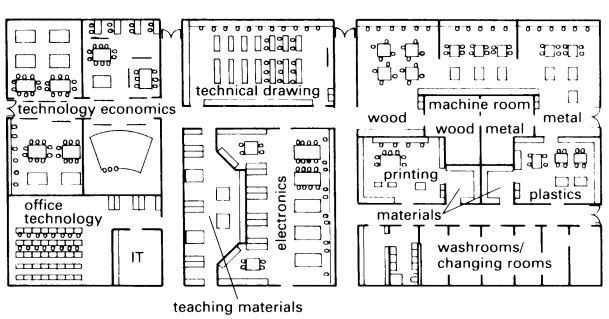
Rooms for preparation, collections and materials for individual subjects or combinations of subjects. Total of 30–40 or 70 m² depending on the size of the school and the science area. Internal rooms with artificial light allowable.

Rooms for photographic work and photographic labs are best associated with the science rooms. Ideally, they should be in the form of a studio, with a lobby between the lab and teaching area. Dark room with areas for printing (1 enlarging table for 2–3 pupils, combined with wet-processing places), for developing negatives and rooms or area for loading film.

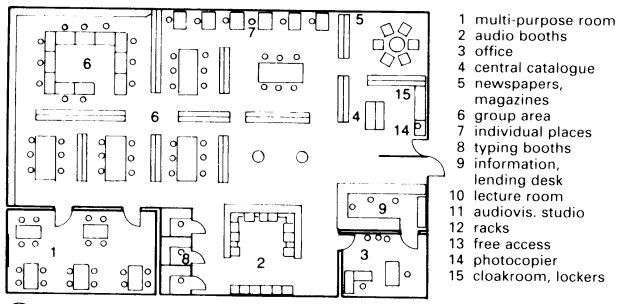
Position of rooms: best north-facing with constant room temperature. Space required depends on number of pupils, generally 6–14 pupils per group, at least 3–4 m² per workplace. Type of photo lab depends on areas and sizes:

- one-room lab 20–30 m², minimum size with separate bay of 1.50–2.0 m² for loading film.
- two-room lab 30–40 m², consisting of lit room, light lock and dark room (positive and negative work), film-loading room 2 m².
- three-room lab, printing room, lit room with necessary light locks, light locks 1–2 m² without furniture, dark room lamps only.

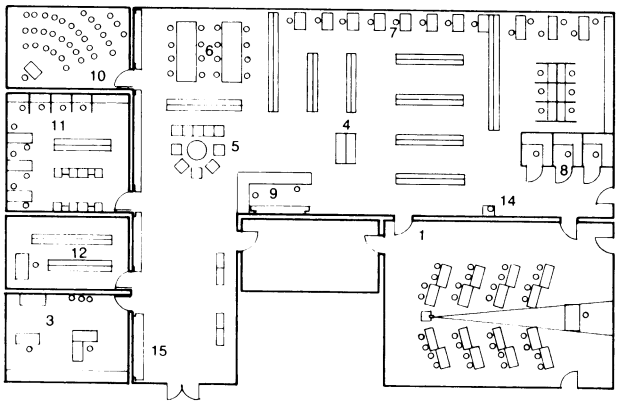
For exhibitions, etc. shared use of other rooms is possible.



⑥ **Areas for economics of technology, office technology, technical drawing and crafts, total of 350 places, 1600 m²**



①



② **Example of school library/media centre**

Library, media centre and central amenities:
Purpose: information centre for classwork, further education and leisure and may be used by pupils, teachers and non-school users.

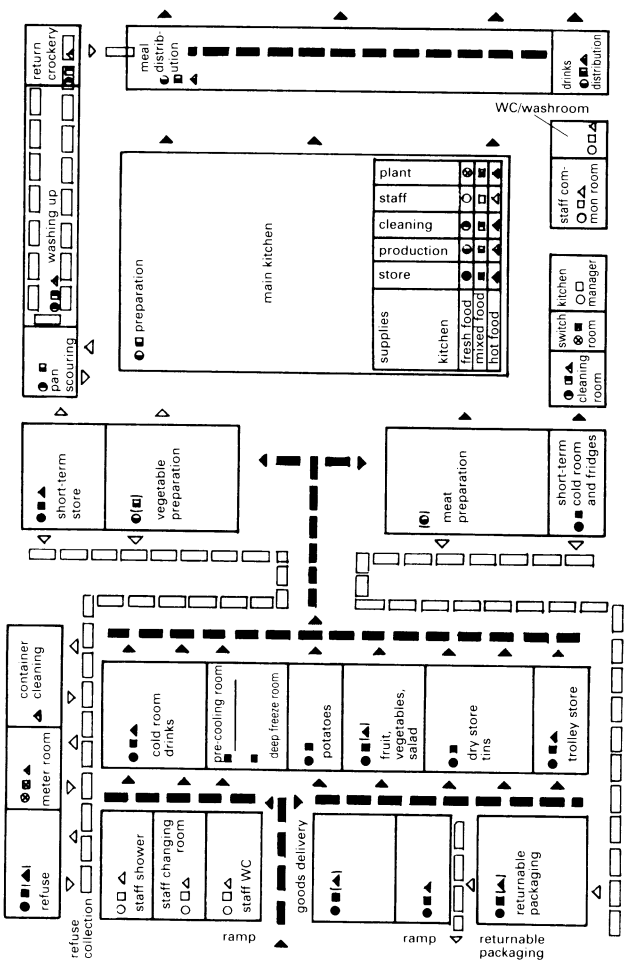
Library includes a conventional school library for pupils and teachers with books and magazines, lending facilities, reading and work places. The media centre is an extension of the library with recording and playback facilities for radio, film, TV, i.e. audio-visual equipment and a corresponding stock of software, microfilm and microfiche facilities.

Standard space requirement overall: library/media centre 0.35–0.55 m²/pupil. Broken down into:

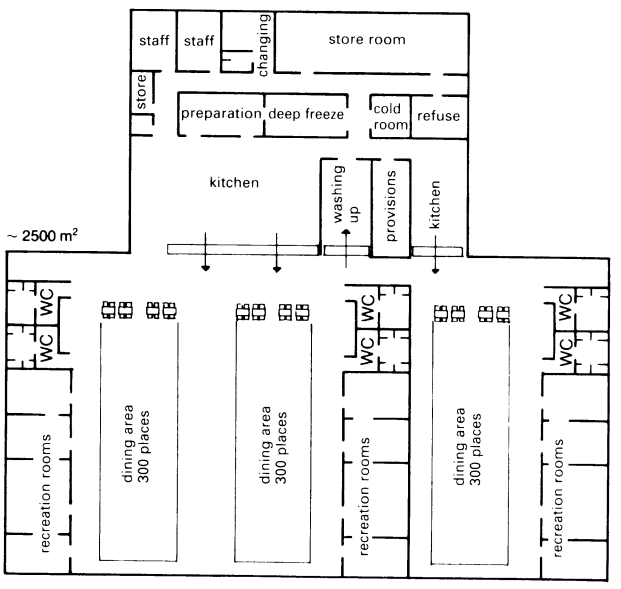
- book issues and returns, 5 m² per workplace, and catalogue space of 20–40 m²
- information: librarian, media advisor, media technician, etc. 10–20 m² per person

Compact book storage in 1000 volume stacks at 20–30 volumes/metre run of shelving. Free access bookcase approx. 4 m² including circulation space, reading places and catalogues. For 1000 volumes reference books 20–40 m², study area generally per 1000 volumes reference books 25 m² for 5% of the pupils/teachers, but at least 30 study spaces at 2 m² each, i.e. 60 m² carrels 2.5–3.0 m². Room for work in groups of 8–10, 20 m² → ① - ②.

For kitchen and ancillary rooms, the size and equipment specification depends on the catering system. Table service for food and table clearing for young children (portions possibly served by teacher), otherwise self-service (e.g. from conveyer belt, counter, cafeteria line or free-flow system). Distribution capacity of 5–15 meals/minute or 250–1000/ hour, variable staffing levels. Space required for distribution systems 40–60 m². Dining room size depends on number of pupils and number of sittings, min. of 1.20–1.40 m² per place. Larger spaces should be divided up. For every 40 places, 1 wash-basin in the entrance area → ③ - ④.



③ **Organisation of space and functions in school kitchen**



④ **Meal and crockery distribution and dining area**

SCHOOLS

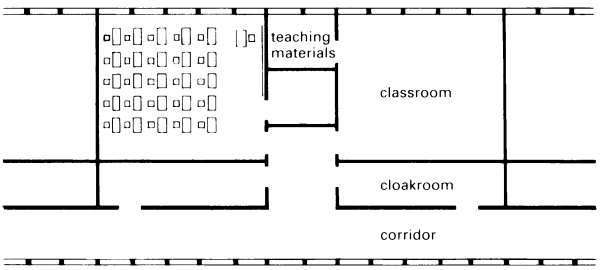
Primary schools

Classrooms: one classroom per class, square if possible, in exceptional cases rectangular, max. 32 pupils, min. of 65–70 m² (approx. 2.00 m² × 2.20 m² per pupil) if possible daylit on two sides → ③ + ⑥. Furniture either in rows or informally arranged.

Front of class: chalkboard with sliding panels, projection space, socket for TV, radio, tape recorder, etc., wash-basin near entrance. Provision for hanging maps. Facility to black out windows. Group rooms divided into separate workspaces to accommodate mixed ability classes only in special cases.

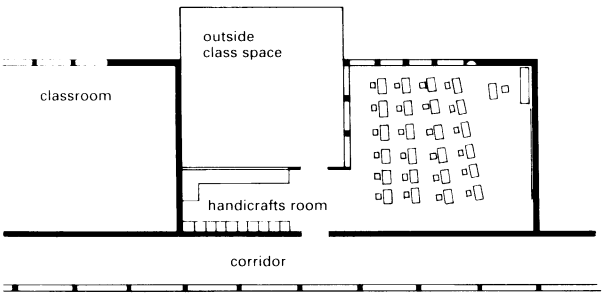
Alternatives to individual classes and group rooms: 2–3 classrooms joined together to make teaching spaces for discussions between pupils and teachers, or lessons in larger groups; can also be divided by partitions. Draught-excluding lobbies and entrance areas also connect to horizontal and vertical circulation (corridors, stairs, ramps) and can be used during breaks (0.50 m²/pupil). Multi-use area for parties, play or exhibitions.

Room for teaching materials 12–15 m²: centrally positioned, part of the staff area or in a multi-purpose room.



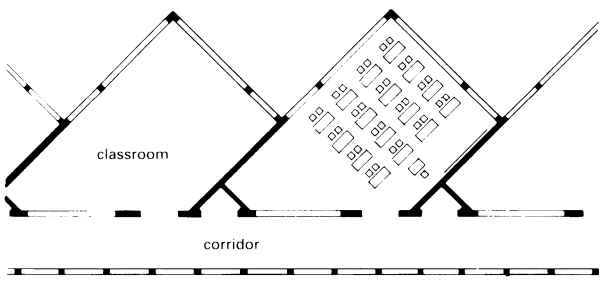
Architect: Yorke, Rosenberg, Mardall

① **Example of school library/media centre. Classroom lit and ventilated from two sides via cloakroom and corridor. Corridor opens out every second classroom with a room for teaching materials**



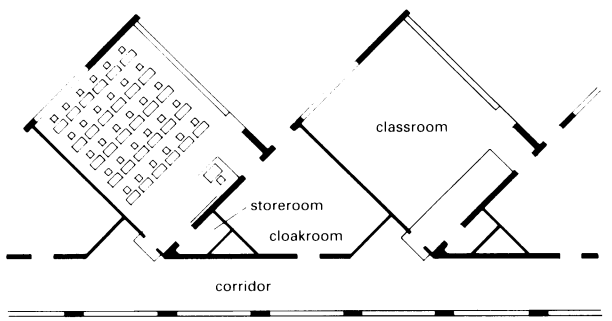
Architect: Neutra

② **Example of joining classroom, outside classroom space and hobby room**



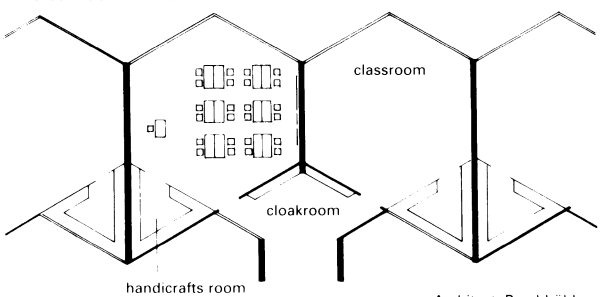
Architect: Carbonara

③ **Saw-tooth layout, risk of disturbance between rooms**



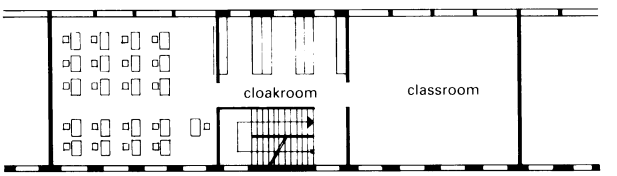
Architect: Carbonara

④ **Classroom with daylight from high window, but no window at the back. Corridor opens out in front of each classroom with cloakroom and store room**



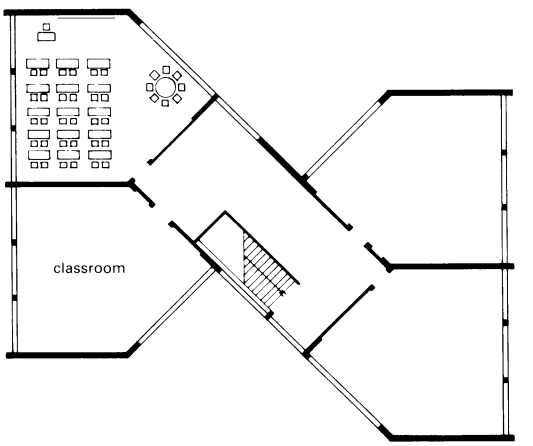
Architect: Brechbühlen

⑤ **Hexagonal classrooms and internal triangular handicrafts room with no windows**



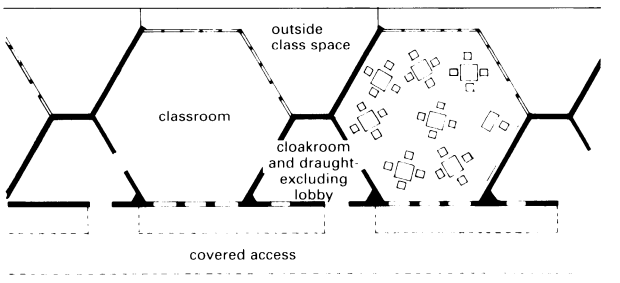
Architect: Schuster

⑥ **Multistorey building, two classes around a staircase, daylight from two sides**



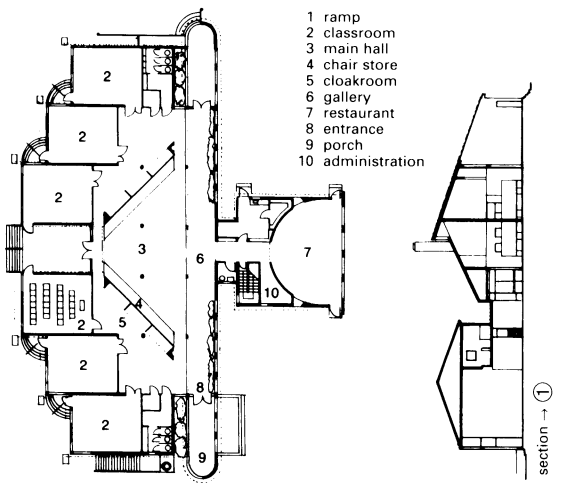
Architect: Haefeli, Moser, Steiger

⑦ **Four classrooms/floor with daylight from two sides, extended on one side for group teaching**



