A MANUAL
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A MANUAL
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SCHOOL HYGIENE

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PREFACE TO THE FIRST EDITION

IN the following pages an attempt has been made to set forth in plain language the guiding principles of the hygiene of childhood so far as it is affected by the circumstances of school-life. The time has passed when the teacher could leave the question of health to the beneficent care of Nature. In great towns Nature has been expelled with a pitchfork, and in the course of a generation compulsion and the examination system have insensibly but steadily increased and tightened the pressure brought to bear on children from the age of five years and upwards. Teachers and pupils alike work under a new and unhealthy pressure, and great watchfulness and care are required to avoid evil consequences.

Fortunately no great amount of detailed knowledge is necessary, but rather observation directed to a right purpose. Part of the object of this book is to inculcate the importance of studying children at first-hand and sifting and selecting those influences which tend to do good from those which tend to do harm. In day-schools three sets of circumstances require consideration: I. The home-life and its surroundings, often exceedingly unhygienic and often entirely beyond the control of the teacher except as a friendly adviser. This is beyond the scope of the present writers. II. The conditions which affect children from the outside, as the arrangements of school-buildings, regulation of temperature, epidemics and accidents, etc. III. The management of the child as a growing and living creature.

Though many reforms are confessedly needed, nothing has been urged that is not within the power of teachers under existing regulations to accomplish. Much has been done of late years for education and the welfare of children, but much remains to be done. Nothing so effectually bars progress as a contented optimism; nothing so effectually tends to improve an institution as a lively discontent springing from a knowledge that a better state of affairs is possible. The first step is increased knowledge on the part of those engaged in the routine work of teaching. They can—if they will take the pains—supply the facts in the life-history of young children that no other observers can glean with an equal facility and continuity. And though the principles of health must necessarily come from the outside as the results of the labours of the physiologist and the medical man, details in the practical work of the school must be in the hands of the teacher. It depends ultimately on his knowledge and convictions whether an individual child is or is not brought up in that fulness of health which it should be the first duty of an educational system to promote.

We desire to acknowledge our obligations to Messrs Willink and Thicknesse, of Liverpool; to Messrs Ashwell and Nesbit, of Leicester; and the proprietors of the *School-Board Gazette* for the use of plans and sections of school-buildings.

E. W. H.
E. A. B.

May, 1901.

NOTE:—The six chapters on *Physiology*, which have been added to the present edition by Dr C. S. Sherrington, do not attempt to cover all the physiology necessary, but rather aim at emphasizing the salient portions of the subject and briefly explaining the principles which underlie the precepts and practice described in the earlier chapters of the book.

September, 1912.

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PART I.

CHAPTER I.

SITE AND SOIL.

It is evident that in the main, the selection of the *school site* must be limited by general considerations of cost, convenience, contiguity to the population to be served, and so on; the necessity for a perfectly wholesome site must however be carefully kept in view and weighed against temporary advantages which may arise on these grounds. Teachers and taught alike are peculiarly susceptible to conditions which are likely under any circumstances to be prejudicial to health; the confined and sedentary nature of the occupation and the mental activity required affect both teachers and pupils, whilst proneness to attacks of some forms of sickness may be regarded almost as incidental to the earlier years of life.

Unwholesome conditions of soil, often avoidable ones, are known upon very definite evidence to be associated with certain forms of disease, and the need for careful selection of site is fully established. If the less desirable ones cannot be altogether avoided, their objectionable features can often be removed if sufficient care be exercised in dealing with them.

The composition of subsoil even in neighbouring or contiguous localities may vary within wide ranges; more especially in the suburbs or outlying districts of growing cities, where may arise the dangers associated with "made" land, and it is clearly impossible always to select exactly such soil as know ledge and experience prove to be the best. For the reasons already indicated, it does not appear necessary to go at any length into the specific connections between soils and climate, but it may be pointed out that the physical conformation of the locality, elevation, fall of plains, watershed &c. exercise influence upon the healthiness of the district. Places where circulation of air, and access of sunlight are interfered with, whether because they be natural ravines and hollows, or whether they be spots surrounded and shut in by trees or by lofty buildings on higher ground, are unhealthy, and unsuitable for school buildings. Moreover such depressions, or those below the level of plains may be damp, and consequently unwholesome from surrounding subsoil drainage.

Soils exercise their important influence upon buildings, chiefly by the readiness with which moisture (dampness) or impurities may be brought into them. It must be remembered also that it is not merely that portion of the site actually covered by occupied rooms, which is important, but under certain circumstances the occupants may be affected by conditions of subsoil which exist at considerable distances. All soils, except perhaps the hardest rocks, are more or less porous, containing innumerable interstices comparable to those of a hard, close sponge; these are filled either with "ground" air, which differs widely in its composition from ordinary atmospheric air, or with "ground" water, which also may be widely different from pure water, and may in fact bring dangerous impurities from a distance. The interstices of the soil then are occupied alternately and for varying periods either with ground air, or ground water; as the water recedes in dry weather it will leave behind it some at least of any impurities which may have been dissolved or suspended in it, and these, by their decomposition, modify the nature of the air in the soil, *i.e.* the "ground" air.

The air in soils differs from atmospheric air in important particulars. The amount of carbonic acid gas is in excess, the amount increasing with the depth of the strata from which the soil air is taken; at the same time the amount of oxygen is diminished. Soil air, again, is usually very moist; it may also contain organic constituents from the decay of animal and vegetable substances. Rainfall and warmth exercise an important effect upon the composition of soil air, as well as upon its movement; variations in volume by change of temperature give rise to continual movement, and the rise of the ground water, consequent upon rain, will slowly force out the soil air. It is not difficult to understand that occupied buildings, artificially warmed in winter, and almost always warmer than the ground which surrounds the sites upon which they stand, must, unless means be taken to prevent it, be continually drawing in ground air not only from below, but also laterally. When the surrounding surface is impervious or rendered so by paving or frost, this is especially likely to happen. In this way leakages, *e.g.* of coal gas, may pass from long distances into schools or occupied buildings and noxious oozings and emanations from defective cesspools, and middens, or from accumulations of manure &c., may also be causes of mischief to premises at a distance. It is especially obvious that schools built on "made" land may be rendered unhealthy so long as the constituents of the foundation contain decomposing impurities, since the impure ground air may ascend into the rooms.

Water, instead of air, may occupy the interstices of soil, and may be derivable from rain, or from percolation and capillarity from subterranean water, pressure from rising of adjacent rivers, &c.

The capability of soils for absorbing and retaining water varies very considerably; almost all soils will take up some, loose sand may absorb as much as two gallons in a cubic foot, sandstone about one gallon, chalk takes up about $15\,{}^{0}/_{0}$, clay

20 $^0/_0$, and is very retentive of it. The distinction must be borne in mind between a soil which is merely permeable, one which takes up water readily, allowing it to percolate through and which dries quickly, and an absorptive soil, retentive of moisture, permeable only to a very limited extent, and remaining wet. Sandstones illustrate the first case, clay the second, rock, which is almost impervious, absorbs practically none.

The rise and fall of ground water is shown by the rise and fall of water in wells, but careful observation is necessary in order to ensure correctness in conclusions.

It will be evident that when soils are damp from any cause a non-retentive permeable soil can be more easily made dry by subsoil drainage than one which does not admit of ready percolation; special drains to take off ground water are frequently laid by the side of sewers.