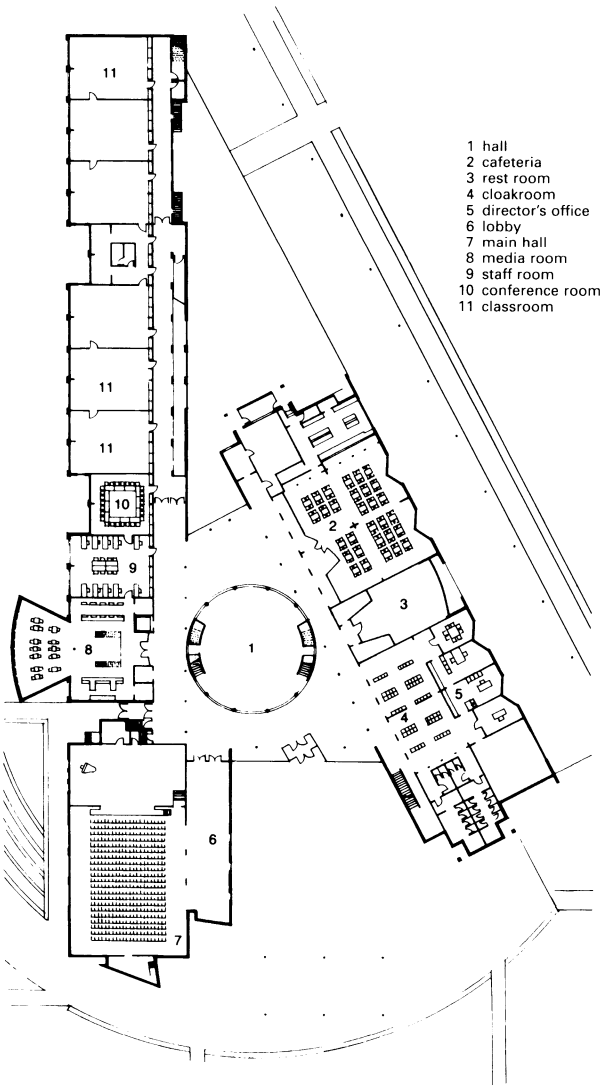
Architect: Gottwald, Weber

⑧ **Hexagonal classrooms with no corridor, access through cloakroom, lobby**



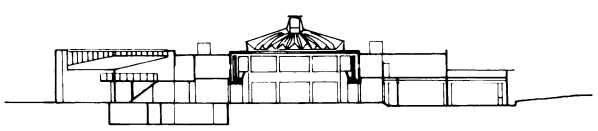
Architects: Mitchell/Giurgola

① **College for vocational training**

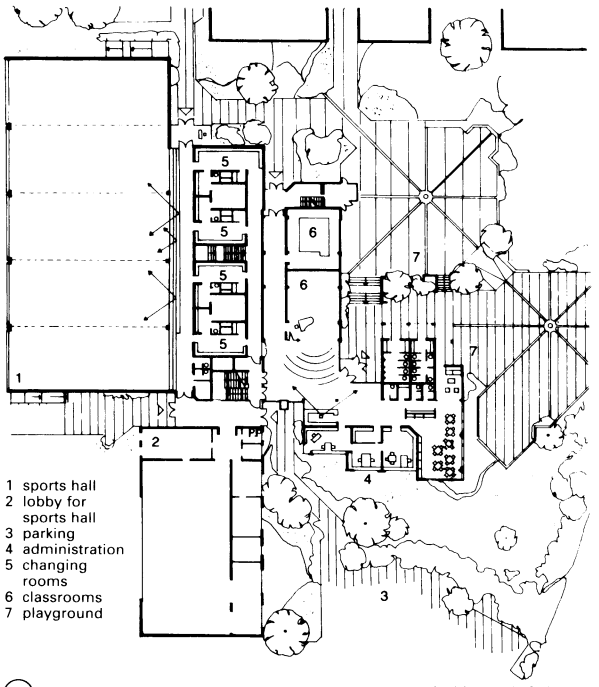


Architects: Burkard, Meyer, Steiger

② **Ground floor of a school in Wohlen**

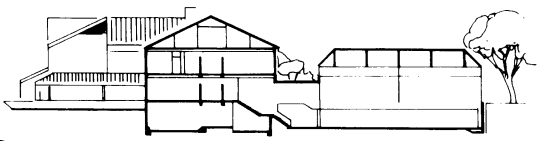


③ **Cross-section → ②**

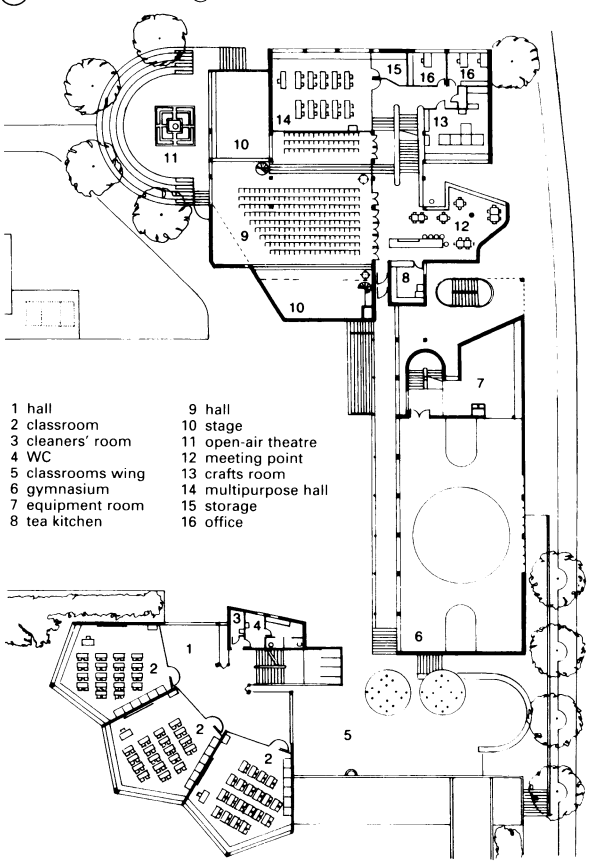


④ **Ground floor of a primary school**

Architects: B. & C. Parade



⑤ **Cross-section → ④**

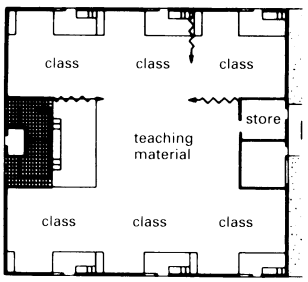


Architects: Naef, E. Studer & G. Studer

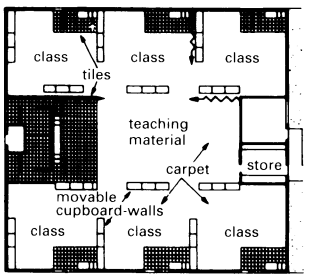
⑥ **Top floor of a school in Zurich**

SCHOOLS

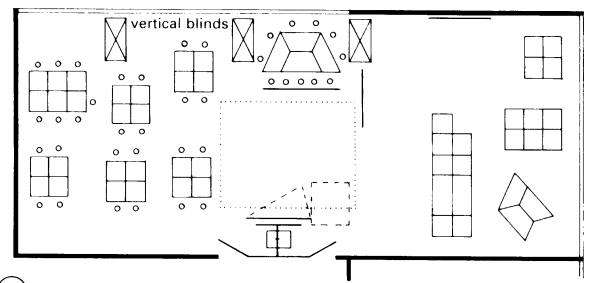
Open-plan



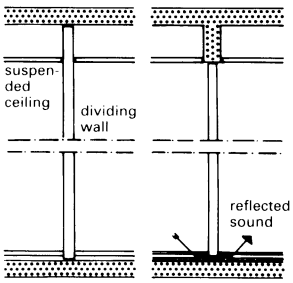
① **Schoolroom without walls**



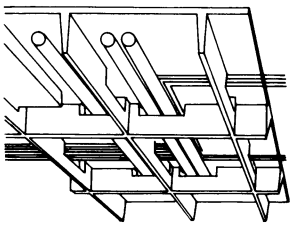
② **Divided by movable cupboard-walls**



③ **Tannenberg School in Seeheim, practising team teaching**



④ **Floor and ceiling connections for partitions**



⑤ **Ceiling void for services**

Nowadays, it is often considered normal for offices to be open plan. This sometimes influences school architecture. The two have similar requirements regarding size of room, lighting, ventilation, acoustics, floor and ceiling finishes, furniture, and colour.

Main advantage: flexibility → ① + ②. Team teaching in groups of up to 100 pupils. Space per pupil (not incl. core) 3.4 m²–4 m².

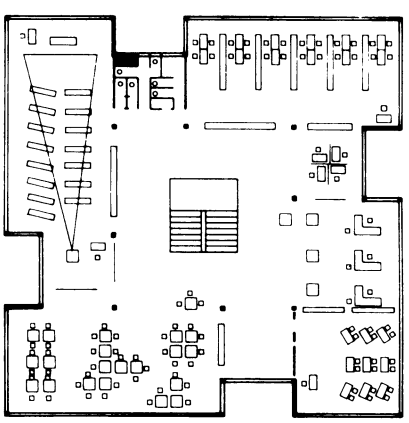
The later addition of partitions should be possible → ④. There are many US examples. German model example: Tannenberg School, Seeheim → ③. However, vertical drainpipes and service ducts, etc. are a problem because of the need to fix sound-insulating partitions → ④. Ceiling panels should be removable so that services in the ceiling void are accessible → ⑤.

Large groups of 40–50 pupils, divided into medium-sized groups of 25–26 pupils, small groups of 10 pupils → ③.

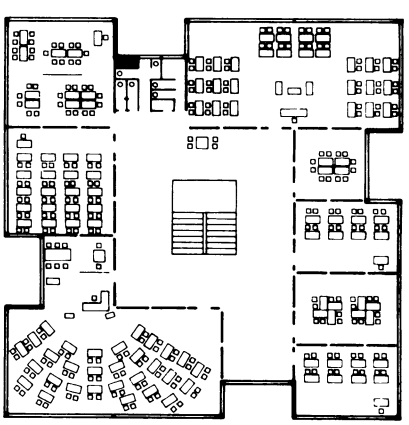
Planning grid 1.20 × 1.20m throughout; clear room height 3m. Movable partitions which can be taken down provide a solution for the transition from old fixed classrooms to open plan → ④. Also, building forms which create small spaces → ① + ② and → ⑥ – ⑧. Examples of seating arrangement for watching films, slides etc → ⑨ – ⑩.

Educational experts maintain that, during conscious learning, people best retain information that they have obtained themselves, more precisely:

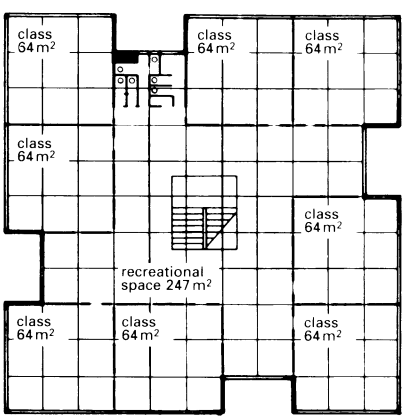
10% of what they read;
20% of what they hear;
30% of what they see;
50% of what they hear and see;
70% of what they say themselves; and
90% of what they do themselves involving their own actions.



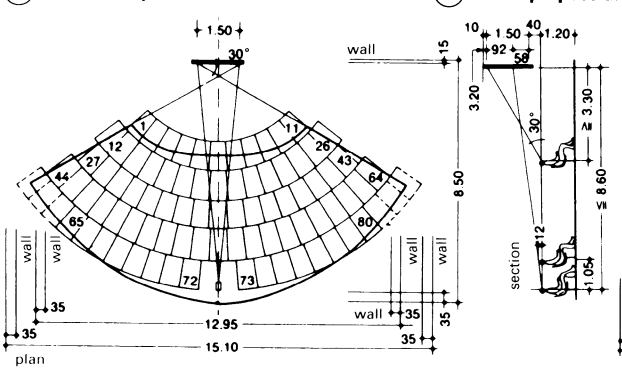
⑥ **Variable layout with 8 classes**



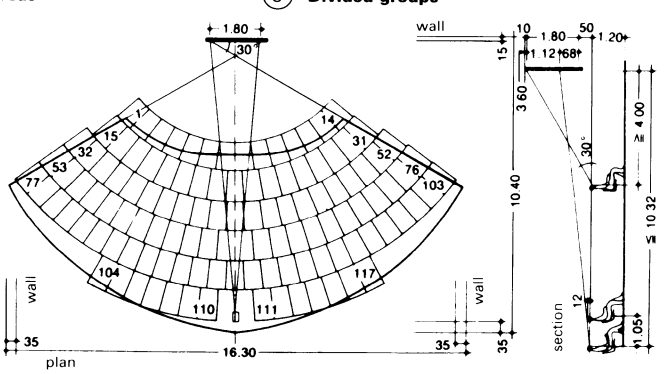
⑦ **Multi-purpose areas**



⑧ **Divided groups**

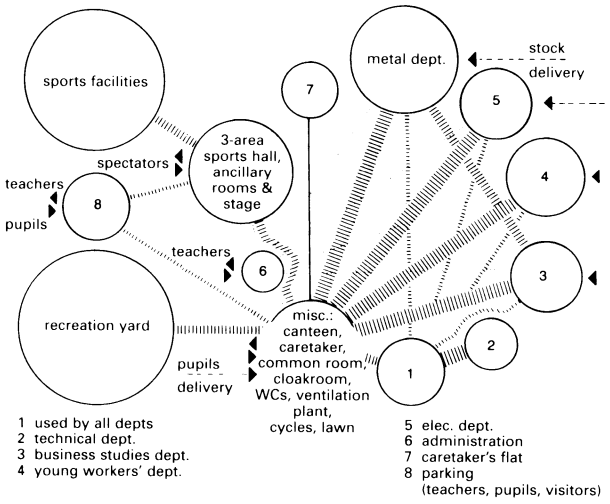


⑨ **Seating arrangement for 80 pupils (over 10 years old) for film, slide and overhead projection**

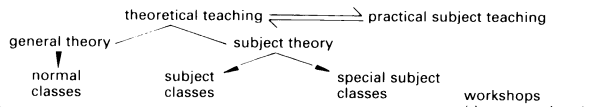


⑩ **for 117 pupils over 10 years old**

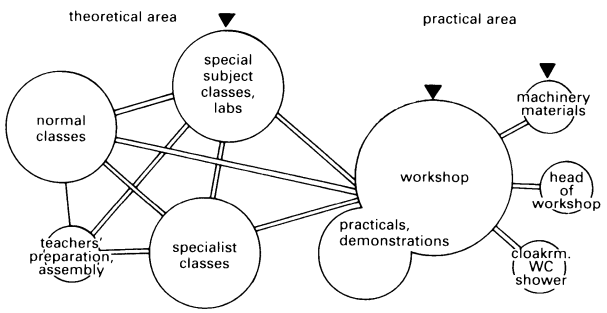
FURTHER EDUCATION COLLEGES



(1) **Space allocation scheme: college of further education**



(2) **Types of teaching and space requirements**

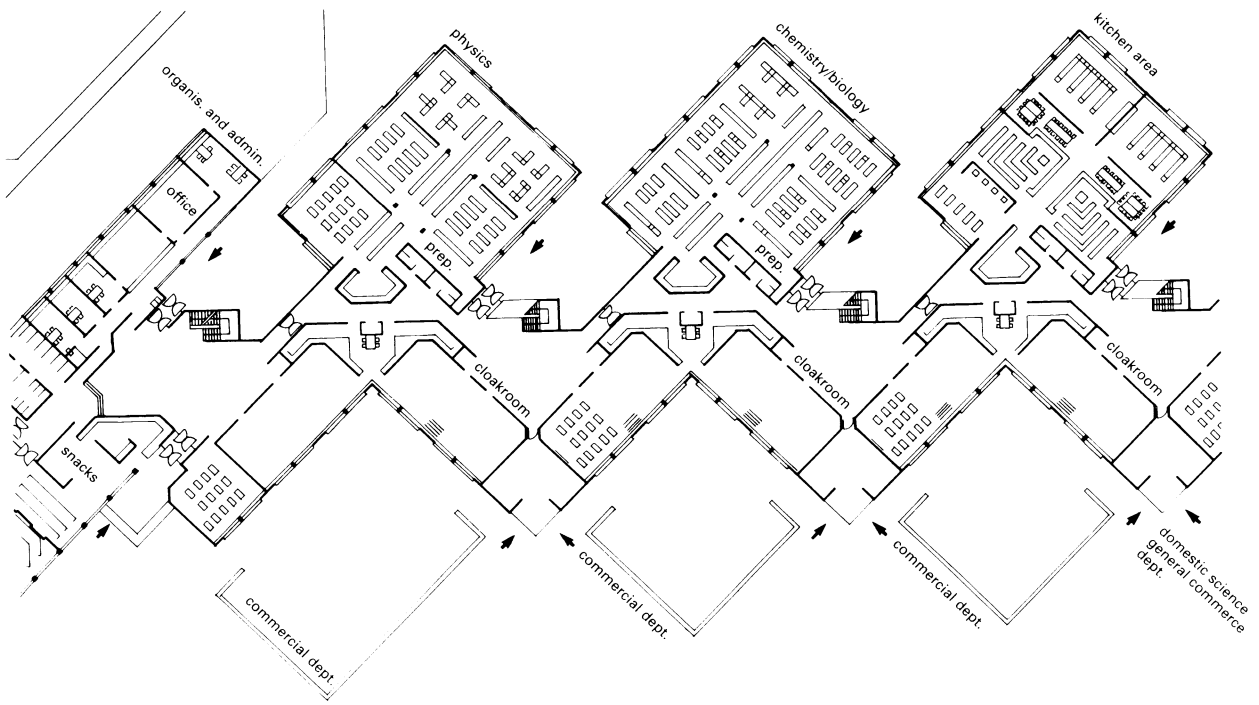


(3) **Organisation of areas**

Technical colleges and colleges of further education
The type of college depends on regional and local factors, so that it is not really possible to give absolute sizes for systems. The figures cover both part-time and full-time students; as an approximate guidelines, and depending on the area served, there are 2000–6000 pupils per 60000–150000 inhabitants. Owing to the large catchment areas, the schools should be well served by public transport. Site: at least 10 m² per part-time student and at least 25 m² per full-time student of college site area, as far as possible free of pollution from noise, smoke, odour and dust. Ensure a good-shaped site and the possibility for extension. Arrangement on the site, type of construction and building design depend on the sizes of the spaces that can be accommodated on several levels (classrooms for general subjects, specialist subjects, administration) and those which cannot - areas for non-academic work, e.g. workshops or sports areas. College buildings are, as a rule, 2–3 storeys, higher only in exceptional cases. Workshop buildings with heavy machines or frequent deliveries are single storey only.

Access: entrance area and foyer with central facilities used as circulation space connecting horizontal and vertical movement as in general school centres or comprehensive schools. Teaching areas divided according to type of teaching and their space requirements. General-purpose teaching areas occupy 10–20% of the space. General classrooms as normal with 50–60 m², small classrooms 45–50 m², oversize classrooms 85 m², possibly open-plan classrooms doubling as a film or lecture hall of 100–200 m².

Building requirements, furnishings and fittings basically the same as for general school centres and comprehensive schools. An assembly room of 20 m² per 5 normal classes.



(4) **Part of the college of further education in the district of Viersen**

COLLEGES AND UNIVERSITIES

Lecture Theatres

Central facilities

Main lecture theatre, ceremonial hall, administration, dean's office, students' union building. Also libraries, refectories, sports facilities, halls of residence, parking.

Technical facilities for central services supply.

Boiler room, services supply.

Subject-specific teaching and research facilities.

Basic facilities for all subjects:

Lecture theatres for basic and special lectures, seminar and group rooms (some with PC workstations) for in-depth work. Departmental libraries, study rooms for academic staff, meeting rooms, exam rooms, etc. → ①.

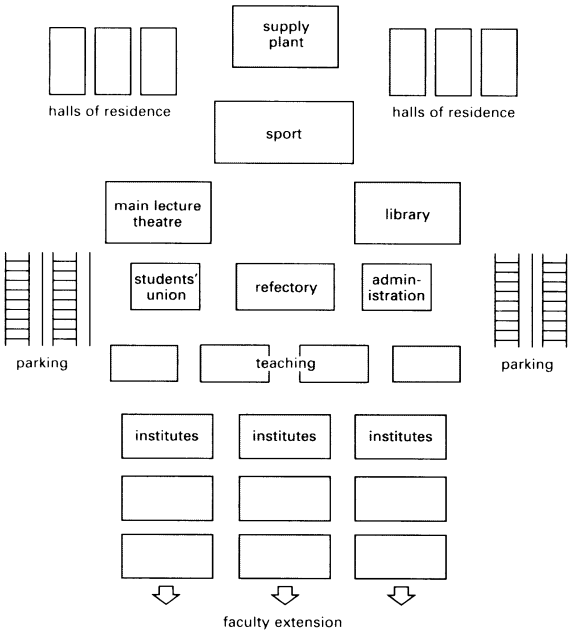
Subject-specific room requirements:

Humanities: no particular requirements.

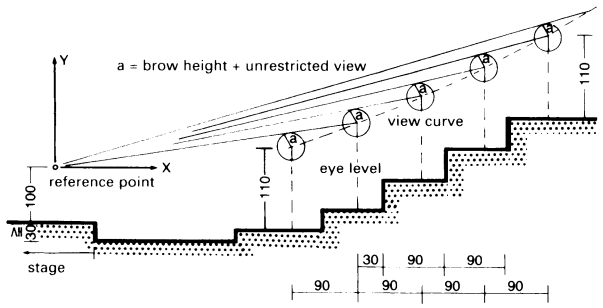
Technical/artistic subjects, e.g. architecture, art, music, etc.: rooms for drawing, studios, workshops, rehearsal and assembly rooms of all kinds.

Technical/scientific subjects, e.g. civil engineering, physics, mechanical engineering, electrical engineering: drawing studios, labs, workshops, industrial halls and labs.

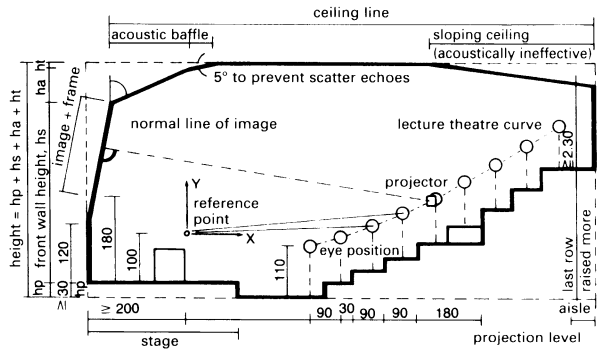
Scientific and medical subjects, e.g. chemistry, biology, anatomy, physiology, hygiene, pathology, etc.: labs with adjoining function rooms, workshops, rooms for keeping animals and for long-term experiments.



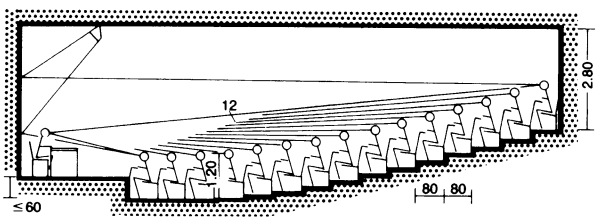
① **Schematic layout of university facilities**



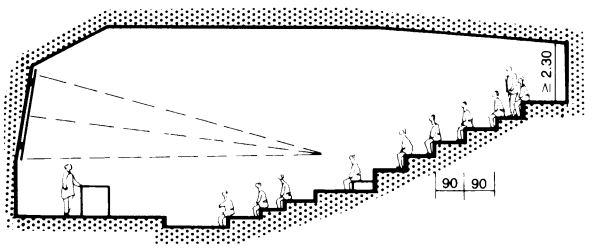
② **Drawing for calculating view curve**



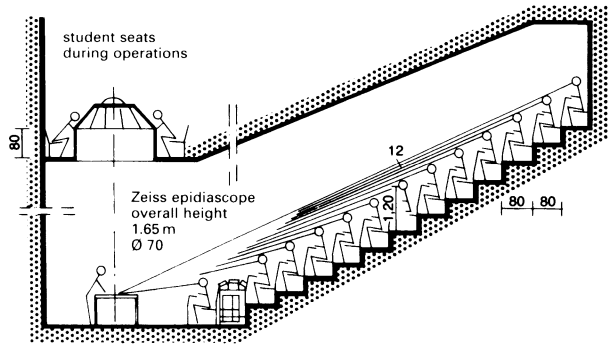
③ **Long section of a lecture theatre**



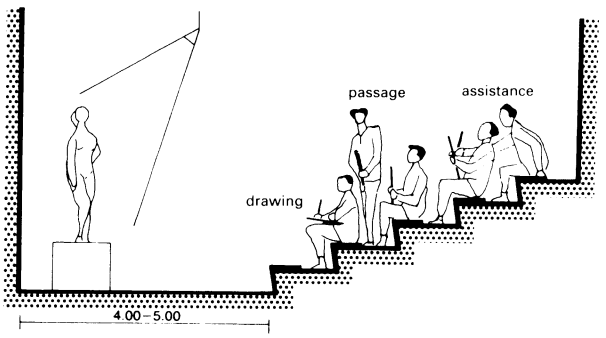
④ **Standard lecture theatre shape**



⑤ **More steeply raked lecture theatre**



⑥ **Lecture theatre with demonstration table (medical)**



⑦ **Tiers in life drawing studio: 0.65 m² seating space per student**

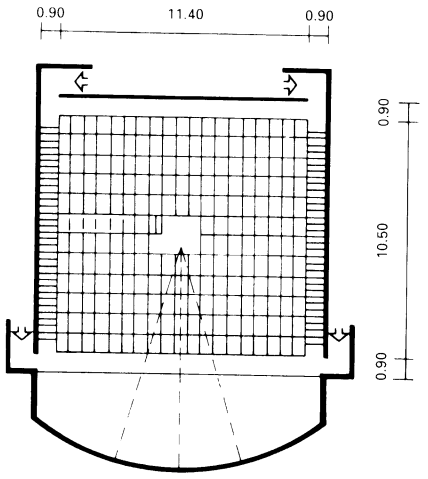
COLLEGES AND UNIVERSITIES

Lecture Theatres

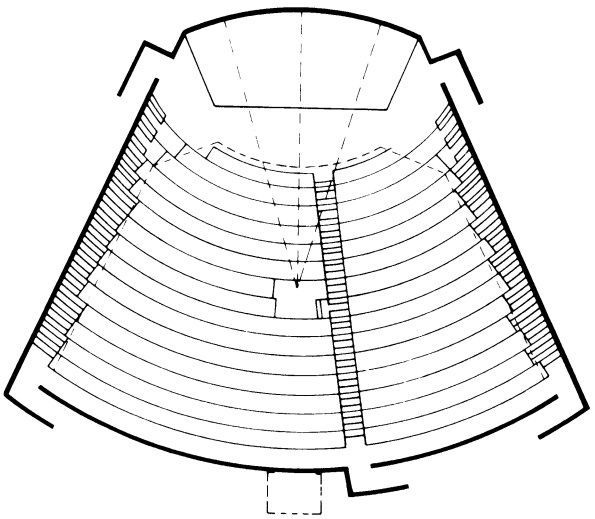
It is preferable to group larger lecture theatres for central lectures in separate complexes. Smaller lecture theatres for lectures on specialist subjects are better in the individual department and institute buildings. Access to the lecture theatre is separated from the research facilities, with short routes and entrances from outside at the back of the lecture hall; for raked seating entrances can be behind the top row and larger theatres can also have them in the centre on each side → ③ + ⑥. Lecturers enter at the front, from the preparation room, from where equipment carrying the experimental animals can also be trollied into the lecture theatre.

Usual sizes for lecture theatres: 100, 150, 200, 300, 400, 600, 800 seats. Theatres with up to 200 seats have a ceiling height of 3.50m and are integrated into the departmental buildings, if larger they are better in a separate building.

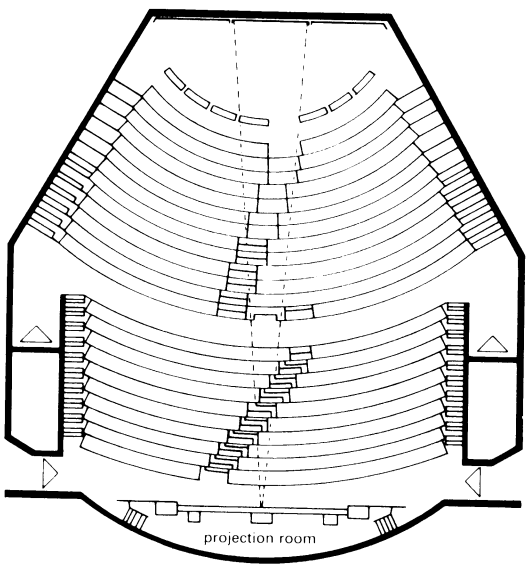
- Lecture theatres for subjects involving writing on chalkboards and projection have seating on shallow rake → p. 315 ④
- Demonstration lecture theatres for science subjects have experiment benches and seating steeply raked → p. 315 ⑤
- Medical demonstration lecture theatres, 'anatomy theatres', have steeply raked seating → p. 315 ⑥



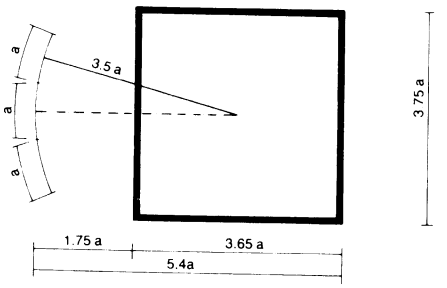
① **200-seat, rectangular lecture theatre**



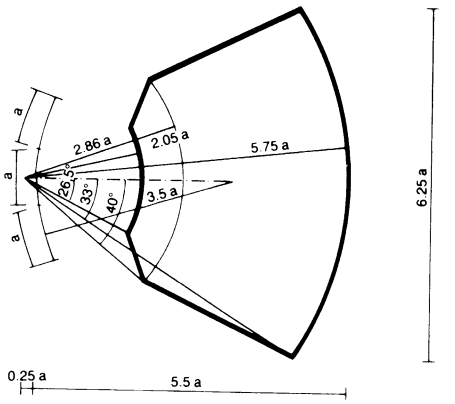
② **400-seat, trapezoidal lecture theatre**



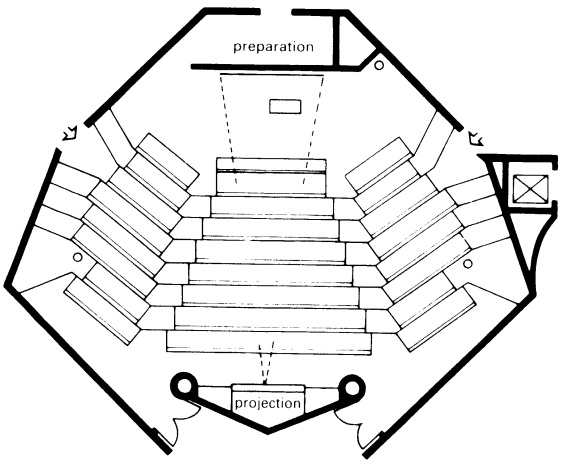
③ **800-seat lecture theatre**



④ **Rectangular plan**



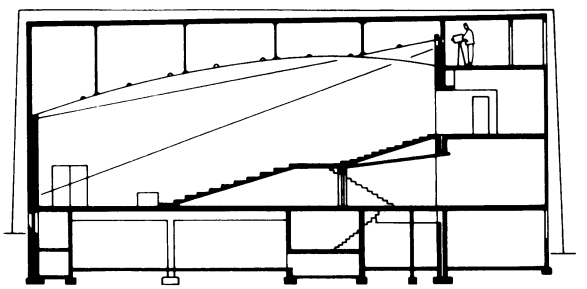
⑤ **Trapezoidal plan**



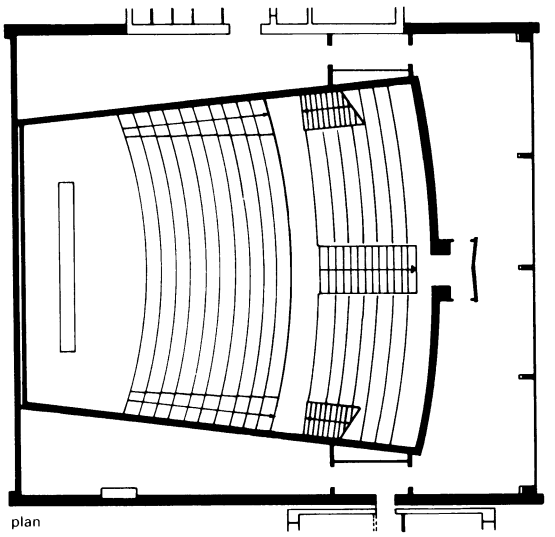
⑥ **200-seat theology lecture theatre at the University of Tübingen**

COLLEGES AND UNIVERSITIES

Lecture Theatres



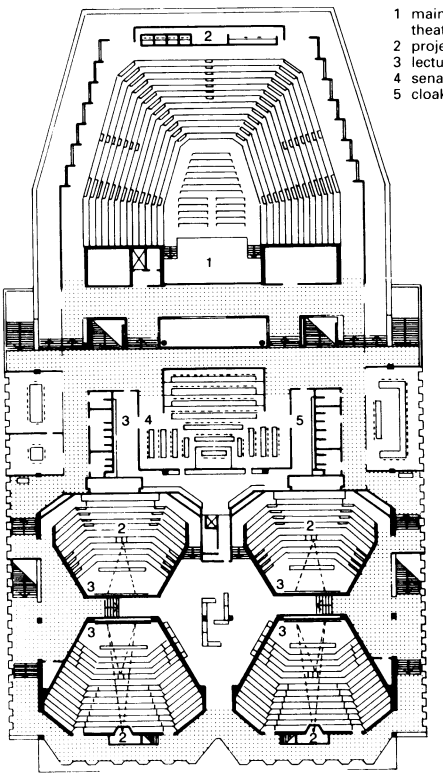
(1) **Section** → (2)



plan

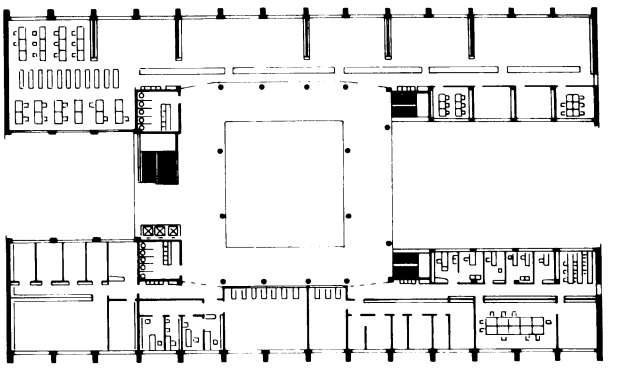
TH Darmstadt

(2) **Physics lecture theatre with double walling to prevent sound and vibration travelling**

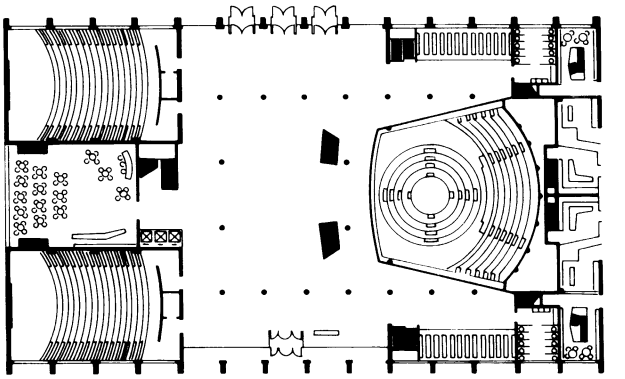


Architect: Brdek + Bakema

(3) **Lecture theatre at the TH Delft**



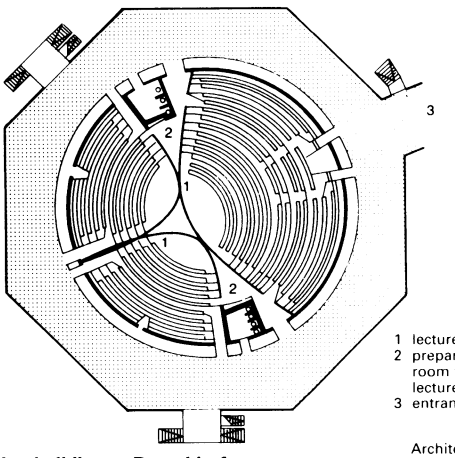
(4) **Typical floor** → (5)



entrance hall and two-storey main lecture theatre; typical floor with seminar rooms and administration offices

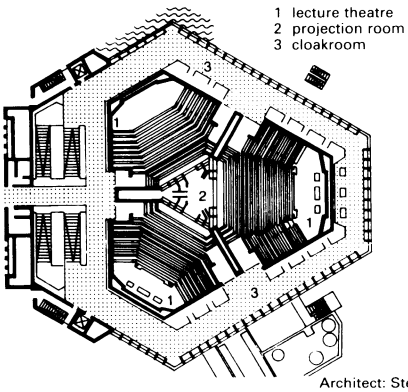
Architect: O.E. Schweizer

(5) **Ground floor of the theological college at the University of Freiburg**



Architect: Pfau

(6) **Teaching building at Dusseldorf**



Architect: Steiner + Gehry

(7) **Lecture theatre at the ETH Honggerberg in Zurich**

COLLEGES AND UNIVERSITIES

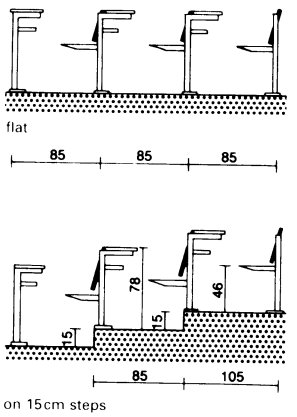
Lecture Theatres

Seating in lecture theatres: combined units of tip-up or swing seats, backrest and writing ledge (with shelf or hook for folders), usually fixed → ① – ③.

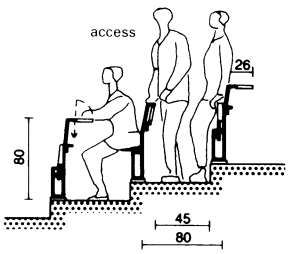
Seating arrangement depending on subject, number of students and teaching method: slide lectures, electro-acoustic systems on a gentle rake; surgery, internal medicine, physics on a steep rake. View curve calculated using graphic or analytic methods → ④ – ⑤.

Amount of space per student depends on the type of seat, depth of writing shelf and rake of floor.

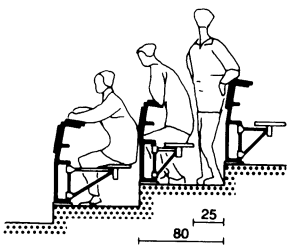
Amount of space per student: for seating in comfort 70×65cm; and on average 60×80 = 55×75cm. 0.60m² needed per student including all spaces in larger lecture theatres under the most cramped conditions; in smaller lecture theatres and in average comfort 0.80–0.95m². (Cont. next page)



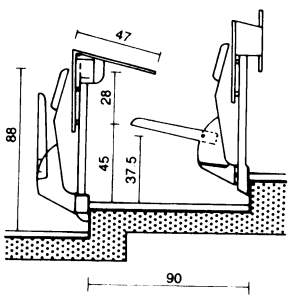
① **Seating for lecture theatre**



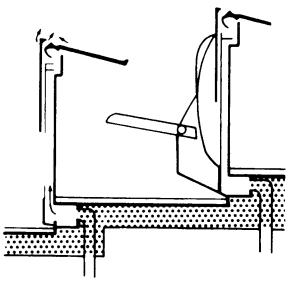
② **Seating arrangement with tip-up seats and writing shelves**



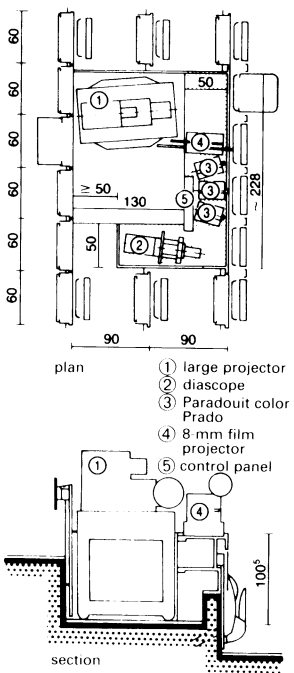
③ **Arrangement with fixed writing shelves and swing seats**



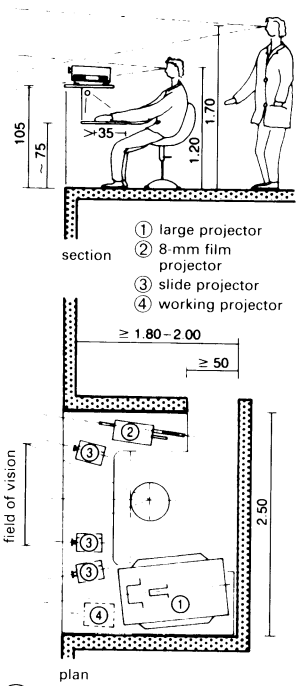
④ **Lecture theatre seating**



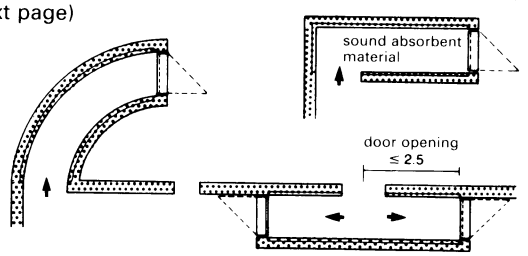
⑤ **Ventilation via desks/air circulation**



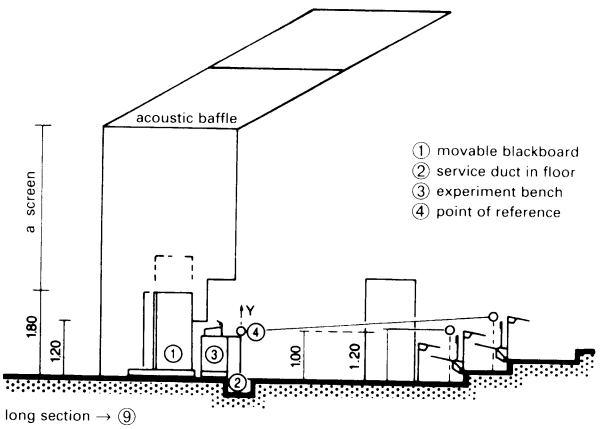
⑥ **Projection stand**

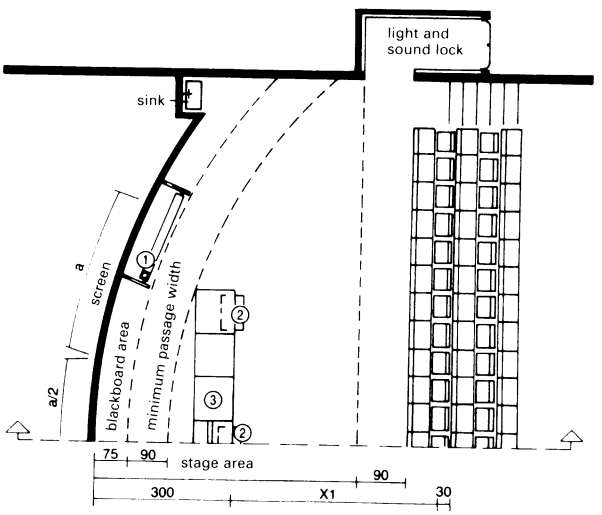


⑦ **Projector room**



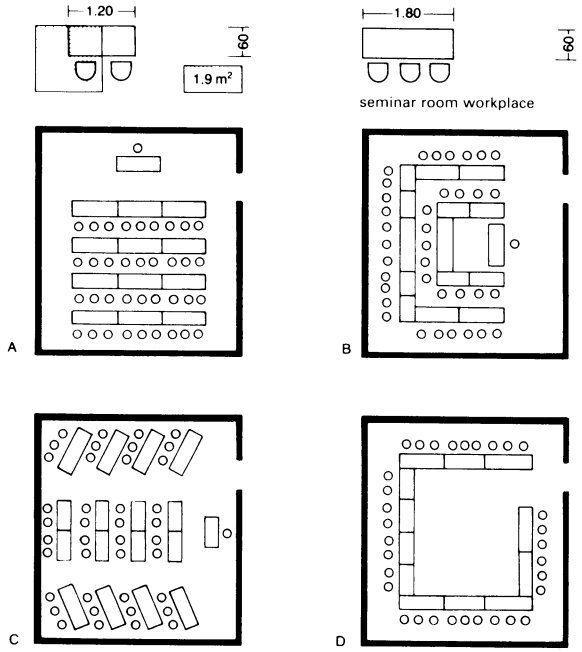
⑧ **Plan of light and sound locks**



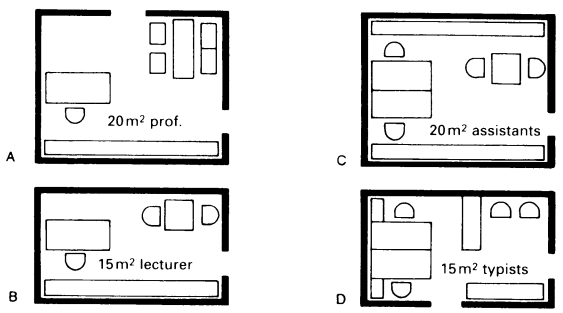


⑨ **Plan of stage area**

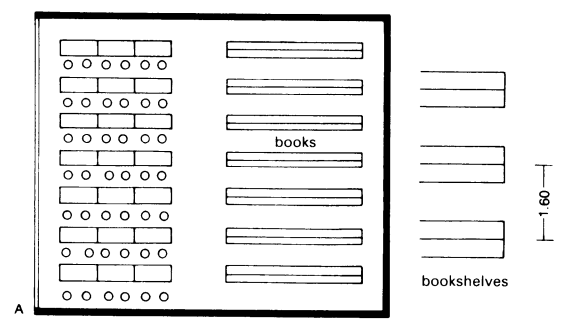
COLLEGES AND UNIVERSITIES



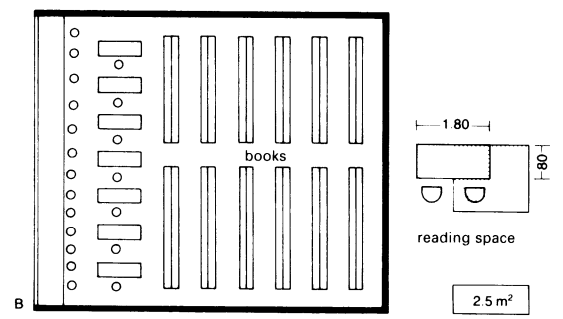
① **Seminar rooms, variable seating arrangements**



② **Basic offices furnishings**



③ **Arrangement of reading places and bookshelves**



④ **Arrangement of reading places and bookshelves**

Experiment benches suitable for laboratory work should, if possible, be interchangeable units on castors and must be provided with a power point.