It is, however, the nature of the soil of the immediate locality that is of importance in the influence which it is likely to have upon the health of the occupiers of the schools. The dry and impermeable rocks, slates, chalk, gravel, permeable sandstones, are usually healthy and dry, unless in the latter case clay may underlie a superficial sand-rock, or sandy soil, when dampness may be found. Clays and alluvial soils are frequently wet and damp and require to be carefully dealt with.

Much attention must be given to the nature of *made soils*, since special importance attaches to the subject by reason of the frequency with which such sites are met with in the rapidly growing suburbs of great towns; these may or may not be unhealthy, and the difference depends upon the original character of the deposited refuse, and the length of time which has elapsed since the deposits were made. Many years ago a careful examination was made into made soils in Liverpool, at the instance of the Corporation, by Drs Parkes and Burdon Sanderson; it was found that in the case of inequalities of the ground which had been filled up with ash-pit refuse, vegetable-matter had disappeared in about three years, as also cloth, wood, and other fibres; other textile fabrics, also hair &c., are much more permanent. Made soils should be carefully examined, and in every case carefully drained.

Without entering into the general question of the well-known influence exerted upon health, and the incidence of diseases by soils, it will be sufficient to say that the influence of damp soils in producing and accentuating diseases of the lungs is established. The same condition, dampness, and the cold associated with dampness, predispose to various forms of rheumatism. Filth-laden soils or the effluvia from them may contribute to, or be responsible for outbreaks of diarrhœa, dysentery, or enteric fever, and may confidently be expected to cause deterioration in health and to give rise to frequent malaise, of a kind likely to interfere seriously with the powers of mental application.

CHAPTER II.

THE SCHOOL BUILDING.

In order to exclude the possibility of damp as well as to keep out ground air, it is necessary to completely cover the whole of the site with concrete, or some material equally close and hard. The character of the material used is of the utmost importance; only the best concrete which can be obtained should be employed, the inferior kinds met with contain too little lime or cement and crumble away, leaving interstices into which air will pass or water will creep by capillarity, not only making the house unwholesome, but possibly endangering the structure. The necessity for careful attention to these precautions is obvious. In the absence of some special foundation, danger may arise not only from gases immediately beneath the building finding their way into it, but—especially in times of frost—they may be drawn from considerable distances beneath the hard frozen surface of the ground. The thickness of the cement concrete should be from 4 to 6 inches.

In many instances this concrete may serve as a floor itself; in passages, halls, out-buildings, this would be the case. When a boarded floor is necessary a space should be left for ventilation between the concrete and that floor. This measure serves as a valuable precaution against dry rot, and a clear and continuous space of at least three inches between the underside of every joist of such floor and the general surface of the asphalte or concrete with which the ground beneath may have been covered, should be allowed. The ventilation of this space can be ensured by means of air-bricks. (Figs. 1 and 3.)

Special care must also be taken to protect the part of the walls which is situated below the level of the ground, and with a view to render them impervious to damp, exceptionally good

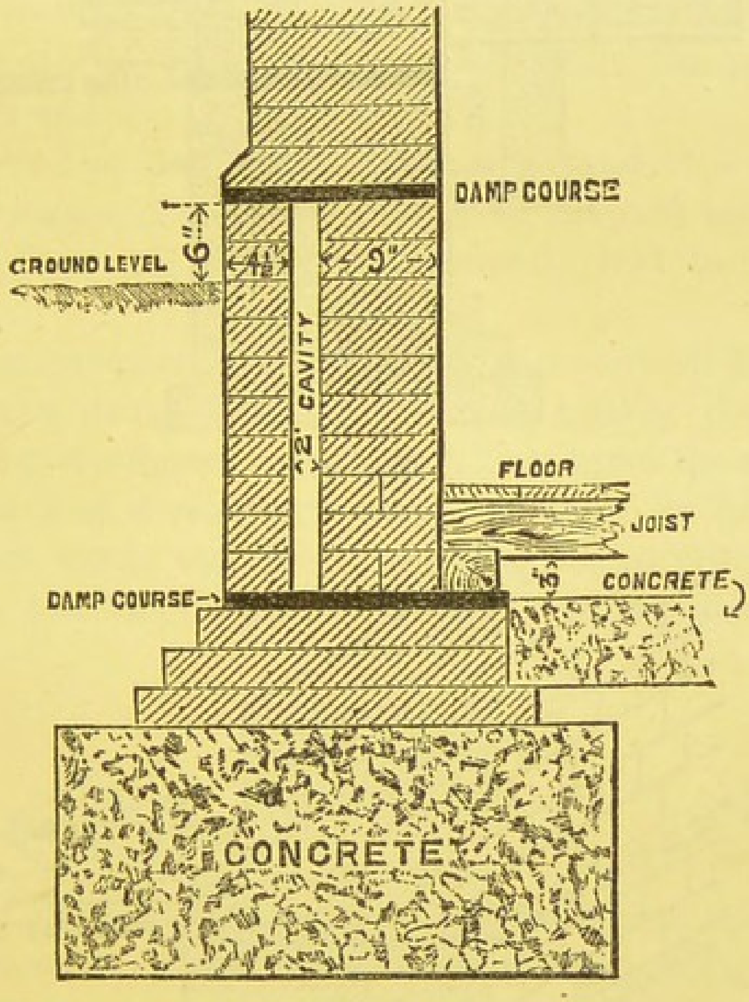


Fig. 1.

material should be used, and a damp-proof course provided in the wall all round the building, or this part of the external wall may be constructed with a cavity 2 or 3 inches wide between the external and internal faces of the wall, the two portions being joined by bonding ties of suitable material of a non-absorbent character. (Fig. 1.)

In order to prevent the passage of moisture up the walls of the building, a damp-proof course must be laid completely across the wall, and extending all around the building. This

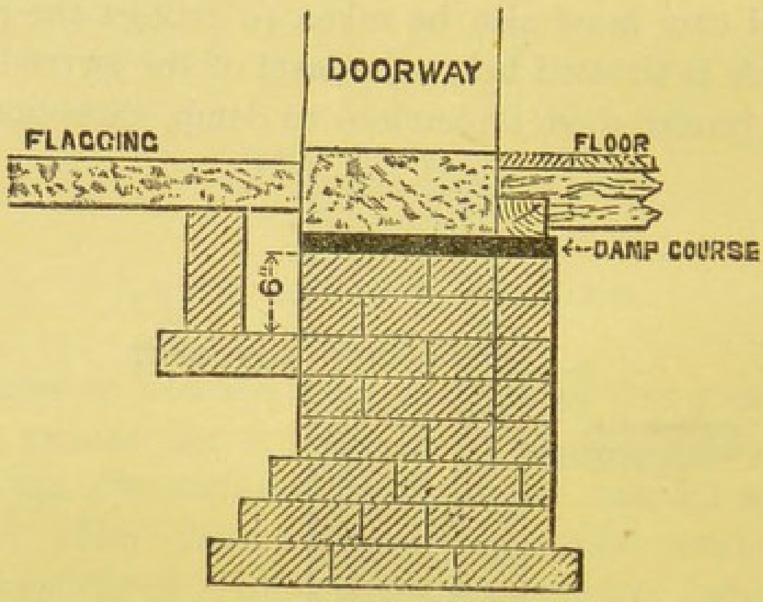


Fig. 2.