Projection screens and boards can be designed as a segmented, curved wall or simply fixed to a flat end-wall. Wall blackboards are usually made up of several sections which can be moved up and down manually or mechanically. They can be designed to drop down beneath the projection area. Blackboards on wheels can also be considered.

Acoustics and lighting

Sound should reach each member of the audience with equal amplitude without any echo. Suspended ceilings for reflection and absorption. Rear walls lined with sound-absorbent material, other walls smooth. Light level in a windowless lecture theatre: 600 lx.

Related additional spaces

Each lecture theatre should have an ancillary room, with no fixed function which can also be used for storage. In lecture theatres where animal experiments are performed sufficient space for preparation should be provided. It should be on the same level and close to the stage. Standard minimum size for a rectangular shaped lecture theatre: 0.2–0.25 m²/seat; for trapezoidal shape: 0.15–0.18 m²/seat. For scientific and pre-clinical lectures: 0.2–0.3 m²/seat.

Spaces for storage and service rooms are essential for the proper running of a lecture theatre complex: a service room for the technical staff servicing the equipment in the lecture theatres, a service room for cleaners, storeroom for spare parts, light bulbs, fluorescent-light tubes, chalkboards, clothes, etc. Minimum room size 15 m², overall space requirement for ancillary rooms at least 50–60 m².

Clothes lockers and WCs: rough estimate for both together 0.15–0.16 m²/seat as a guideline.

Basic room requirement for all subjects

General-purpose seminar rooms usually have 20, 40, 50 or 60 seats, with movable double desks (width 1.20, depth 0.60); space required per student 1.90–2.00 m → ①.

Different arrangements of desks for lectures, group work, colloquiums, language labs, PCs, labs and meeting rooms have the same space requirements → ①.

Offices for academic staff:
Professor 20–24 m² → ② A
Lecturer 15 m² → ② B
Assistants 20 m² → ② C
Typists 15 m² (if shared by two typists 20 m²) → ② D
Departmental (open shelf) libraries:
Capacity for 30000–200000 books on open shelves

Book space: → ③
Bookcases with 6–7 shelves, 2 m high (reach height)
Distance between bookcases 1.50–1.60 m
Space required 1.0–1.2 m²/200 books

Reading spaces: → ④
Width 0.9–1.0 m/depth 0.8 m
Space required 2.4–2.5 m² per space

Control counter at entrance with locker for personal property, catalogue and photocopying rooms.

DRAWING STUDIOS

Various space requirements for technical subjects, including architecture, and art academies (painting and modelling rooms).→ ① - ②

Basic equipment

Drawing table of dimensions suitable for A0 size (92×127 cm); fixed or adjustable board → ②, ⑤ - ⑦. Drawings cabinet for storing drawings flat, of same height as drawing table, surface can also be used to put things on → ②. A small cupboard on castors for drawing materials, possibly with filing cabinet, is desirable → ② + ⑪ - ⑫. Adjustable-height swivel chair on castors. Drawing tables, upright board, adjustable height or usable as flat board when folded down → ⑤ - ⑪. Further accessories: table top for putting things on, drawing cabinets for hanging drawings or storing flat, suitable for A0 at least → ⑨ - ⑩. Each workplace should have a locker.

Drawing studios

Each space requires 3.5–4.5 m², depending on size of drawing table → ①.

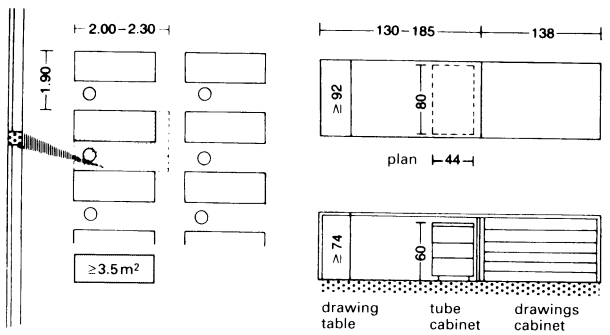
Natural lighting is preferable and so a north-facing studio is best to receive even daylight. For right-handed people it is best if illumination comes from the left → ③. Artificial light should be at 500 lx, with 1000 lx (from mounted drawing lamps or linear lamps hung in variable positions above the long axis of the table) at the drawing surface.

Rooms for life drawing, painting and modelling:

Accommodated if possible in the attic facing north with large windows (1/3–1/4 of floor space) and, if necessary, additional top lights.

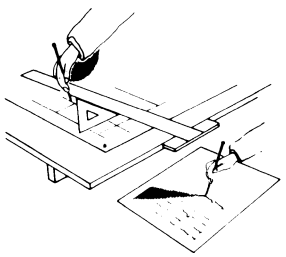
Rooms for sculptors and potters

Large space for technical equipment such as potters' wheels, kilns and pieces of work, also storeroom, plaster room, damp room, etc.

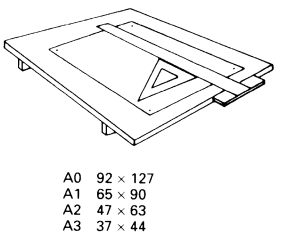


① Workplace in drawing room

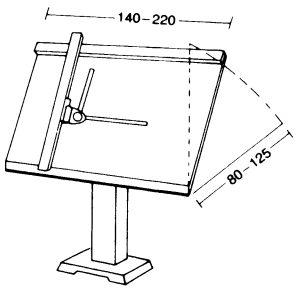
② Work surface



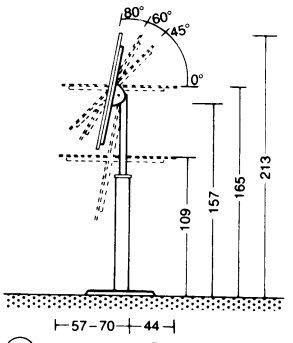
③ Light for writing coming from behind left, and for drawing from the front left



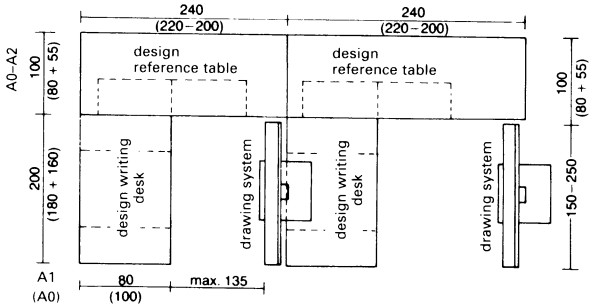
④ Drawing board sizes



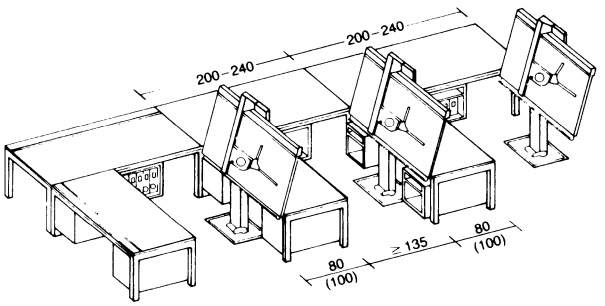
⑤ Adjustable drawing table



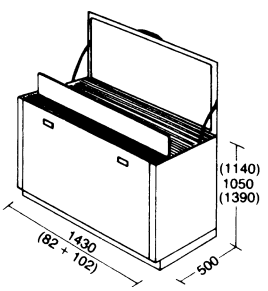
⑥ Section → ⑤



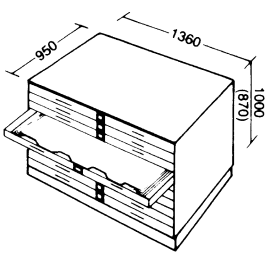
⑦ Work space plan → ⑧



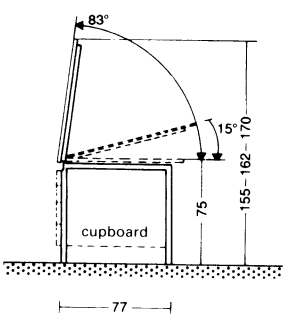
⑧ Drawing office



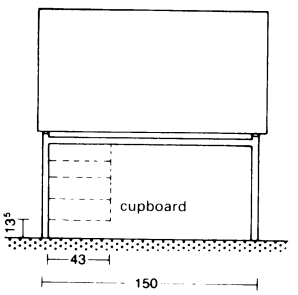
⑨ Drawings stored upright



⑩ Sheet steel drawings cabinet

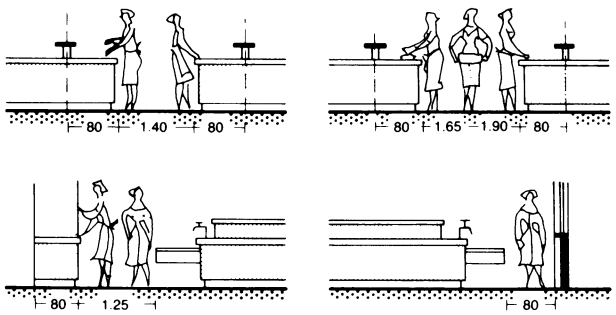


⑪ Section → ⑫

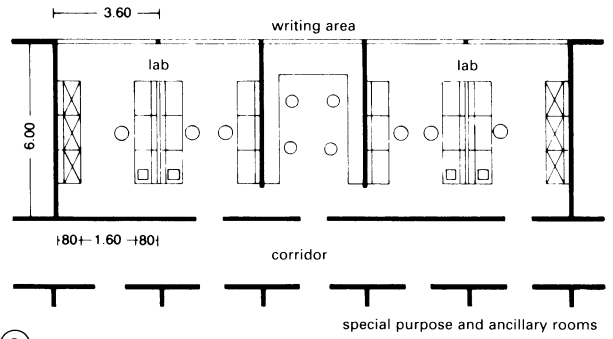


⑫ Adjustable angle desk and drawing table

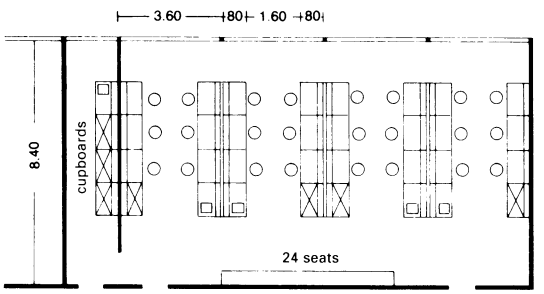
LABORATORIES



① **Minimum passage width between workstations**



② **Research lab**

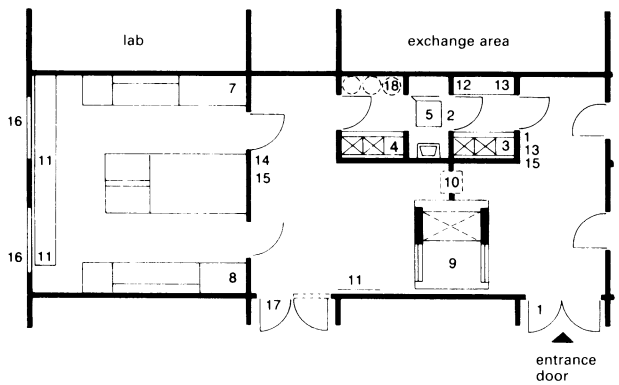


③ **Lab for teaching and practicals**

Lab safety level 3
1 warning sign
2 double-door safety lobby, self-closing doors
3 outdoor clothing
4 protective clothing
5 floor trough (pos. disinfectant mat) in front of shower
6 hand wash basin with disinfectant dispenser
7 workbench (clean bench) with separate special filter
8 extractor
9 autoclave (in lab or building)
11 flat panel radiator (7.5 cm from wall)
12 control and monitoring cupboard: electricity box, emergency mains off-switch, error board
13 pressure difference display readable from inside and out with acoustic alarm
14 emergency telephone, telephone
15 two-way intercom, electric door-opener
16 windows: gas-tight, non-combustible, leaded
17 pass-door: fireproof

Lab safety level 4
2 three-chamber safety lobby. Doors self-closing and gas-tight
5 personal shower (L-3 system can be upgraded*). Collect and disinfect waste water
7 gas-tight, enclosed workbench, separate air supply and extraction, additional special filter
9 autoclave with lockable doors on both sides, disinfect condensation
10 flood lock
18 autoclavable container for used protective clothing

*) Only required if upgrading to L-4 lab.

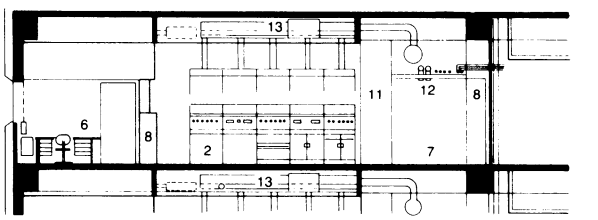


④ **Example of clean-room lab**

Laboratories differ according to type of use and discipline.

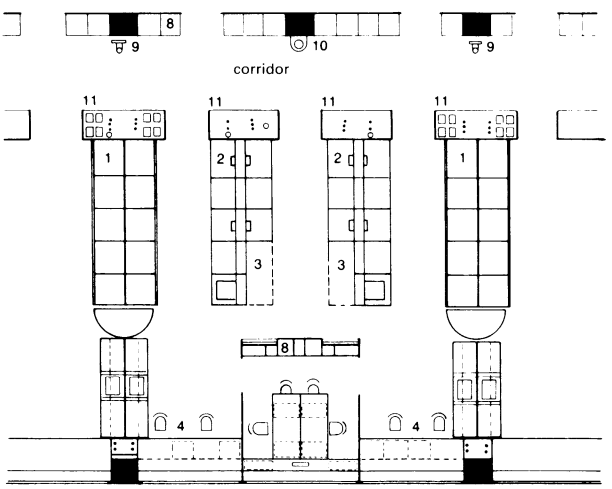
According to use:
Laboratories for teaching and practicals, comprising a large number of workstations, usually with simple basic equipment. → ③ Research labs are usually in smaller spaces with special equipment and additional rooms for activities such as weighing and measuring, centrifuges and autoclaves, washing up, climatised and cold storage rooms with constant temperature, photographic rooms/dark rooms, etc. → ②.

According to subject:
Chemistry and biology labs with fixed benches. Rooms have frequent air exchange, often additional fume cupboards (digestors) for work which produces gas or smoke. Digestors often in separate rooms. Physics labs mainly with movable benches and a range of electrical installations in trunking in the wall or suspended from the ceiling; few air changes. Special labs for specific requirements, e.g. isotope labs for work with radioactive substance in differing safety categories. Clean-room labs → ④ for work needing dust-free filtered air, e.g. in the field of microelectronics or for particularly dangerous substances, which should be prevented from entering surrounding rooms by separate air circulation and filtering systems (microbiology, genetic engineering, safety levels L1–L4).



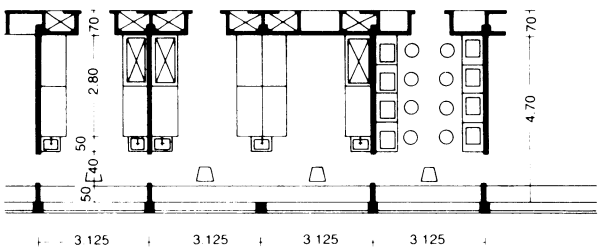
1 fume cupboards
2 workbenches
3 reserves
4 dry work places
5 weighing tables
6 workstation for chemist
7 corridor
8 materials cupboards
9 eye douche
10 hand-held fire extinguisher
11 vertical energy supply
12 overhead pipes
13 ventilation and environmental control system

⑤ **BASF plastics laboratory: section**

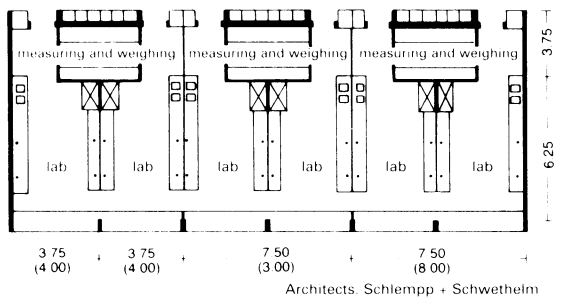


⑥ **Plan** → ⑤

LABORATORIES

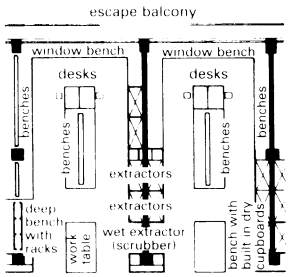


① **Room dimensions derive from bench size (size of workstation). Services and cupboards in corridor wall. Separate weighing room.**

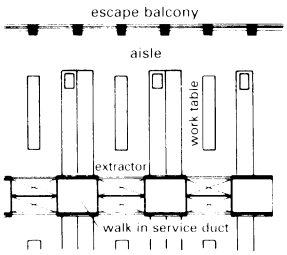


Architects: Schlempp + Schwethelm

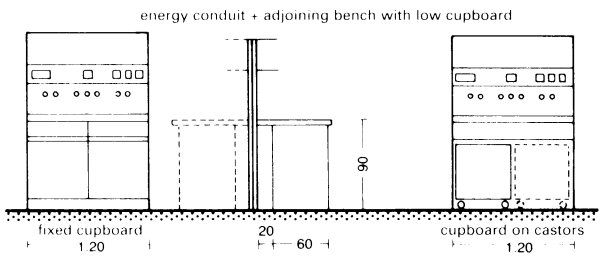
② **Uniform labs with measuring and weighing rooms in front of them (University clinic in Frankfurt/Main)**



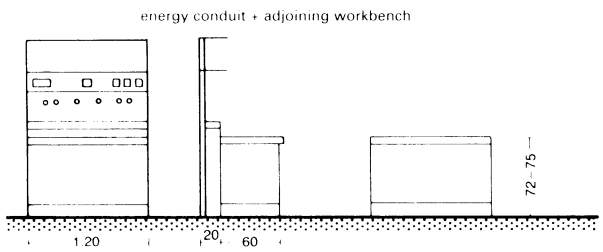
③ **Laboratory equipment in main science lab (Bayer AG dye factory)**



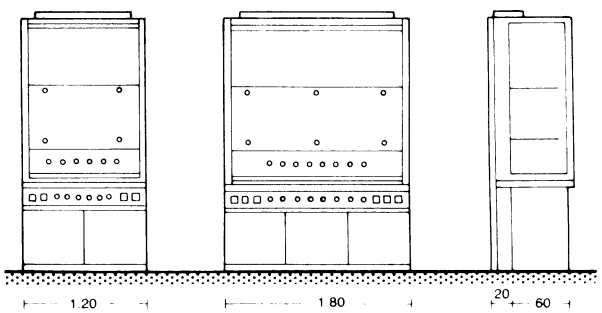
④ **Arrangement of walk-in ducts (BASF)**



⑤ **Chemistry bench**



⑥ **Physics bench**



⑦ **Digestors (fume cupboards)**

Unserviced work rooms are also part of the lab area:

Study cells, service rooms for lab. personnel. Also central rooms such as general storerooms, chemicals stores and supplies with special protective equipment, isotope stores with cooling containers, etc. Experimental animals are kept in a special location. Particular kinds of equipment are needed, depending on the type of animal and they have differing requirements for separate air circulation.

Lab workstation

The bench, fixed or movable, is the module which determines the lab workstation; its measurements, including work space and passage space, form the so-called lab axis, the basic spatial unit. Normal measurements for standard workbench: 120cm width for practicals, several times this for a research lab, 80cm depth of work surface including energy conduit → ⑤ - ⑥.

Benches and fume cupboards are usually part of a modular system, width of elements 120cm, fume cupboards 120 and 180cm → ⑦. The conduit carries all the supply systems; benches and low cupboard are placed in front of it → ⑤ - ⑦.

Benches are made of steel tubing, with work-surfaces of stoneware panels without joints, less frequently tiles, or chemical-resistant plastic panels. Low cupboards are of wood or chipboard with plastic laminate. Supply services are from above from the ceiling void, or from below through the floor structure.

Ventilation:

Low-pressure or high-pressure systems, the latter are recommended particularly in multi-storey buildings for institutes with higher air requirement in order to reduce the cross-sections of the ducts. Cooling and humidification as required. Ventilation systems have the highest space requirement of all services.

Labs where chemicals are used must have artificial air supply and extraction. Air changes per hour:

chem. labs 8
biology labs 4
physics labs 3–4 (in extraction area)

Electrical services:

Where a high number of connections and special supplies of electricity are required, a separate transformer in the building is essential. Electrical plant must be in a fireproof enclosure without any other cables running through it.

LABORATORIES

There are various possible arrangements of service ducts, columns and vertical circulation cores:

① Services concentrated in internal main shafts at each end of the building, vertical circulation core inside

② Services concentrated in external shafts at each end of the building, vertical circulation core outside

③ Services concentrated in main shafts centrally in each part, circulation core as link element

④ Services distributed in discrete duct installations, vertical circulation core inside

⑤ Main services inside linked to vertical circulation core

⑥ Service shaft outside, vertical circulation core off-centre.

Vertical services system

There are many vertical service ducts inside the building or on the façade, taking the services directly into the labs in separate ducts: decentrally distributed air supply and exhaust air to fume cupboards, separate ventilators on the roof.

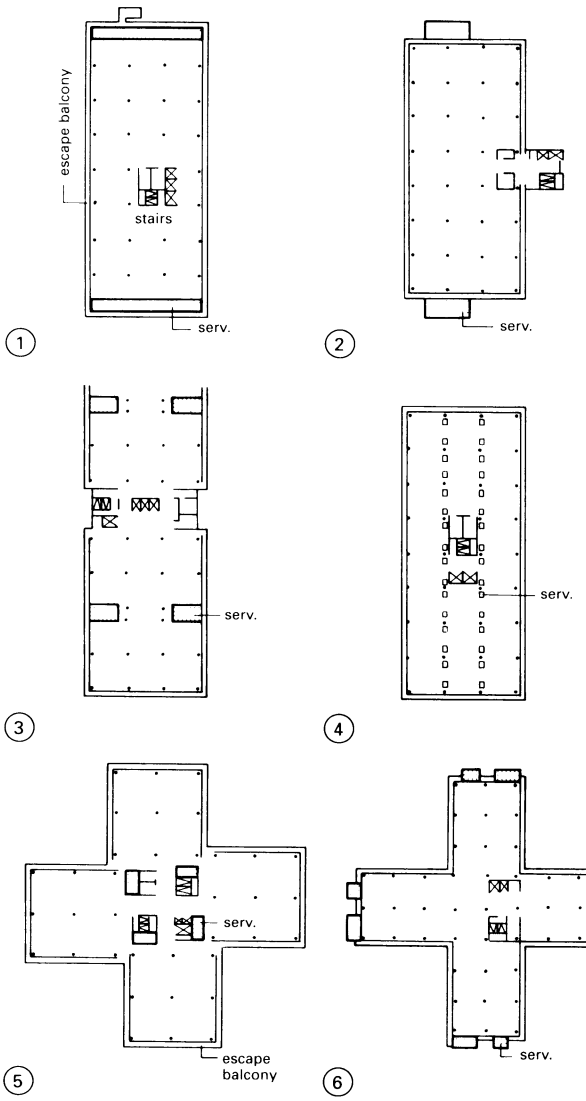
Advantages:
Maximum supply to individual workplaces. Short, horizontal connections to the bench.

Disadvantages:
Plan flexibility limited, more space needed on services plant floor → ⑦.

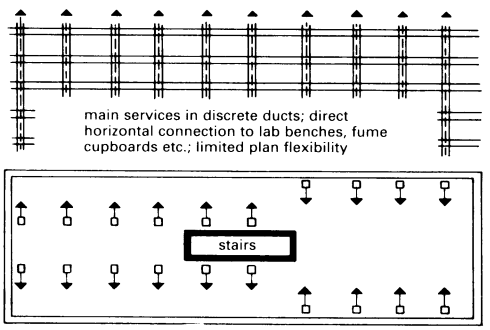
Horizontal services system

Vertical main services concentrated in shafts and distributed from there horizontally via the service plant floors to the bench by connections from above or below.

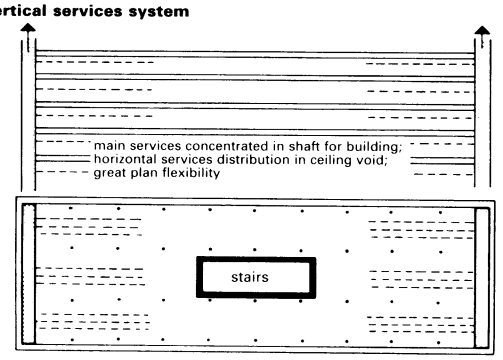
Advantages:
Fewer conduits and less space needed for the services ducts, greater flexibility of plan, easier maintenance, central ventilation plants, later installation easier → ⑧. High density of services requires more space. Vertical mains ducts with concentrated services are more manageable, access is easier and they can be installed later. Conduits insulated from heat, cold, condensation and noise → ⑨ – ⑩.



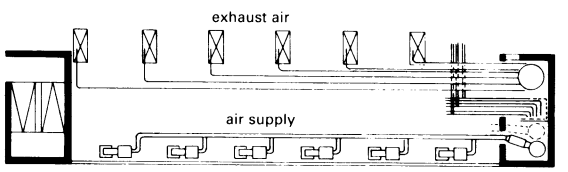
① ② ③ ④ ⑤ ⑥



⑦ **Vertical services system**

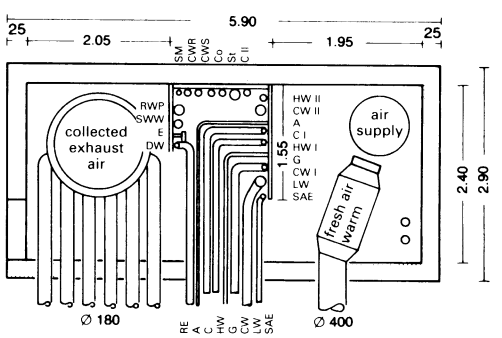


⑧ **Horizontal services system**



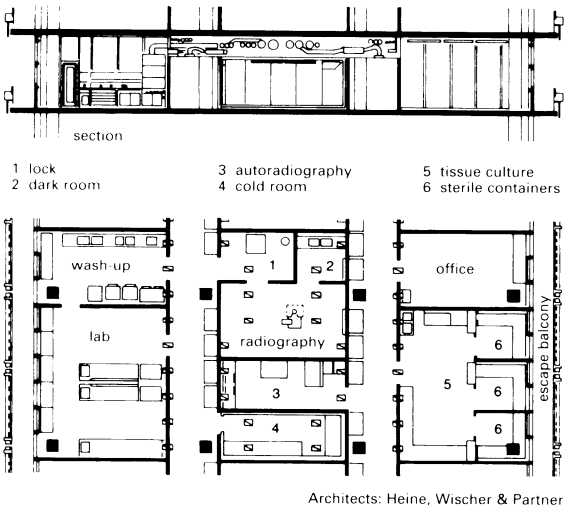
CW	cold water	St	steam	SAE	secondary air extraction
HW	hot water	Co	condensate	SWW	sanitary waste water
C	circulation	A	air	RWP	rainwater pipe
DW	distilled water	G	gas		
CWS	cooling water supply	SM	special medium		
CWR	cooling water return	E	emptying		
I	1st pressure level	RE	reserve		
II	2nd pressure level	LW	lab water		

⑨ **Horizontal conduit distribution on one storey** → ⑩



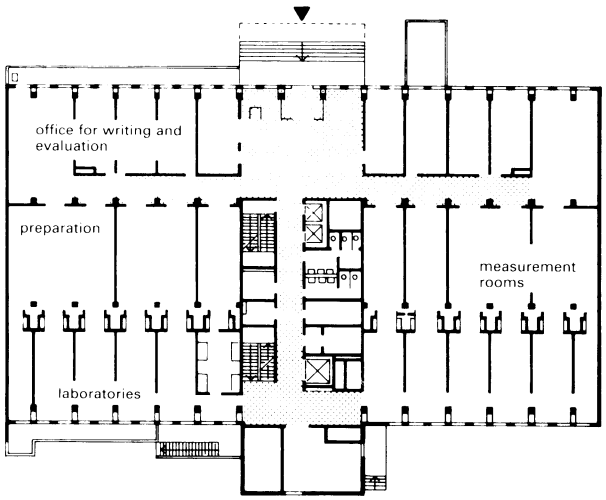
⑩ **Main services concentrated in shaft: plan** → ⑨

LABORATORIES

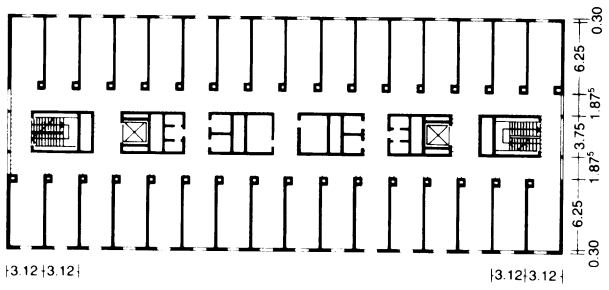


Architects: Heine, Wischer & Partner

① **Part of plan of cancer research centre in Heidelberg**

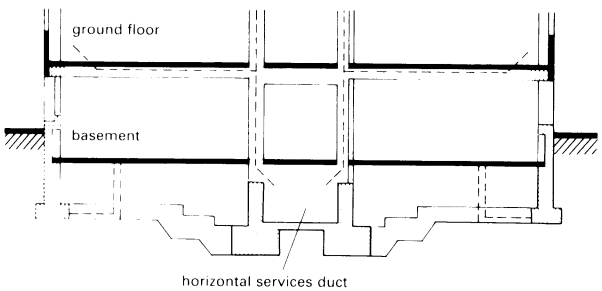


② **Analytical physics lab (BASF, Ludwigshafen)**



Architect: W. Haake

③ **Typical plan of a variable multi-purpose institute**



④ **Cross-section of lab with well-positioned central corridor**

Rooms are used according to a schedule of accommodation and plan. Rooms with natural or artificial light and ventilation, with high or low servicing, allow the creation of zones of differing use and technical qualities. For this reason laboratory buildings often have large internal areas (with two corridors) → ① + ③. The building length depends on the longest reasonable horizontal run of wet services.

Services floors for plant in the basement or at roof level.

Grid for structure and fittings:

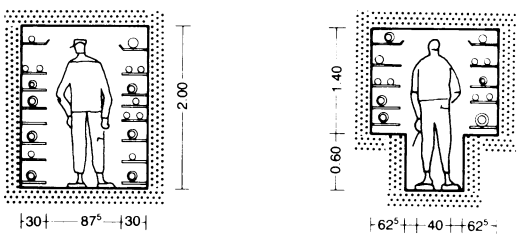
For adaptability of use, a reinforced concrete frame structure, pre-cast or poured in-situ, is preferable. The main structural grid is a multiple of the typical planning grid of 120 × 120 cm (decimal system). A convenient structural grid for a large proportion of rooms without columns is: 7.20 × 7.20 m, 7.20 × 8.40 m, 8.40 × 8.40 m. Storey height normally 4 m, clear room height up to 3.0 m.

Columns stands on the grid off-set from the planning grid to increase the flexibility of the servicing. Separation is by a system of partitions and suspended ceilings which enclose the rooms. Movable dividing walls should be easy to assemble and have chemical-resistant surfaces. Ceilings should be designed to be disassembled and should absorb sound. Floor coverings should be water- and chemical-resistant, without joints and be poor electrical conductors: as a rule welded plastic sheet or tiles.

Provide viewing windows into the labs from the corridor or in the doors.

Isotope labs have smooth surfaced walls and ceilings without pores, rounded corners, shielded in lead or concrete, waste water monitoring, with shower cubicles between the lab and exits. Concrete container for active waste and refuse, concrete safe with lead doors, etc.

A weighing table is part of every lab, usually in a separate balance room. Benches lie along the wall in front of vibration-free walls.



⑤ **Section of main service route (walk-in) varies according to number of ducts it is carrying**

CHILD DAYCARE CENTRES

Child daycare centres provide social and educational facilities for daytime care of pre-school children and school children up to the age of 15. Children's needs should be taken into consideration in the planning. Division according to age groups:

Creche from 8 months to 3 years, groups of 6–8 children; kindergarten from 3 years to school age groups of 25–30 children; children's after-school care centre from 6–15 years, groups of 25–30 children. If possible, provision should be made for age groups to be combined. The centre should be near housing and traffic-free.

Size of rooms, schedule of accommodation and details → ① + ②.

Creche 2–3 m² floor space/child (babies, crawlers and toddlers) plus spaces for: nappy changing table, playpens, cupboards, toy racks, child-size tables and chairs.

Kindergarten 1.5–3 m² floor space/child. 15–30 children/room plus spaces for cupboards, toy racks, child-size tables and chairs, chalkboards, etc.

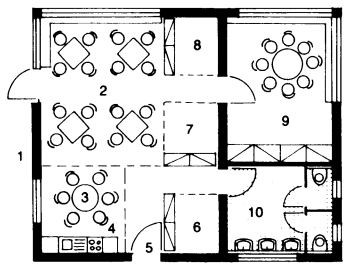
After-school care centre 1.5–4 m² floor space/child. 20 children/room plus spaces for cupboards, toy racks, child-size tables and chairs, chalkboards, storage facilities, homework room with cupboard for teaching material, shelves, desks and chairs. Arts and crafts room with cupboard for tools and materials, workbench, carpentry bench, etc.

With more than two group rooms a multipurpose room is required, preferably next to the group rooms and with a view of them. Good sound insulation, so as to help concentration in group learning processes, e.g. play rehearsals, etc.

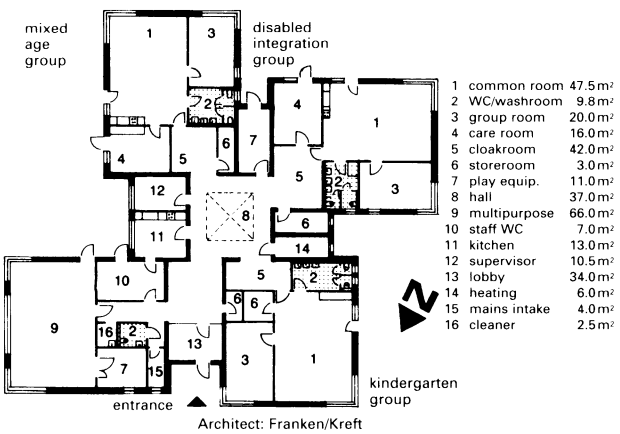
If the room is large enough (min. 60 m²) it can also be used as a gymnasium and for afternoon naps. Apparatus store.

There is a trend towards two-storey buildings with staircases and emergency stairs, especially in high-density urban areas; and child daycare centres with longer opening hours for working or single parents (07.30 – 17.00). Facilities for disabled children, WCs and washrooms accessible to wheelchairs, therapy room. Min. 6 parking spaces and space for bicycles and prams.

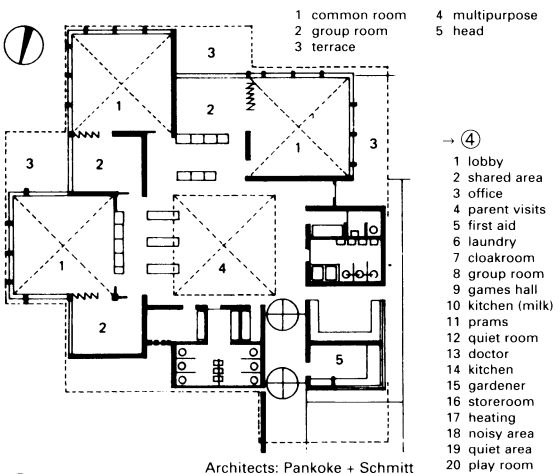
Driveway and parking for staff and people collecting children, playground.



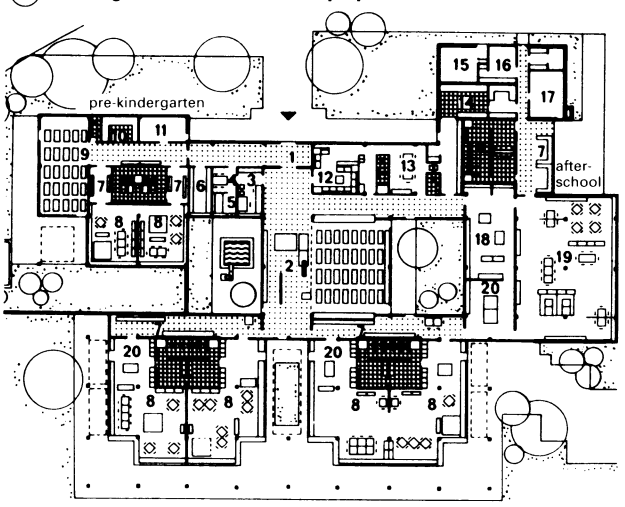
① **Kindergarten: typical plan**



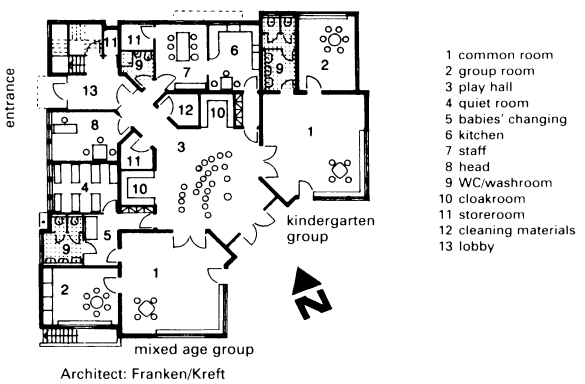
② **'Robin Hood' daycare centre: ground floor**



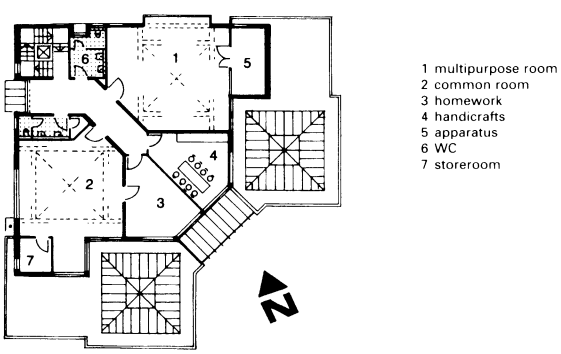
③ **Kindergarten with central multipurpose room**



④ **Child daycare centre**



⑤ **'Pusteblume' child daycare centre: ground floor**



⑥ **First floor** → ⑤

PLAYGROUNDS

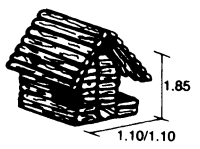
Play makes a fundamental contribution to the development of a child's personality. It is mainly through play that small children adapt to their environment. Play areas must be varied, changing and changeable. They must meet children's needs. Play is a social experience, through it children learn to understand the consequences of their behaviour.

Requirements of play areas: traffic safety, no pollution, adequate sunshine, ground water level not too high.

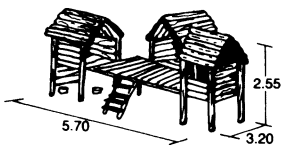
Play areas should be focal points within residential areas and should be connected to residential and other areas by simple networks of paths. They should not be pushed out on to the periphery but planned in connection with communication systems. Guidelines for planning playgrounds take into account the following data: age group, usable space per person, play area size, distance from dwellings, etc.

age group	area (m^2)	distance from home (m)	(minutes)
0 – 6	0.6	110 – 230	2
6 – 12	0.5	350 – 450	5
12 – 18	0.9	700 – 1000	15

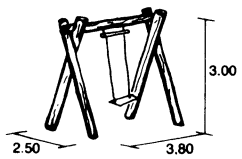
When building housing, private outdoor playgrounds in the grounds of the housing complex should be provided for younger children up to the age of 6, for children from 6–12 and for adults. A basis for calculating the size of all public playgrounds can often be found in planning regulations. For example, 5 m^2 play area per housing unit, minimum size of playground 40 m^2. Open spaces for play must be enclosed by a barrier at least 1 m high (dense hedge, fences, etc.) to protect them from roads, parked cars, railway lines, deep water, precipices and other sources of danger.