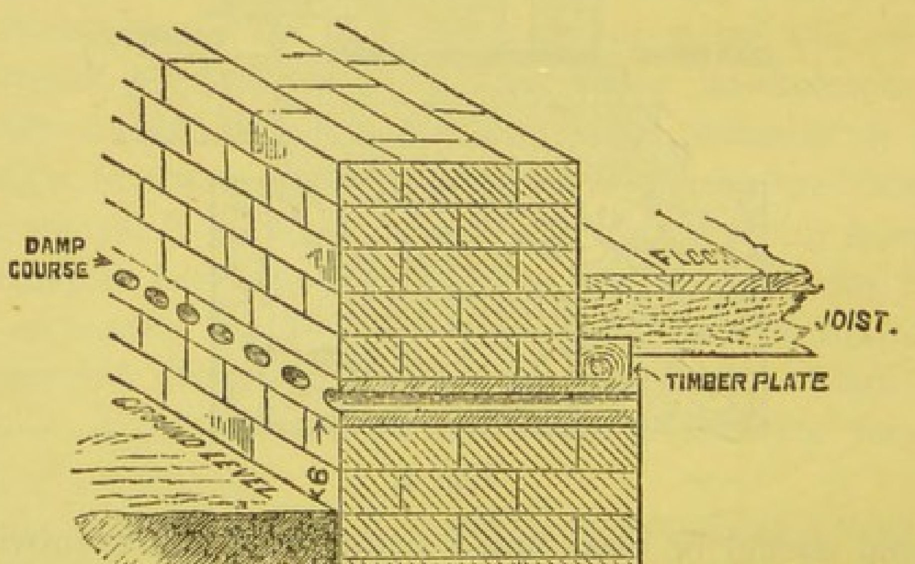


Fig. 3.

damp-proof course should be laid a little distance, say a few inches, above the ground level, and it should be employed in all cases, whether the site be a damp one or not. It may consist of asphalte, slate, cement, or pitch, or slate in cement, or other material. Sometimes a sunk area may be necessary, in order that any mound of earth rising higher than the damp-proof course may be kept away from the wall. In this way the building would either have an open area above the damp-proof course or a specially constructed dry area.

Questions of solidity, foundations, proper width of footings, solidity and thickness of walls, &c. fall within the province of the architect and the builder.

Whenever the dampness of the site renders such a precaution necessary, the subsoil should be drained by means of suitable earthenware field pipes, properly laid to a suitable outfall.

Whilst such careful precaution is necessary to protect the building from damp from below, it is equally necessary to guard against dampness from rain falling upon the roof; suitable gutters and downspouts must therefore be provided to carry off such water, and these downspouts must not pass down direct into the drain, but terminate over suitable trapped gullies.

Sewerage.

Some of the salient points in connection with the drainage must be considered in a little more detail. The "house drain" or "private communicating sewer" between the soil pipe and the main sewer should be constructed of stoneware glazed pipes, jointed in such a manner as to be absolutely watertight. It should in no case pass under any part of the building, unless this cannot be avoided. It should then, in that part of its course, be bedded in concrete at least six inches thick all round, and provided with means of inspection at either end.

The whole course of this "private connecting sewer" or "house drain" should be in a straight line, or as direct as possible: if one line cannot be adopted, there should be straight lines from angle to angle with an inspection shaft at each angle. It should be laid at such an inclination as will secure a velocity of not less than 3 feet per second, and the diameter should be 4 or 6 inches in accordance with the number of lavatories discharging into it. A disconnecting trap with a fresh air inlet on the house-side of it, should be placed upon the house drain at a convenient place near to the common sewer.

The soil pipe should be 4 inches in diameter and left open at the top, which should be carried to a safe place above the eaves without any lessening in the diameter. Sometimes a wire cage is placed over the soil pipe to prevent birds building in it.

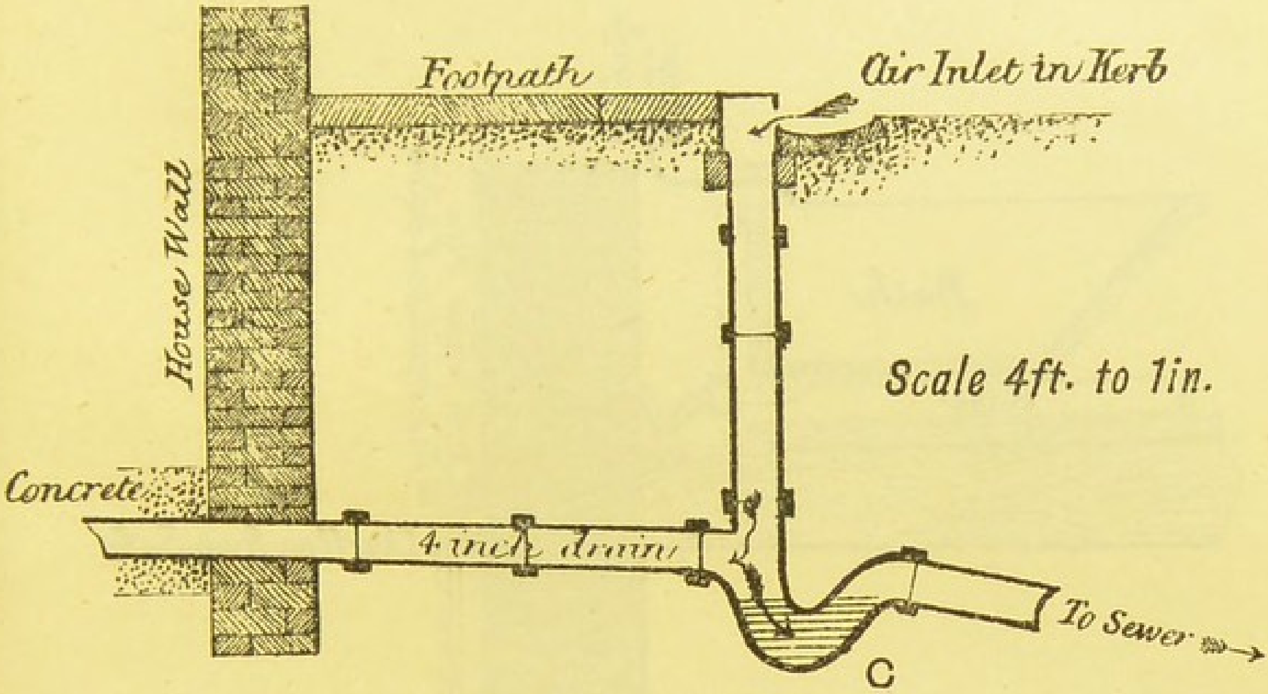
Provision should be made for flushing the house drain in addition to the incidental flushes given when the waterclosets or lavatories are made use of.

Drains, Lavatories, Waterclosets.

The general aim in connection with the drainage of a building is to ensure a prompt and complete removal of all waste, deleterious matter, the retention of which may prove prejudicial to health.

This is effected by means of suitably arranged pipes or drains which shall convey the waste water from baths, lavatories, &c., but the removal of this and the construction of the pipes must be so arranged that, whilst they permit water to flow away into the sewers, they shall not permit the access back again of any gases, produced by decomposition, from the drains or sewers themselves into the building.