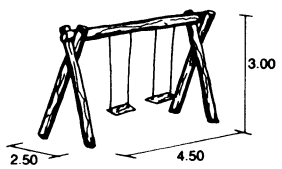


① Playhouse

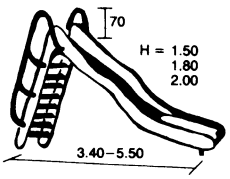


② Group of houses

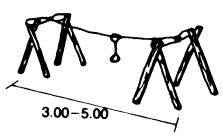




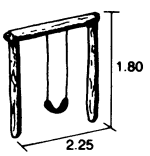
③ Swings



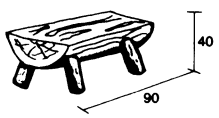
④ Slides



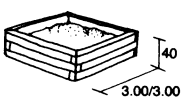
⑤ Aerial runway



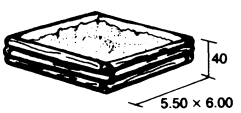
⑥ Toddler's swing



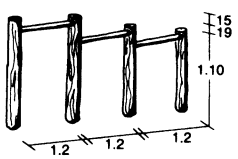
⑦ Dough table



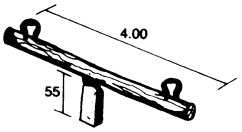
⑧ Sandpit (planks)



⑨ Sandpit (logs)



⑩ Exercise bars

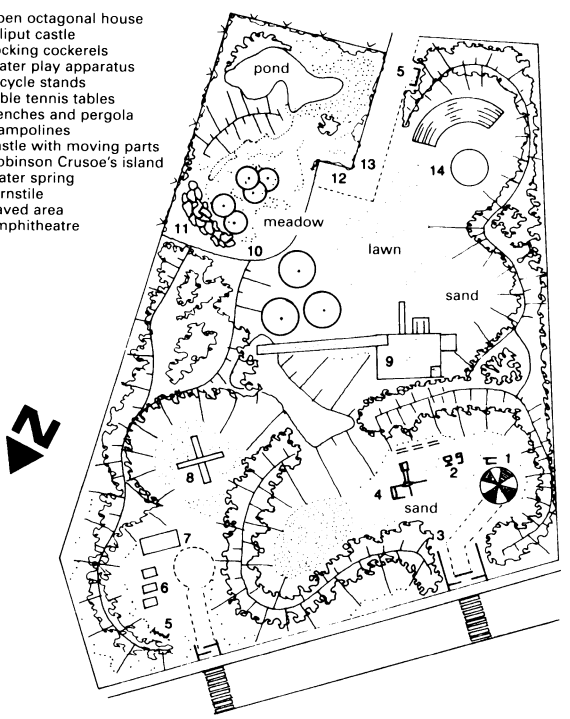


⑪ See-saw

D/W/H 7.30/3.80/3.40

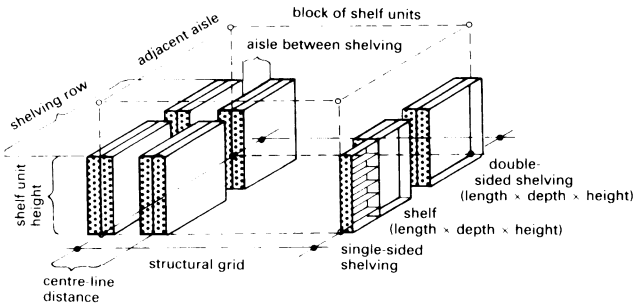
⑫ Slide and climbing frame

1 open octagonal house
2 lilliput castle
3 rocking cockerels
4 water play apparatus
5 bicycle stands
6 table tennis tables
7 benches and pergola
8 trampolines
9 castle with moving parts
10 Robinson Crusoe's island
11 water spring
12 turnstile
13 paved area
14 amphitheatre

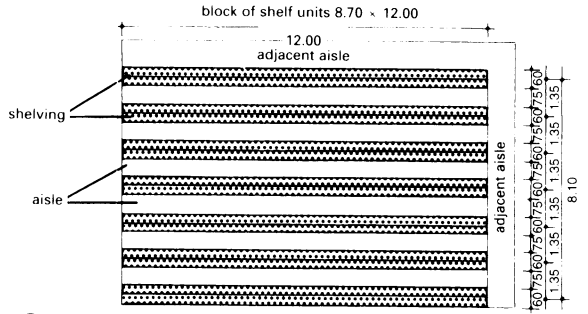


⑬ 'Karnacksweg' playground

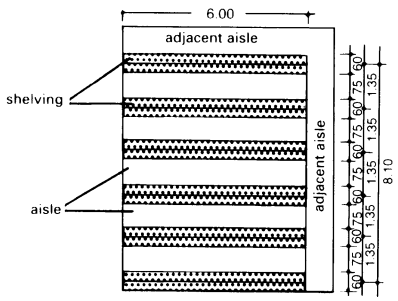
LIBRARIES



① **Drawing to explain terms used in calculating floor area for shelving (not to scale)**



② **Floor space for bookshelves in areas closed to the public**



area	centre-line distance (m)
stacks	1.35 (1.20) 1.44
open-access shelving	1.40 1.70
enquiry area and reading room	1.60 2.00

③ **Floor area for open-access bookshelves 8.70×6.00 m per block of shelf units**

structural grid	7.20 m × 7.20 m	7.50 m × 7.50 m	7.80 m × 7.80 m	8.40 m × 8.40 m
n × centre-line distance	6 × 1.20	6 × 1.25	6 × 1.30	6 × 1.20
	5 × 1.44	5 × 1.50	5 × 1.56	5 × 1.40
	4 × 1.80	4 × 1.87	4 × 1.95	4 × 1.68

④ **Example distances between shelf unit centre-lines; common grids**

area	volumes per shelf
stacks	25–30
open-access shelving	20–25
enquiry area and reading room	20

⑤ **Volumes per shelf**

	structural grid							
	3.60	4.20	4.80	5.40	6.00	7.20	8.40	
stacks		1.05		1.08		1.10		1.05
open-access shelving	1.20	1.20	1.20	1.10	1.20	1.20	1.20	1.12/1.2
								1.29
open-access shelving		1.40	1.37	1.35	1.33	1.32	1.31	1.40
	1.44				1.50	1.47	1.44	
			1.60	1.54			1.60	1.53
		1.68				1.65		1.68
reading room	1.80			1.80	1.71		1.80	
			1.92		2.00			
		2.10					2.07	2.10
work spaces (2.25)	2.40	2.10	2.40	2.10	2.40	2.20	2.40	2.10
group work spaces	3.60	4.20	4.80	3.60	4.00	4.40	3.60	4.20

⑥ **Suitability of common structural grids for fundamental library functions**

shelves above one another	7	6	5	on the basis of a book size distribution of up to 25 cm 65% 25 up to 30 cm 25% 30 up to 35 cm 10% an assumed floor load of 7.5 kN/m² results
maximum book height (cm)	25	30	35	
average book depth (cm)	18	20	22	
load per shelf	0.38	0.51	0.55	

⑦ **Loadings for 7.5 kN/m² book stack floors**

Libraries perform a range of functions in society. Academic libraries, for example, obtain, collect and store literature for education and research purposes, and are usually open to the general public. Public libraries provide communities with a wide choice of more general literature and other information media, with as much as possible displayed on open shelves. The functions of academic and public libraries are often combined in a single library in larger towns. National libraries, for example, may house collections of literature and historical documentation produced in one country or region (deposit copies) and are open to the public, whereas specialist libraries for the collection of literature and media in limited subject areas often have limited access.

In academic libraries, reference rooms are provided. There may also be counters for loans from the closed stacks, and free access to the open shelves of magazines, books or separately presented educational material in reading rooms. Apart from books and journals, almost all the different information media forms are collected and presented for use in an accessible way. The number of reading places depends on the number of students in the various subjects. The information is arranged in a systematic way, i.e. by subject. The services offered include inter-library loans as well as photocopying, and reading and printing from microforms (microfiche and microfilm). In addition, an on-line literature search and a literature search on data bases stored on CD-ROM are available.

University libraries are organised in either one or two layers. The one-layer system is administered centrally (book processing and services) and normally has very few separate branch or subject libraries. The two-layer system includes a central library and usually a large number of faculty, subject and institute libraries. The stock is held on open shelves in reading rooms, or in accessible book stacks (with the same shelf spacing as in closed stacks), as well as in restricted-access closed stacks. Arrangements such as these are found in various proportions in almost all academic libraries. The proportions of loan (open and closed access) and reference stocks depend on the type of organisation, i.e. the aims of the library and the form of the buildings often have a significant effect. The number of book shelves depends on the type of organisation, accessibility for users, type of shelving (fixed or mobile), the system of subject ordering in use and its method of installation, the separation of different formats and also the structural grid of the building → ④ - ⑦.

Reading room areas, with space for reading and working, should be easily accessible and therefore situated on as few levels as possible. This also aids book transport. There should be a clear directional system with easily read signs giving directions to services and book shelves. Avoid offset levels. Access to the operational areas and reading rooms on different floors should be by staircase, but lifts must also be provided for the use of disabled people and for book transport. Floor loadings in the operational and reading areas should be ≥ 5.0 kN/m².

Circulation routes should be >1.2 m wide, and clear spaces between shelves at least 1.3–1.4 m wide (or in accordance with local regulations). Avoid crossings and overlapping of routes for users, staff and book transport. Access to reading rooms can be through control gates equipped with book security equipment and, if possible, only one entrance and exit. For functional reasons, the control gates should be near the lending desk/central information desk.

	distance between centre lines of shelving (m)	volumes per metre of single shelf	number of stacked shelves	volumes per metre of shelving	space needed for 1000 volumes (m^2)	volumes per m^2
closed stacks (additional area 20%)	1.20	30	6	360	3.99	250.6
		30	6.5	390	3.68	271.7
		25	6.5	325	4.43	225.7
		30	7	420	3.42	292.3
		25	6	300	4.80	208.3
	1.25	30	6	360	4.16	240.3
		30	6.5	390	3.84	260.4
		25	6.5	325	4.61	216.9
		30	7	420	3.56	280.8
		25	6	300	4.99	200.4
	1.30	30	6	360	4.33	230.9
		30	6.5	390	3.99	250.6
		25	6.5	325	4.80	208.3
		30	7	420	3.70	270.2
		25	6	300	5.19	192.6
	1.35	30	6	360	4.50	222.2
		30	6.5	390	4.15	240.9
		25	6.5	325	4.98	200.8
		30	7	420	3.85	259.7
		25	6	300	5.40	185.1
open stacks (additional area 25%)	1.40	30	6	360	4.85	206.1
		30	6.5	390	4.47	223.7
		25	6.5	325	5.17	193.4
		30	7	420	4.16	240.3
		25	6	300	5.82	171.8
		20	5.5	220	7.63	131.0
	1.44	25	6	300	6.00	166.6
		25	5.5	275	6.53	153.1
		20	6	240	7.50	133.3
		20	5.5	220	8.17	122.3
	1.50	25	6	300	6.25	160.0
		25	5.5	275	6.81	146.8
		20	6	240	7.81	128.0
		20	5.5	220	8.51	117.5
reading room (additional area 25%)	1.68	25	6	300	7.00	142.8
		25	5.5	275	7.62	131.2
		20	6	240	8.75	114.2
		20	5.5	220	9.53	104.9
	1.80	20	5.5	220	10.22	97.8
		20	5	200	11.25	88.8
	1.87	20	5.5	220	10.62	94.1
		20	5	200	11.68	85.6
	2.10	20	5.5	220	11.92	83.8
		20	5	200	13.12	76.2
		20	4	160	16.40	60.9

Source: Schweigler

(1) **Floor area calculation for double-sided shelving**

library area/ floor type	closed and open stacks	compact storage systems	reading room and open-access shelving	administration
on floors with lateral distribution	7.5	12.5	5.0	5.0
on floors without lateral distribution	8.5	15.0	5.0	5.0

(2) **Assumed floor loads (kN/m2)**

number of shelves	distance between centre-lines of shelf units (m)							
	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80
4	3.83	3.72	3.62	3.54	3.46	3.39	3.33	3.27
5	4.38	4.24	4.11	4.00	3.90	3.81	3.73	3.65
6	4.93	4.75	4.60	4.46	4.34	4.23	4.13	4.03
7	5.48	5.27	5.09	4.93	4.78	4.65	4.53	4.42
8	6.03	5.79	5.58	5.39	5.22	5.07	4.93	4.80
9	6.58	6.31	6.07	5.85	5.66	5.49	5.33	5.18

(3) **Live floor loadings for different numbers of shelves and centre-line distances**

Facilities inside the controlled area should include reading room information, bibliographies, on-line catalogue terminals, the issue and return of books which can only be used in the reading room, copying equipment (in separate rooms), open-access book shelves, work spaces and, if necessary, the open-access book stacks.

Facilities outside the controlled area should include cloakrooms or briefcase and coat lockers, toilets, a cafeteria, a newspaper reading area, an exhibition room, lecture and conference rooms (possibly for use outside library opening hours), an information desk (central enquiries), card and microfiche indexes, on-line catalogue terminals, book return and a collection area for ordered/reserved books.

The provision of work spaces in college libraries depends on the number of students and the distribution of individual subject groups. Special work places are required for people with disabilities (wheelchair users and the visually impaired) and for special operations (microform reading and enlarging equipment, PCs, terminals, use of CD-ROMs etc; take note of the relevant guidelines), as well as for individual study (cubicles, carrels, individual work rooms). Work spaces should preferably be in daylight areas. The area required for a simple reading/work place is 2.5 m^2; for a PC or individual work place, ≥ 4.0 m^2 is needed.

Security is vitally important in user areas. Fire precautions must comply with national and local building regulations and procedures. The installation of a book security system will prevent theft, and the optimal security of unsupervised escape exits is achieved with automatic electronic lock-up when an alarm is triggered. Securing emergency doors mechanically with acoustic and/or visual alarms is less effective.

The archive store is best situated in the basement because of the high floor loads and the more even climate. 'Book towers' are not convenient because of the increased need for climate control, transport and staff, as well as limited flexibility. The most efficient method is to have linked areas which are as large as possible without changes in level. The divisions between fixed stacks and those of mobile (compact) systems are dependent on the structural grid of the columns. Capacity can be increased by approx. 100% by using mobile stacks. The floor loading with fixed stacks is at least 7.5 kN/m^2; with mobile stacks it is at least 12.5 kN/m^2.

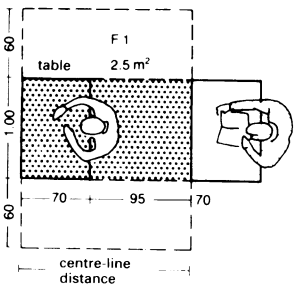
The internal climate in user areas should be 20° ±2°C, with approx. 50 ±5% relative air humidity and air changes (fresh replacement air) of 20 m^3 per hour per person. These values can be increased or reduced depending on the weather conditions. Avoid direct sunlight, since UV and heat radiation destroy paper and bindings. Because of the high energy consumption, and therefore high running costs, air conditioning should be introduced only where absolutely necessary. Natural ventilation is possible with narrow buildings.

The internal climate in archive stores should be 18° ±2°C, with 50 ±5% relative air humidity and air changes (fresh replacement air) of ≥3 $m^3h^{-1}m^{-1}$. Air filtration is necessary to eliminate any harmful substances in the atmosphere (e.g. dust, SO_2, NO_x etc.). By using wall materials with good moisture- and heat-retaining properties, it is possible to reduce the necessity for air conditioning. Slight air circulation is necessary to prevent the growth of mould, particularly with mobile stacks (use open ends). Special collections and materials (e.g. photographic slides, film, and sound and data media, as well as cards, plans and graphics) require a special internal climate. The internal environment should be appropriate to each area of the library, rather than being uniform throughout, and no open-plan offices should be sited in administrative areas. However, full environmental control is needed in stacks, because the building structure alone cannot provide suitable conditions

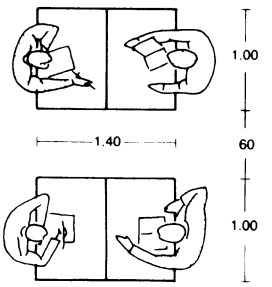
Floor loading in administration and book-processing areas should be >5.0 kN/m^2. In technical areas (workshops), individual structural requirements will depend on the types of machinery and equipment. Reinforced concrete and steel-frame buildings with a structural grid of >7.20 m × 7.20 m have been found to be suitable owing to the flexibility they allow in fitting out. Room heights should be ≥3.00 m.

Transport books horizontally in book trolleys (avoid thresholds; changes of level should have ramps ≤6% or platform lifts) and/or on conveyer belts. Transport books vertically in lifts, on conveyer belts (the route must be planned very carefully, with sloping inclines; very low maintenance costs), by a container transport system (mechanically programmable, a combination of horizontal stretches and paternoster lifts) or by an automatic container transport system (routes can be horizontal and/or vertical as desired, fully automatic, generally computer-controlled; high investment cost, rather high running costs).

LIBRARIES



① **Floor area for an individual workstation**



② **Minimum distances between tables**

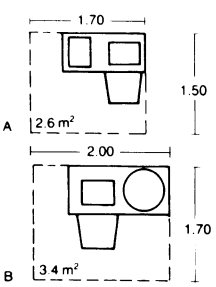
$$F_1 = b \cdot e \cdot (1 + \frac{N\%}{100}) \quad \text{formula 1}$$

F1 floor area required for an open workstation for library user
b width of table
e distance between centre-lines of tables arranged one behind the other
N% percentage of area allowed for adjacent aisles providing access to individual workstations

Under the conditions listed above, the floor area required for an individual workstation is approx. 2.50 m². Example:

$F_1 = 1.00\ m \cdot (0.70 + 0.95) \cdot (1 + \frac{50}{100})$
$F_1 = 2.48\ m^2$

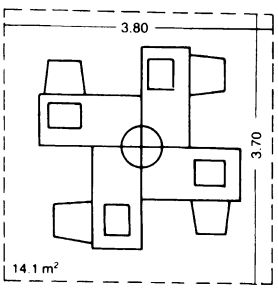
③ **Floor area calculation (m²)** → ①



④ **Microfiche reading workstation**

Workstation for microfiche reader: 60 × 120 cm table with rotating table stand (having maximum 10 vertical hanging storage units) → ④ A

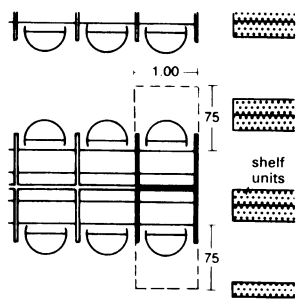
Workstation for microfiche reader: 75 × 150 cm table with table stand (for maximum 15 storage units) or rotating stand (having maximum 50 hanging storage units → ④ B



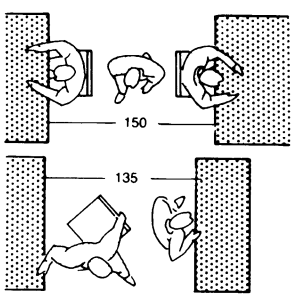
⑤ **Four-seat microfiche station**

Four-seat microfiche reading workstation: 75 × 150 cm tables for one (or two) rotating stands with maximum 50 (or 100) hanging storage units (3.70 × 3.80 m) → ⑤

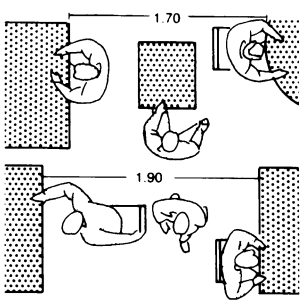
⑥ **Dimensions ④ – ⑤**



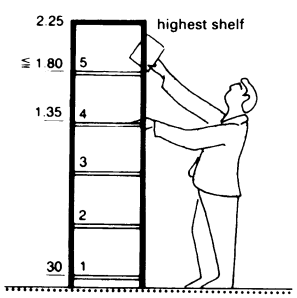
⑦ **Individual study booths**



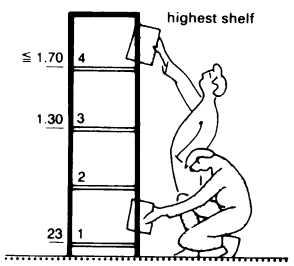
⑧ **Minimum free space in reading area** → ⑨



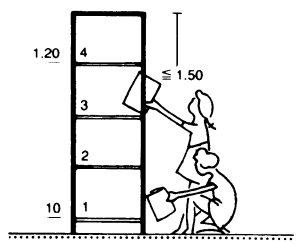
⑨ **When books are moved between seated and standing users**



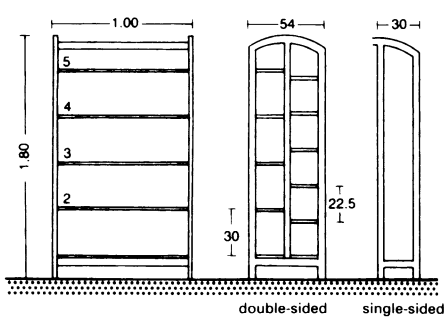
⑩ **Height of five-shelf unit**

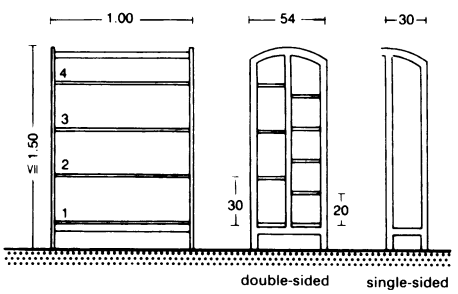


⑪ **Bookshelf for schoolchildren**



⑫ **Height of four-shelf unit for small children**



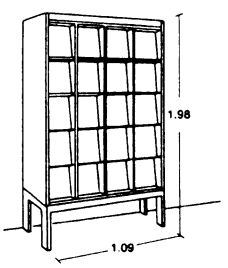


⑭ **Shelf units: for adults, 5–6 shelves; for children 4–5 shelves** → ⑫

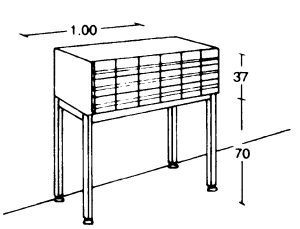
A pneumatic tube system can convey information such as lending tickets. Modern systems tend to use plastic conveyors, running in plastic tubes, with comparatively small plants. Other methods of sending call-slip information to the stack as part of retrieval communication are faxes, gravity tubes and document carriers. A computer link between the request counter and the stack is also possible. Ideally, all material should be moved directly to where it is required. The return of books to their correct place on the shelf is very important.