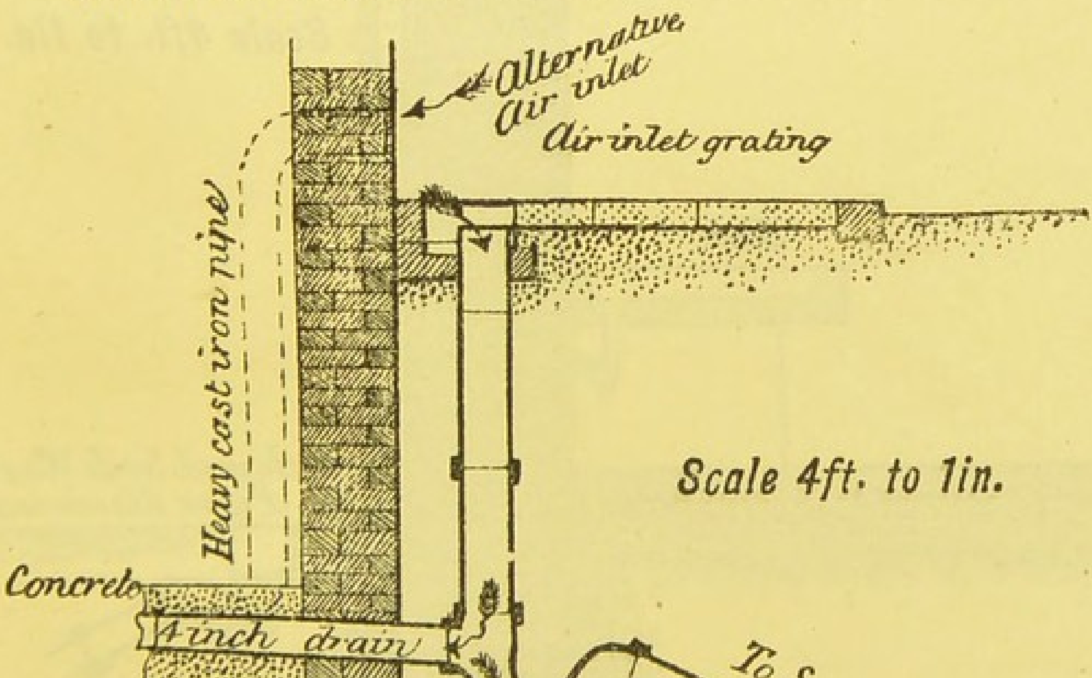
MAIN DRAIN DISCONNECTING TRAP WITH AIR INLET IN KERB OF STREET FOOTPATH.



GENERAL SECTION.

Fig. 4.

DETAIL OF MAIN DRAIN DISCONNECTING TRAP WITH AIR INLET IN STREET FOOTPATH.



GENERAL SECTION.

Fig. 4 *a*.

DRAINAGE FROM SINK, BATH AND RAIN WATER PIPE.

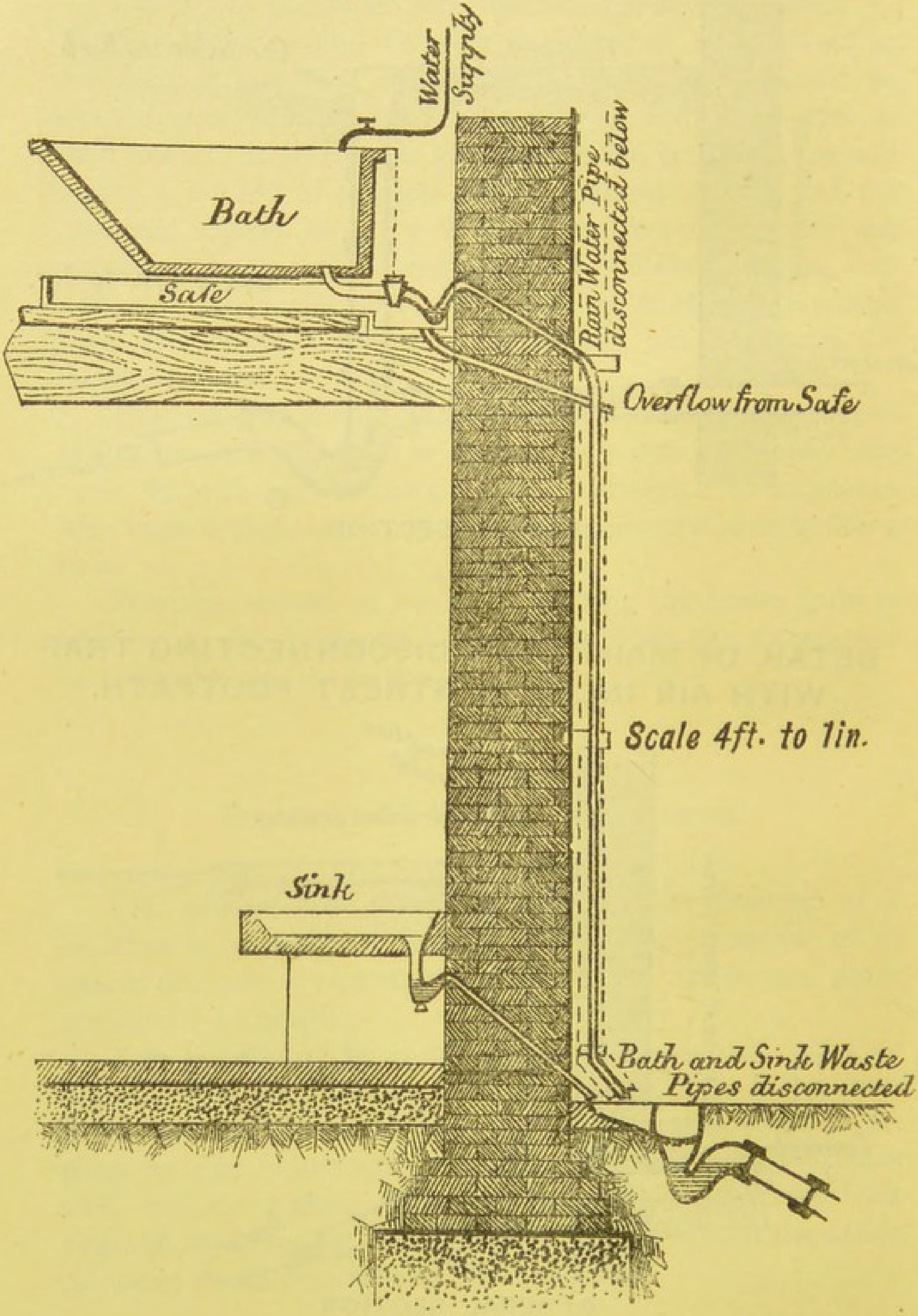


Fig. 5.

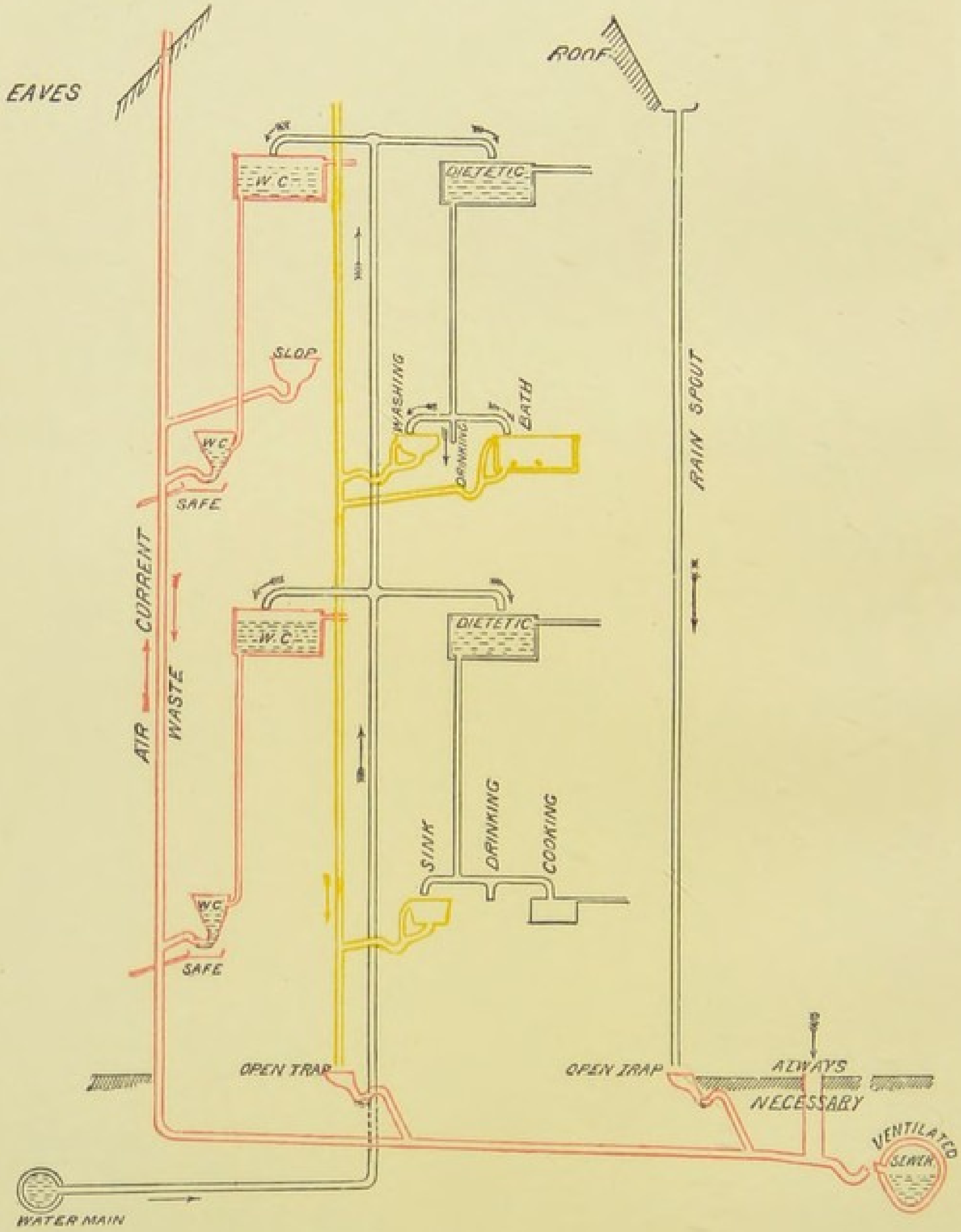


Fig. 6.

To face p. 13.

The object is attained by the use of simple ventilating traps, so placed as to afford no obstruction to the outflow of the liquid, whilst they effectually prevent the reflux of gases into the building, the pressure in the sewers being relieved by appropriate ventilation into the open air. A trap is the name given to a bend placed upon the pipe in such a manner as to permit the flow of liquids but prevent the reflux of gases. (*C*, Fig. 4.)

The diagram (Fig. 6) indicates the principles to be aimed at. The system coloured *red* indicates that section of the drainage system connected with the watercloset and with the disposal of *foul water*. It will be seen that the outflows from the closets and the slops passes directly into the soil pipe, which, placed external to the building, is continued straight up to the roof without bend or curve, and is open at the top full bore. Below, the soil pipe is directly continuous with the drain, which with an appropriate fall, to ensure sufficient velocity to its contents, passes first an open ventilator and immediately after that a trap, before terminating in the ventilated sewer. Separate cisterns are provided for flushing the closets or lavatories. *Waste water* from baths and sinks is dealt with by the system coloured *yellow*, and it will be seen that the yellow pipes do not pass directly into the drain but they terminate in the open air over a gully, which is itself trapped off from the drain. The *pure water* supply is indicated in *black*. Further, a long black line indicates the way in which the downspouts carrying off *rain water* are dealt with. These also terminate over trapped and ventilated gullies. They must not pass down into the drain direct, nor can they be made use of as ventilators for the drain, because in times of rainfall they are running full and consequently cannot act as ventilators.

Cloak-rooms.

It is essential in every day-school to provide adequate space for hats and coats, &c., and for drying overcoats, and other outer garments, boots, &c., in wet weather. Cloak-rooms should be large, provided with hooks and rails, or partitions sufficient to allow one for each scholar, and sufficiently spaced so that the clothing of different scholars may not hang in contact; a place for umbrellas should also be provided. A drying chamber can be used by an attendant for drying the wet clothing during school hours.

The approach to the cloak-room should be easy, to avoid crushing, and it should be provided with a separate exit; the ventilation must be very free, otherwise the room will become close and offensive.