Lighting should be appropriate to the use to which the area is put. Bookshelves should be protected from daylight. Sensitive materials should not be exposed to a level >50 lx. Artificial light is preferable in an exhibition area since it is easier to control. The best illuminance distribution ratio at workstations is 10:3:1 (book:surface:background). Non-work rooms need 100–300 lx, stacks need 150–300 lx, office and administration blocks need 250–500 lx, and reading rooms without individual lights and catalogue rooms need 300–850 lx. Lighting should have separate switches in each area and be individually adjustable at each work station.

Building design should be based on climate, and internal environmental control should be based on the building. The recommended temperature for reading rooms and open access areas is 22°C in summer and 20°C in winter, with 50–60% relative humidity and six or seven air changes per hour. Stacks should be kept at 17–22°C in summer and 17°C in winter, with 50–60% relative humidity and six to seven air changes per hour. The recommended humidity level in libraries is between 45% and 55%. Special measures should be taken for unusual and sensitive materials; humidity which is too low or too high can damage films. The air should be changed at least three times per hour, depending on the area of the library and time of year. The air intake per cycle should preferably be 25%, but is often reduced to 15% for economic reasons.

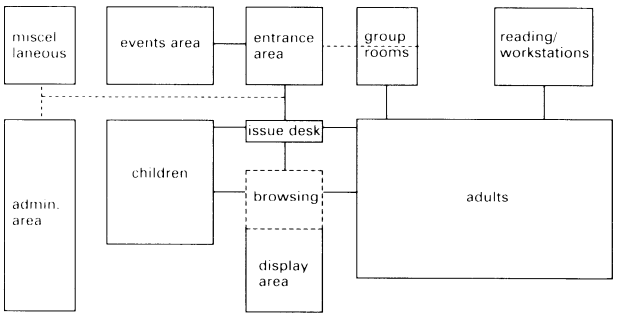


⑬ **Periodical rack**

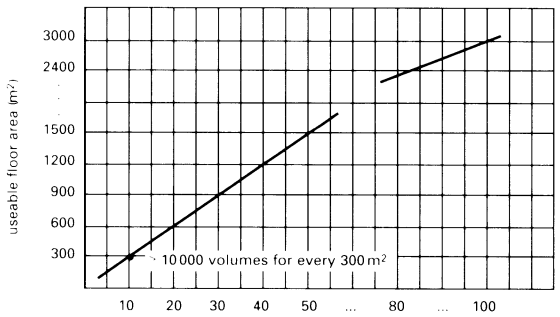


⑪ **Traditional card index**

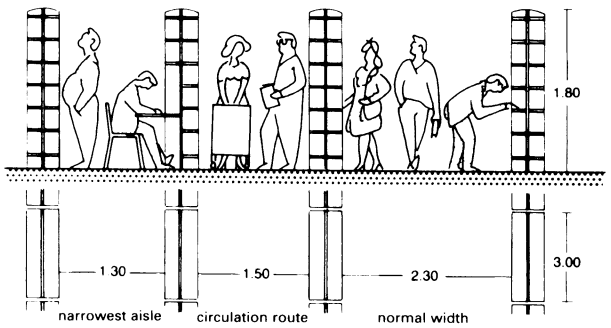
LIBRARIES



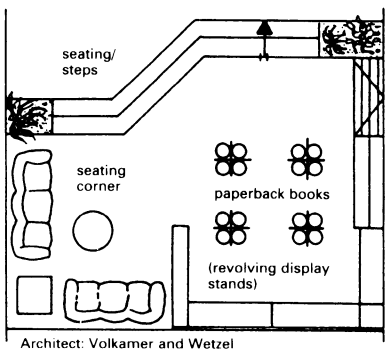
(1) **Functional diagram of medium-sized library**



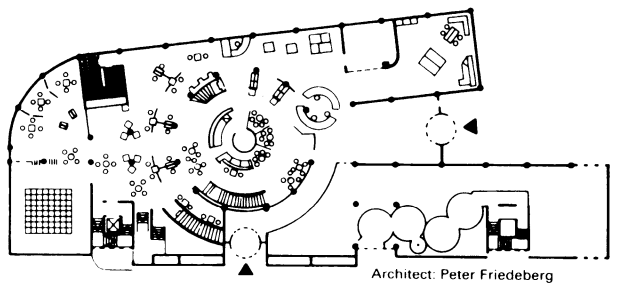
(2) **Public library floor area as a function of collection size**



(3) **Minimum distances**



(4) **Small browsing area**



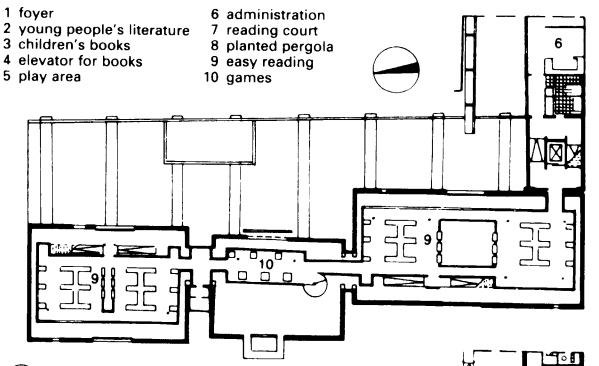
(5) **Library in Gütersloh**

Public libraries offer general literature and other information media which are directly accessible on open shelves. Systematic collections and subject searches of material in print and in other media are limited to the larger public libraries. Public libraries have no academic collection obligations or archiving functions, and are usually without, or with only very small, archive stores. They are freely accessible to the public, and are used by children, adolescents and adults. Public libraries orientate their level and choice of stock and services to the needs of their users. As a communication 'market-place' for all population groups, in addition to the traditional provision of books, the library may have browsing areas, a citizens' advice/enquiries desk, a cafeteria, music listening facilities, recreation and meeting rooms, and study seating for groups and individuals. It may also include a music library, an art lending library and a mobile lending service. In addition to books and newspapers, the collection may include periodicals, brochures, games, or new media (CDs, videos, PC software) to be used in the library or borrowed.

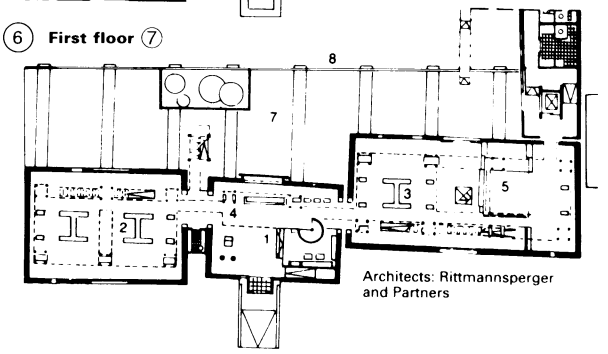
The room design should encourage adults, children and young people to spend time in separate open-plan spaces where activities take place. The floor area depends on the size of the collection. There should be 300 m² of usable floor area for every 10 000 units of media in the collection → (2). The objective is to have a minimum of two media units per occupant.

Ideally, the design should include large, open, extendible multipurpose areas, which are roughly square, and organised horizontally rather than vertically, and an inviting entrance. Areas for adult users can have five or six shelf levels (maximum reach 1.80 m → (3)); in the children's area there should be four shelf levels with a reach height of around 1.20 m. Shelf aisles should not be more than 3 m long, and can also be used to produce niches and exhibition stands. Book transport should be with book trolleys 920 mm × 990 mm × 500 mm (D × H × W). The goods elevator should be at the service entrance, and larger libraries should also have book conveyors.

Floor loadings in public libraries should not exceed 5.0 kN/m², in archive storage and similar open access areas with closely spaced stacks they should be 7.5 kN/m² maximum, and with compact storage (mobile shelving) 12.5 or 15.0 kN/m².



(6) **First floor** (7)

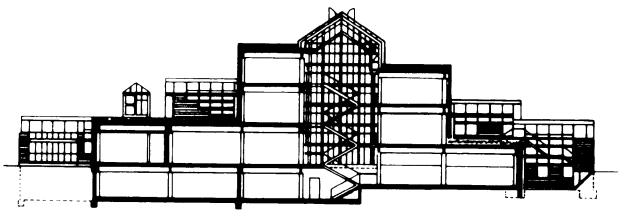


(7) **Ground floor of Viernheim library (conversion)**

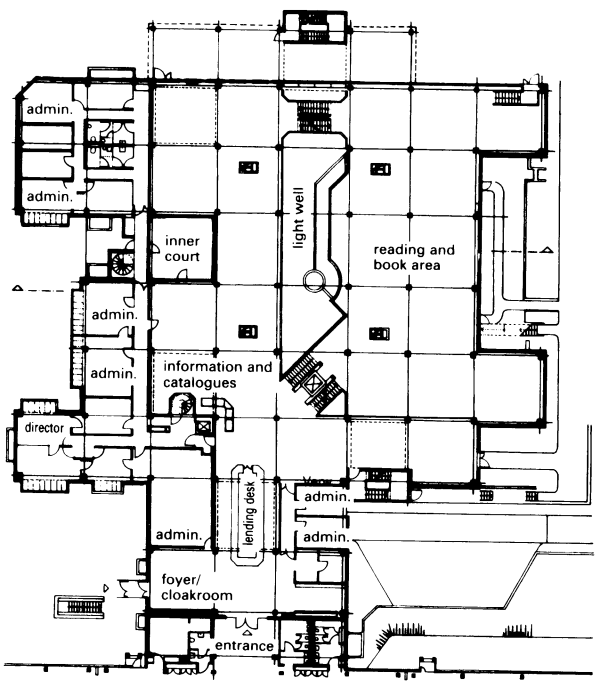
LIBRARIES

Science Libraries

Science libraries have always had a central position in science and the life of universities. They are not only locations to store books, but also places to work with books. Important and decisive contributions to world literature have been produced in libraries. The erection of libraries is one of the most notable building duties of society. Important architectural examples from the 19th century (such as the Biblioteca Laurenziana, Florence, and the Bibliothèque Nationale, Paris) show how these demands were met. The Bereichsbibliothek, Berlin → ①, has a gross area of 3800 m² containing 200000 books in the reading rooms, 300000 volumes in the open stacks and 8500 journals.

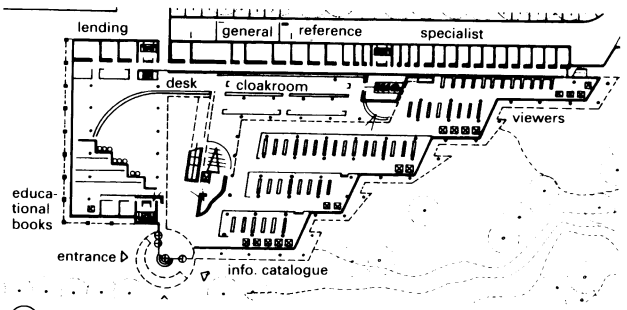


① **Section through Bereichsbibliothek Berlin** → ② ③ ⑥

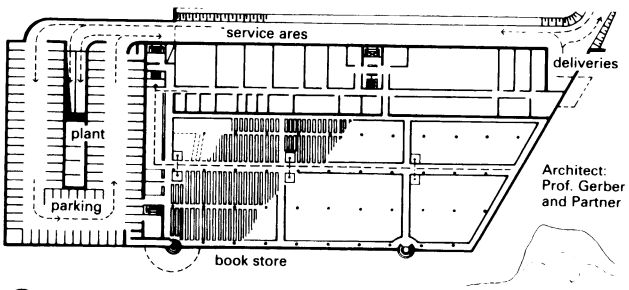


② **Ground floor**

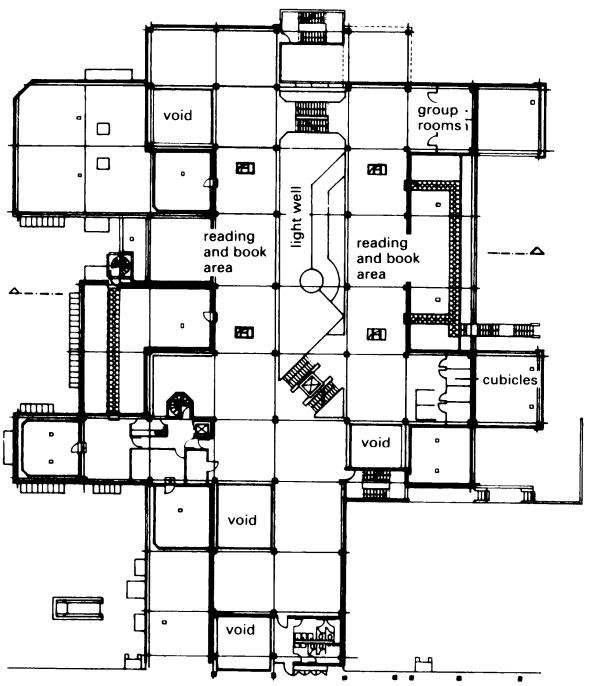
Architect: M. Shiedheim



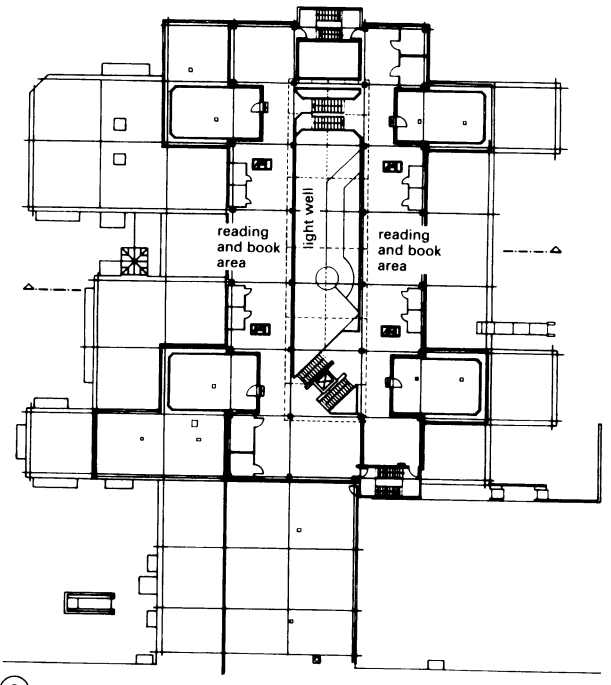
④ **State and University Library, Göttingen: ground floor**



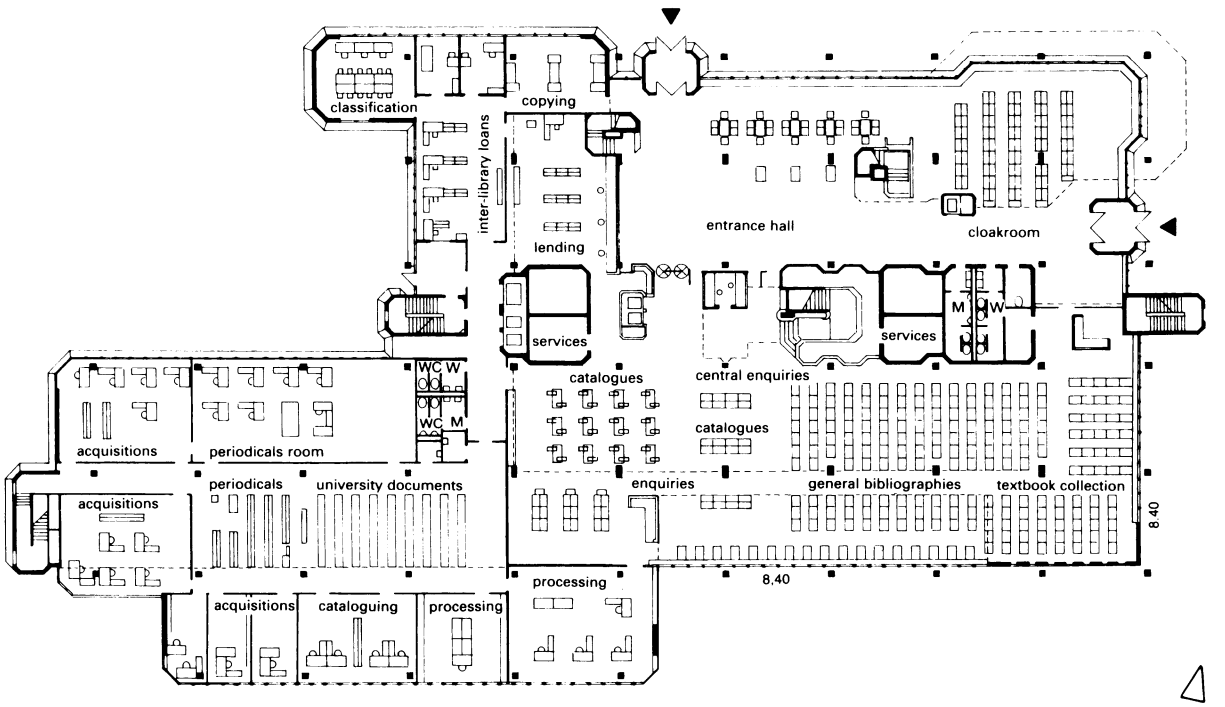
⑤ **Basement** → ④



③ **First floor**

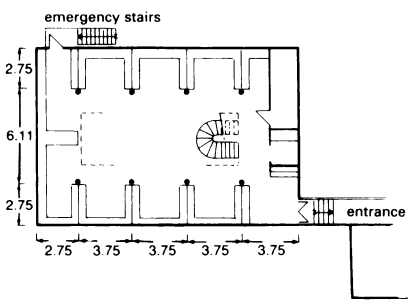


⑥ **Second floor**

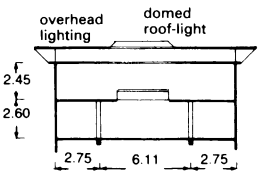


① **Ground floor of Düsseldorf University Library**

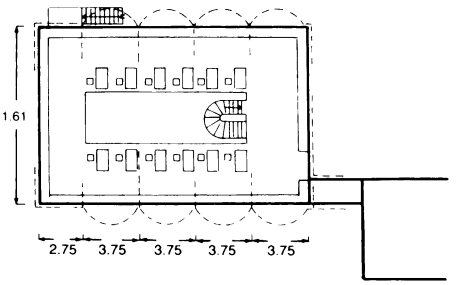
Designed by: Düsseldorf Architects Department



② **Ground floor of institute library**

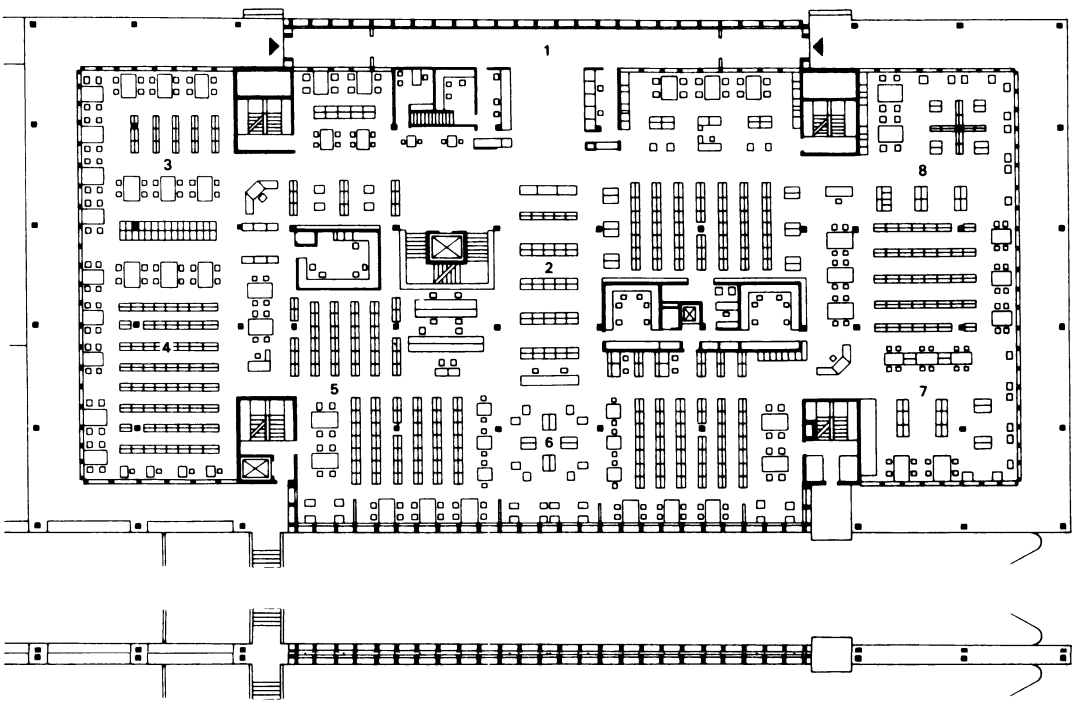


③ **Cross-section** → ② - ④



④ **Upper floor**

Architect: author

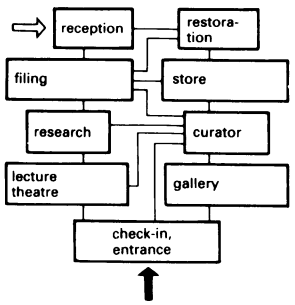


1 entrance hall
2 catalogues hall
3 periodicals
4 natural sciences
5 reference section
6 human sciences
7 arts and music
8 poetry and fiction