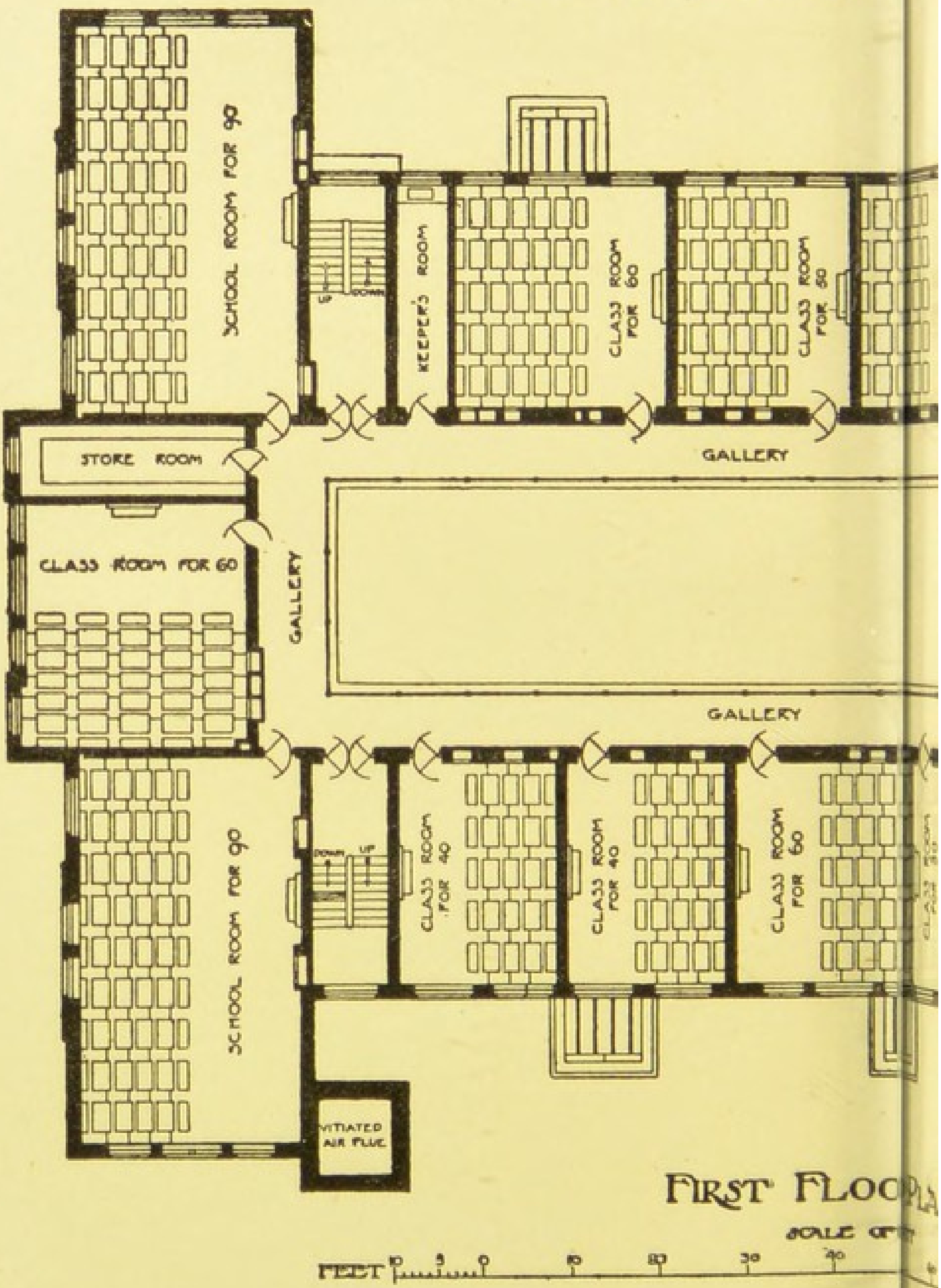
Class-rooms.

The class-room is not, as a rule, occupied more than one hour at a time without an opportunity for thoroughly ventilating it in this way for at least a few minutes; the size of the room will vary greatly, but as the number that one master or mistress can control and effectively teach will average thirty, a room to accommodate this number may be taken as the type. What has been said in regard to the connection between ventilation and cubic space must be borne in mind and every opportunity to ventilate the room must be taken. The height of the class-room is a matter of importance; in calculating cubic space no greater height than twelve feet should be considered as advantageous.

It should be the duty of the head master or head mistress to see that whenever the class-room is temporarily vacated the windows should be opened.

The question of *lighting* of school-rooms is fully dealt with in Part II.

THE FOLLOWING PLANS ILLUSTRA
OF A LARGE



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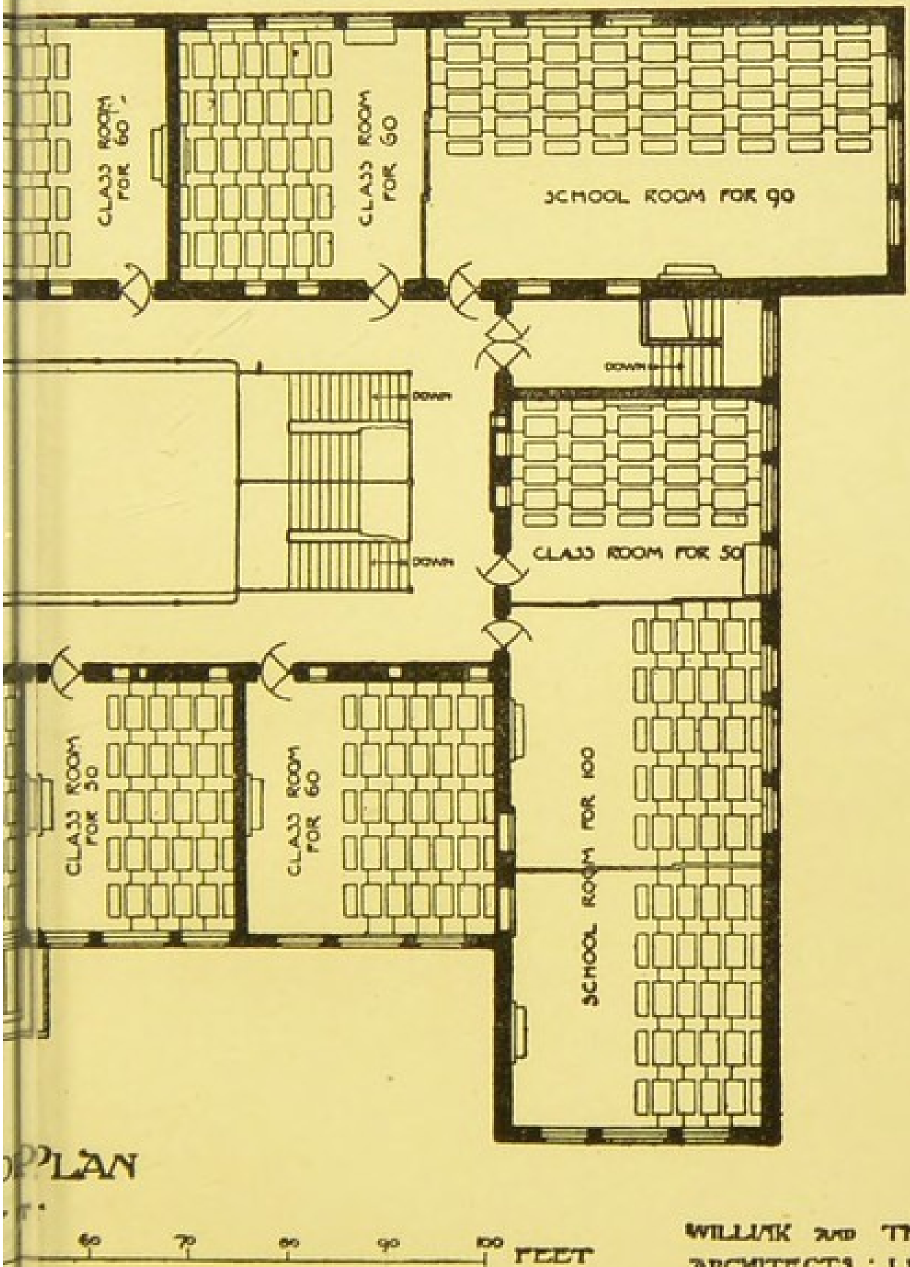
...E THE GENERAL ARRANGEMENTS ...OARD SCHOOL.



WILLINK AND THICKNESSE
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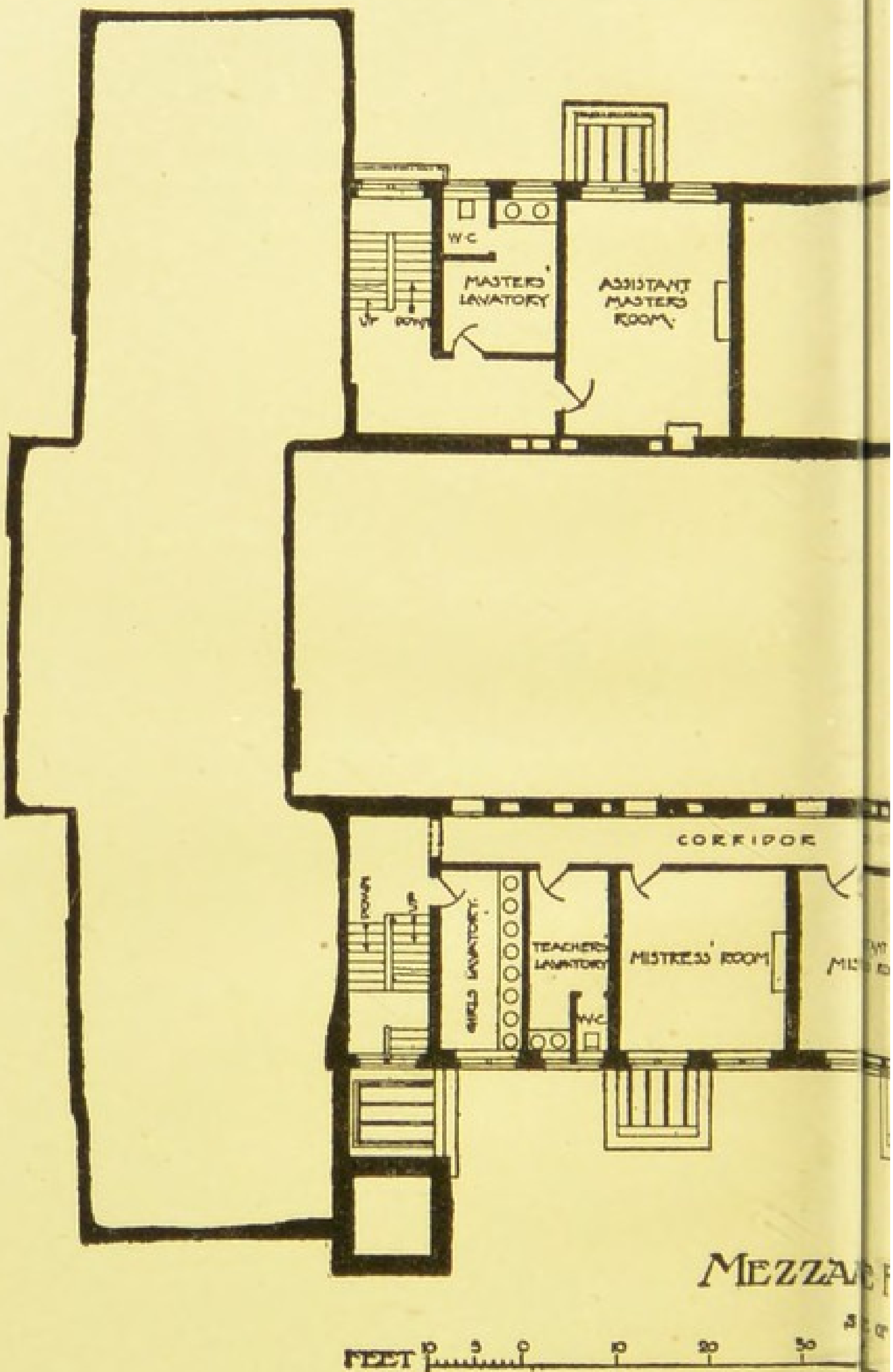
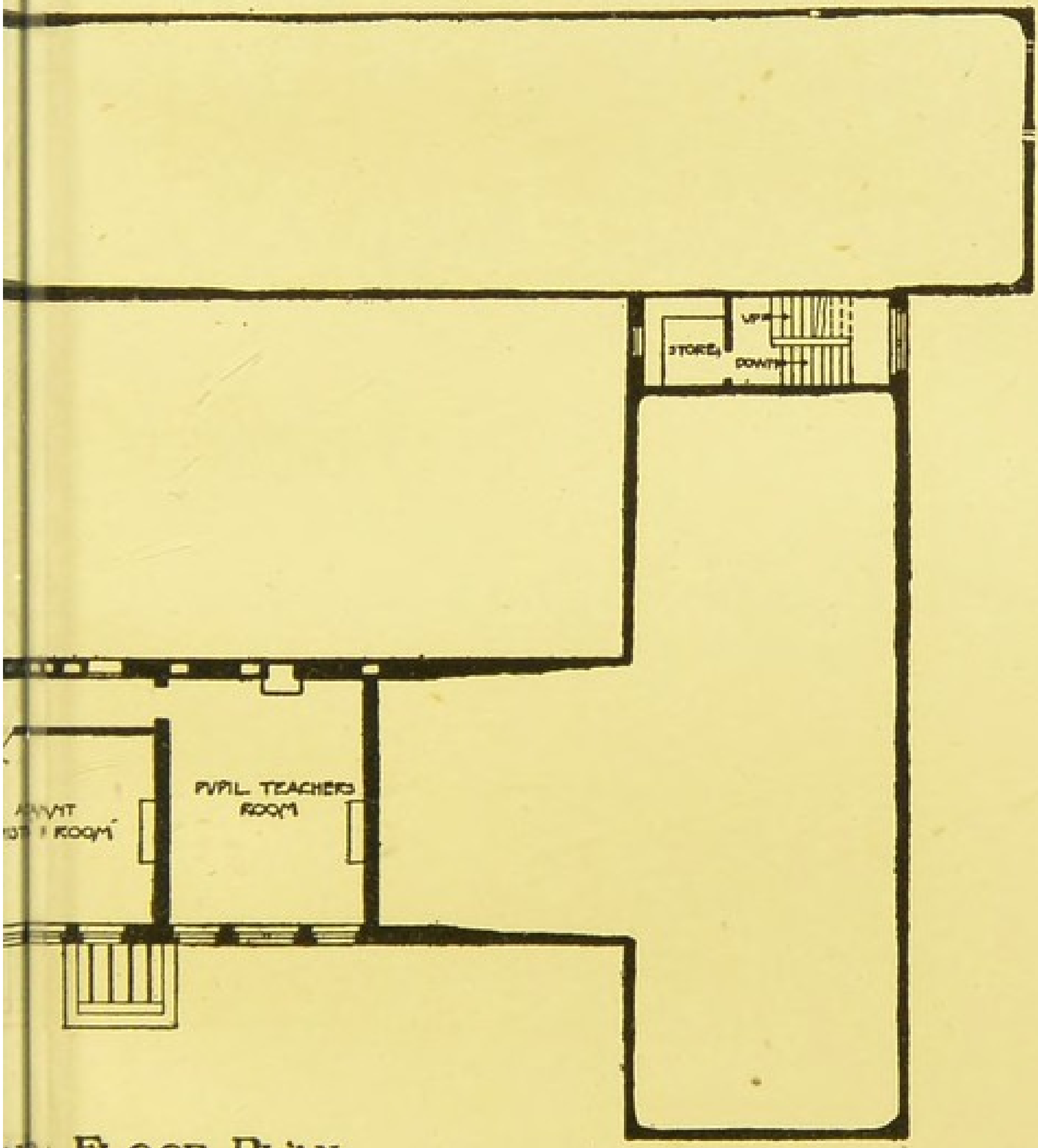