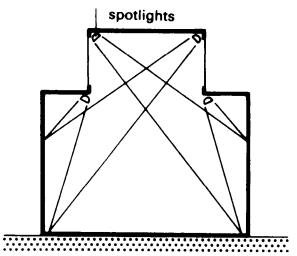
⑤ **Large library in USA**

Architect: Curtis and Davis

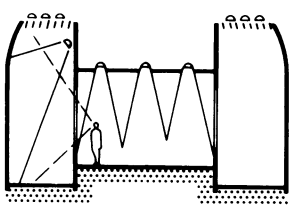
MUSEUMS AND ART GALLERIES



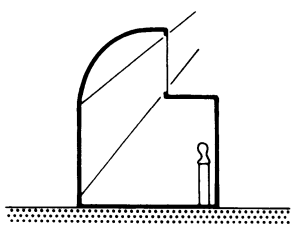
① **Circulation diagram**



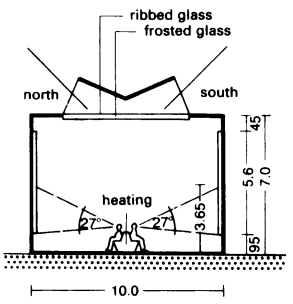
② **Install lighting so that angles of incidence correspond with natural light**



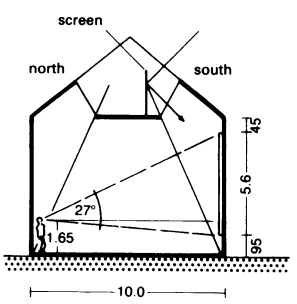
③ **Typical cross-section for museum of natural history**



④ **Gallery passage, lit from one side only, lower part with indirect, attenuated lighting**



⑤ **Well-lit exhibition hall based on Boston experiments**



⑥ **Ideal uniform lighting from both sides (following S. Hurst Seager)**

Museums and art galleries tend to have several of the same concerns, and as building types they tend to share many of same features. In general, the main concerns of museums and art galleries are collecting, documenting, preserving, researching, interpreting and exhibiting some form of material evidence. For this purpose, many people with varied skills are required. There are, however, important distinctions not only between museums and art galleries, but also between the different types of museum and art gallery. There are institutions such as heritage centres, exploratoria and some cultural institutes which are considered to be types of museums.

To show works of art and objects of cultural and scientific interest, the institution should provide protection against damage, theft, damp, aridity, sunlight and dust, and also show the works in the best light (in both senses of the term). This is normally achieved by dividing the collection into (a) objects for study, and (b) objects for display. Exhibits should be displayed in a way which allows the public to view them without effort. This calls for a variety of carefully selected, spacious arrangements, in rooms of a suitable shape and, especially in museums, in an interesting and logical sequence.

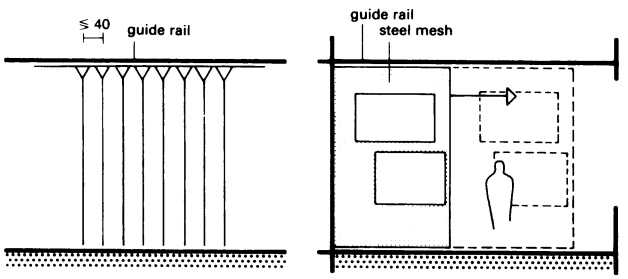
As far as possible, each group of pictures in an art gallery should have a separate room and each picture a wall to itself, which means small rooms. This option also provides more wall space in relation to floor area than large rooms, which are nevertheless necessary for big pictures. The normal human angle of vision starts 27° up from eye level. For a standing viewer, this means that well-lit pictures should be hung 10 m away with the top not more than 4.90 m above eye level and the bottom about 70 cm below → ⑥. The best hanging position for smaller pictures is with the point of emphasis (the level of the horizon in the picture) at eye level → ⑨.

It is necessary to allow 3–5 m² hanging surface per picture, 6–10 m² ground surface per sculpture, and 1 m² cabinet space per 400 coins.

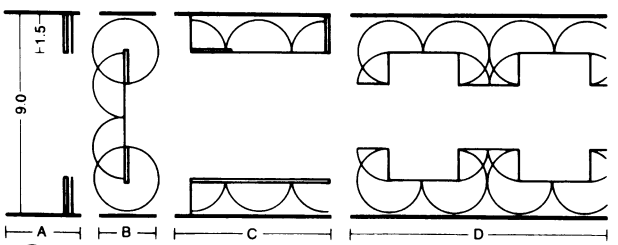
Calculations for museum and art gallery lighting are highly theoretical; the quality of light is decisive. Experiments carried out in America can be useful. Recently there has been a steady increase in the use of artificial lighting instead of daylight, which constantly changes even if north light is used.

According to experiments carried out in Boston, a favourable viewing space is between 30° and 60° up, measured from a point in the middle of the floor. This means a sill height of 2.13 m for pictures and a viewing range of 3.00–3.65 m for sculpture → ⑩.

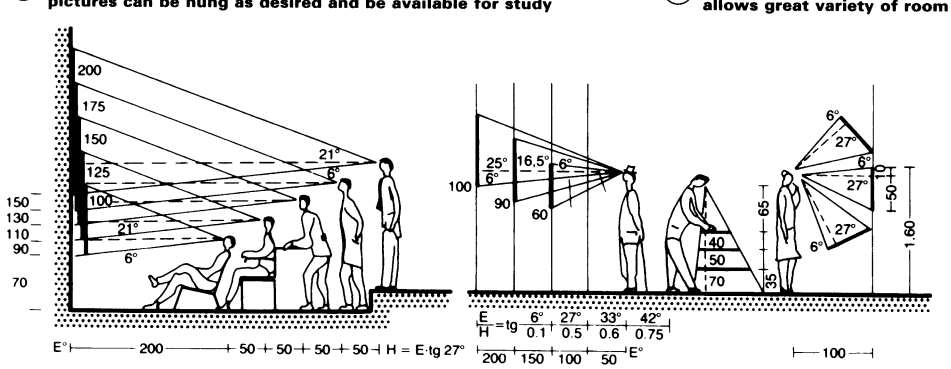
In art galleries there is generally no continuous circular route, just separate wings. Both museums and art galleries need side rooms for packing, dispatch, administration, a slide section, conservation workshops and lecture theatres. Disused castles, palaces and monasteries are usually suitable for housing museums. They are particularly suitable for historical objects, for which they provide a more appropriate setting than some modern museums.



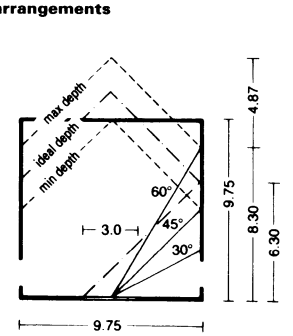
⑦ **Painting store with sliding steel mesh frames on which pictures can be hung as desired and be available for study**



⑧ **Exhibition room with folding screens (design: K. Schneider) allows great variety of room arrangements**



⑨ **Field of vision: height/size and distance**

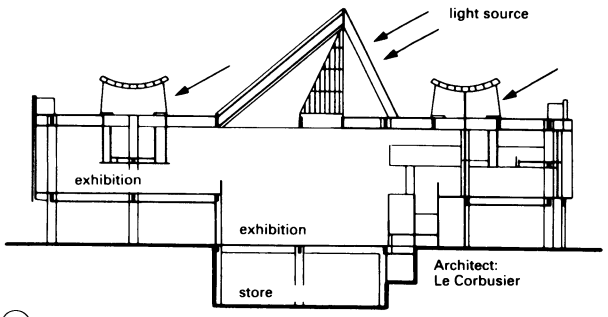


⑩ **Exhibition room with side lighting**

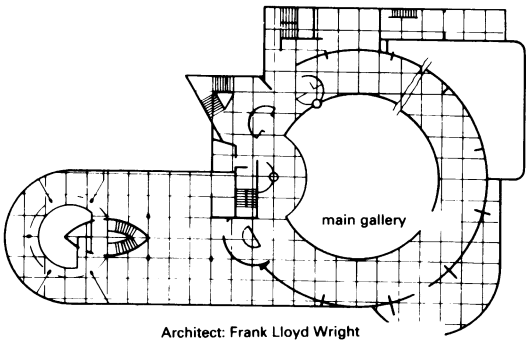
MUSEUMS: EXAMPLES

Nowadays, many museum buildings are also used as culture centres, and this possibility must be included in the planning stage. Spaces must be available for permanent and temporary exhibitions, libraries, media rooms and lecture theatres. There should also be places for relaxation and refreshments, as well as space for transport, storage, conservation, workshops and administration.

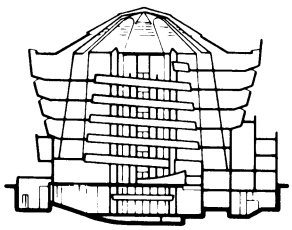
Technological innovations are having a big effect not only on museum function, but also on the design of exhibits. Two examples are the computerisation of collection records and design documentation, and lamp miniaturisation and fibre optics and their effect on lighting design.



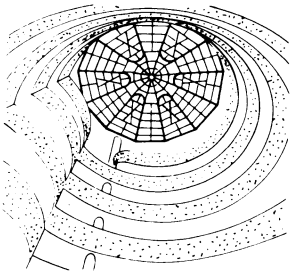
① **National Museum of Western Art, Tokyo: section**



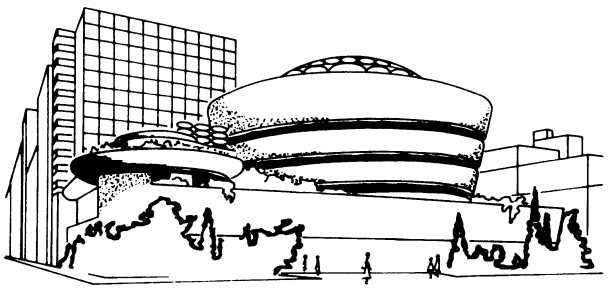
② **Guggenheim Museum, New York: plan** → ③,④,⑤



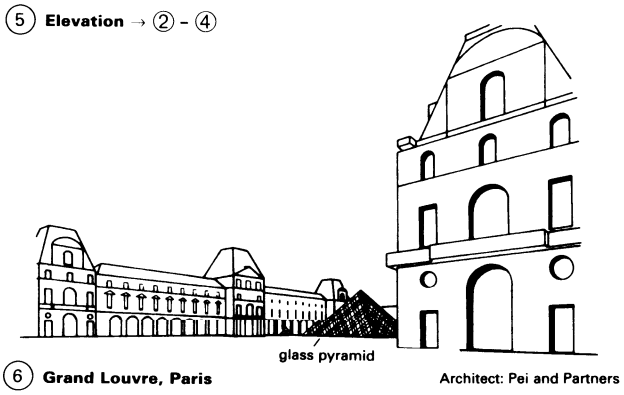
③ **Section** → ②



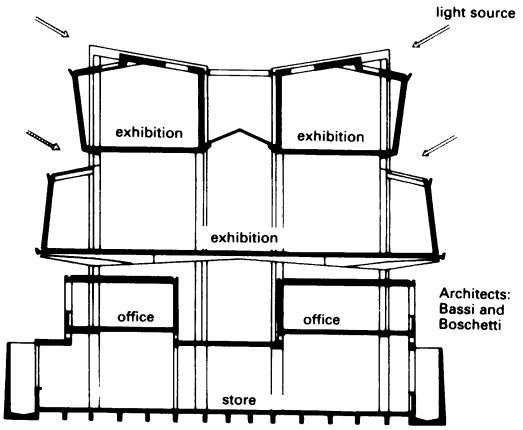
④ **Interior** → ② - ③



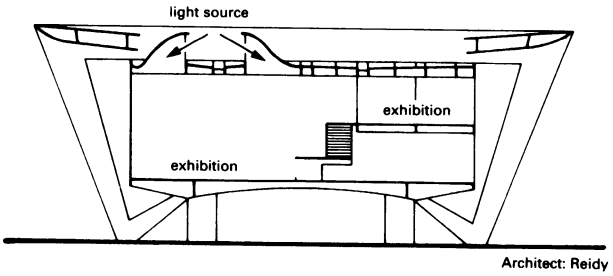
⑤ **Elevation** → ② - ④



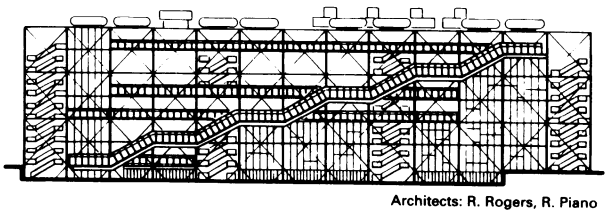
⑥ **Grand Louvre, Paris**



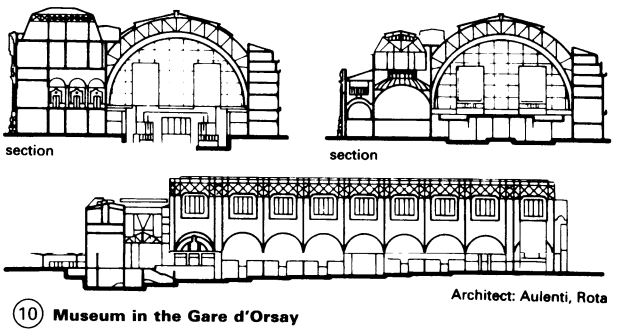
⑦ **Section and light sources Museo Civico, Turin**



⑧ **Section and light sources Museum of Modern Art, Rio de Janeiro**

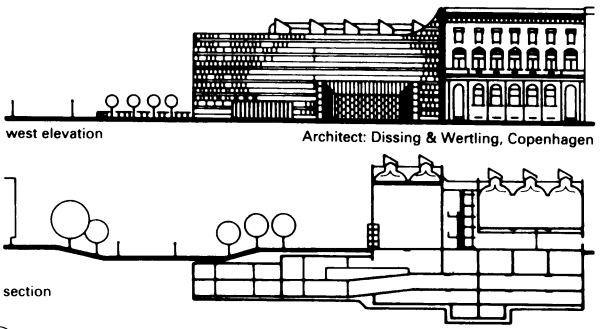


⑨ **Centre Pompidou, Paris: elevation**

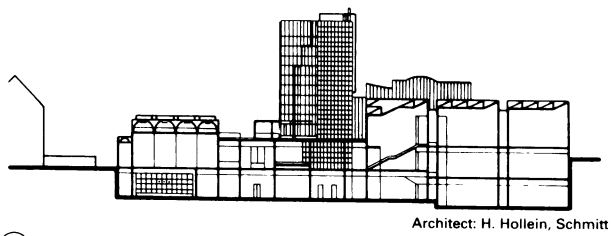


⑩ **Museum in the Gare d'Orsay**

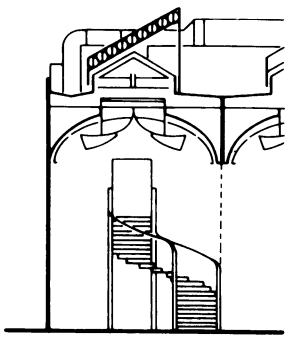
MUSEUMS: EXAMPLES



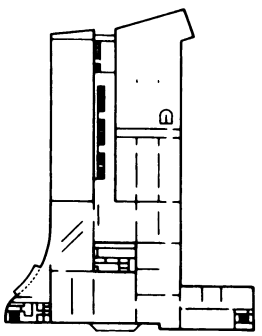
(1) **Art collection of North Rhine-Westphalia, Düsseldorf**



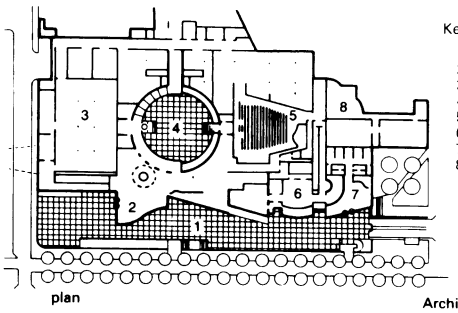
(4) **Museum of Modern Art, Münchengladbach**



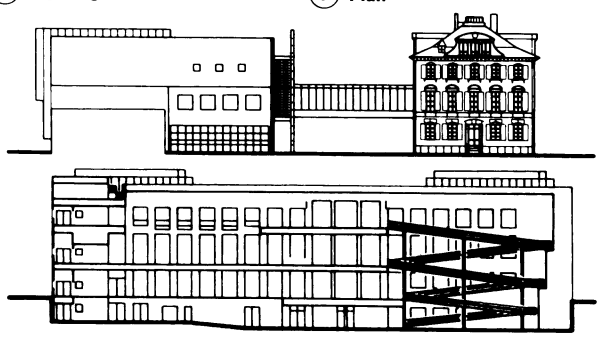
(2) **Lighting detail**



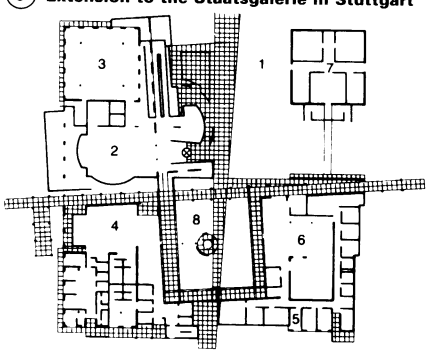
(3) **Plan**



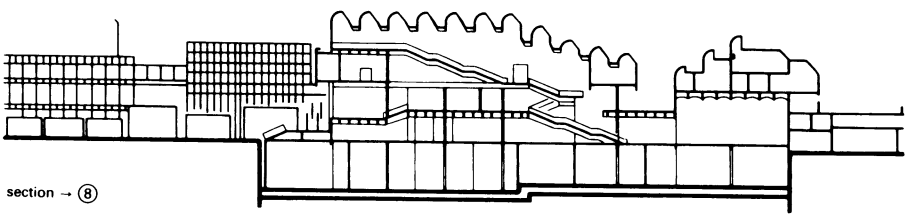
(5) **Extension to the Staatsgalerie in Stuttgart**

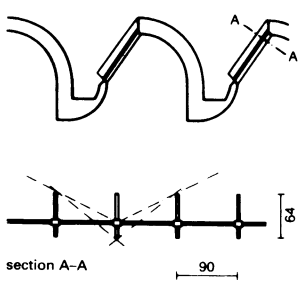


(6) **Museum of Arts and Crafts, Frankfurt: east elevation and section**

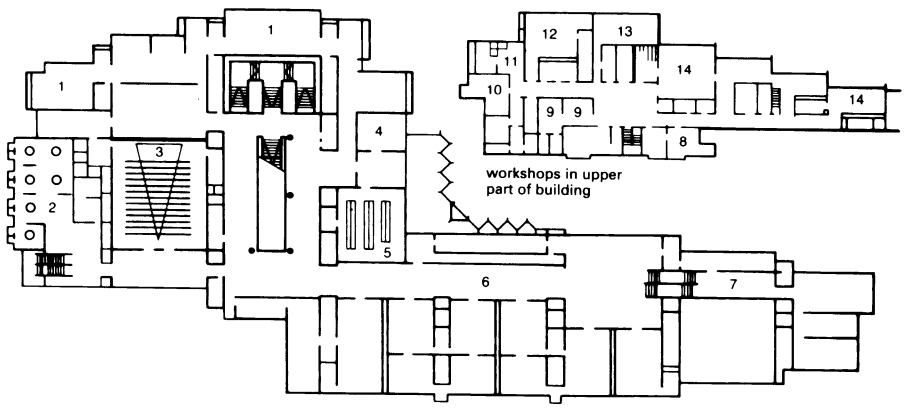


(7) **Ground floor plan → (6)**





(9) **Typical cross-section, northern light, 53° glazing**



key → (8)
1 exhibition
2 reading room
3 lecture theatre
4 administrator
5 graphics
6 museum way
7 gallery
8 chief restorer
9 testing
10 physics
11 chemistry
12 paper restorer
13 photographic studio
14 studio

(8) **Wallraf Richards Museum, Ludwig Museum, Cologne**
Architect: Busmann, Haberer