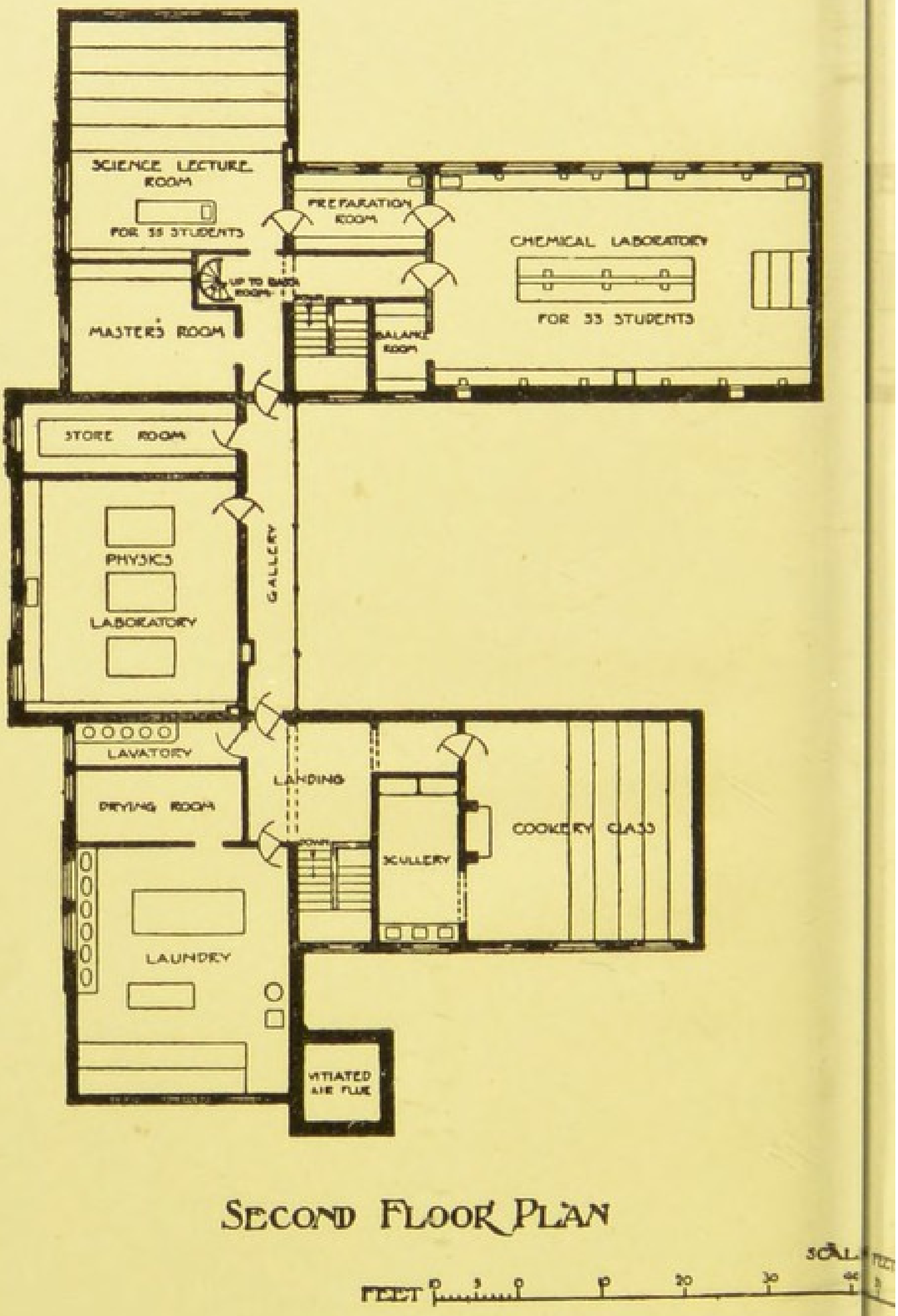
To follow Plan I.

PLAN II



FLOOR PLAN

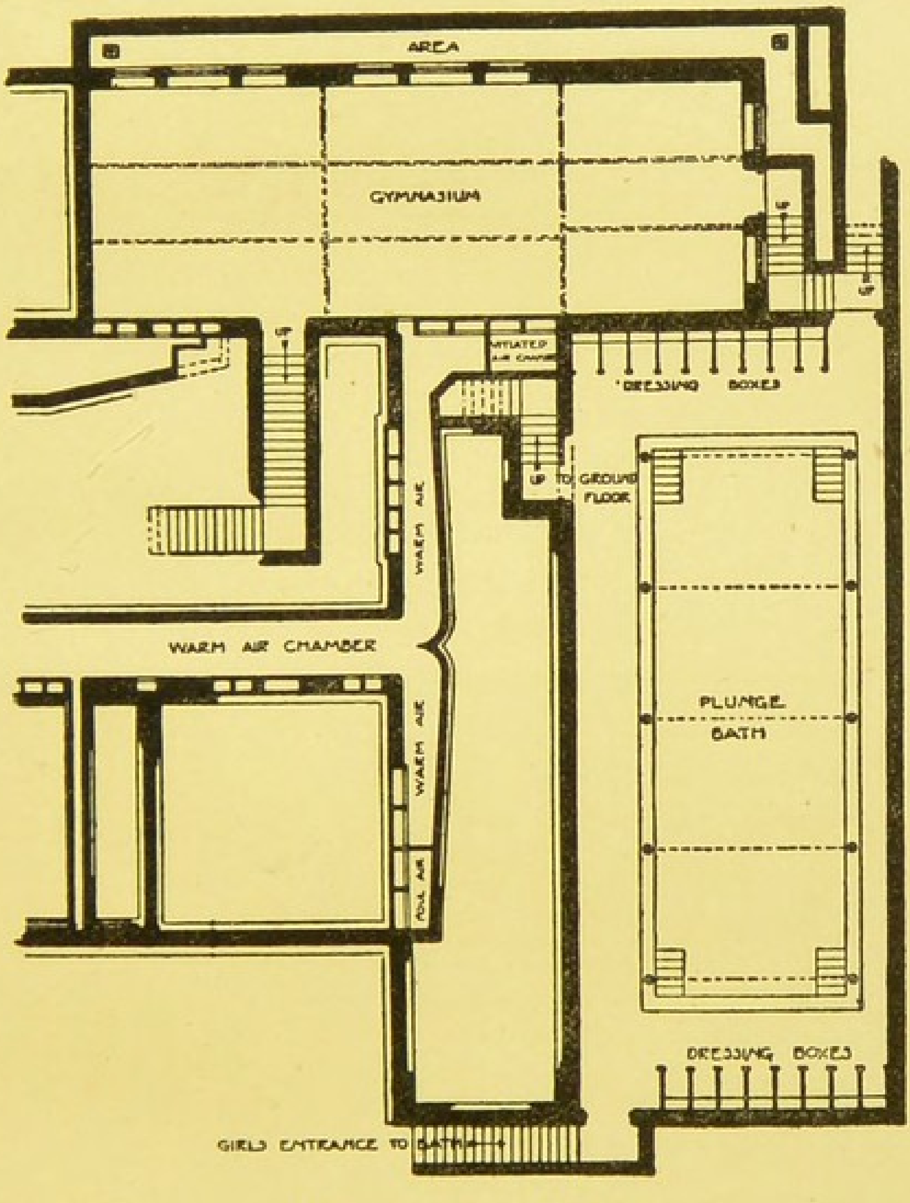
50 60 70 80 90 100 FEET



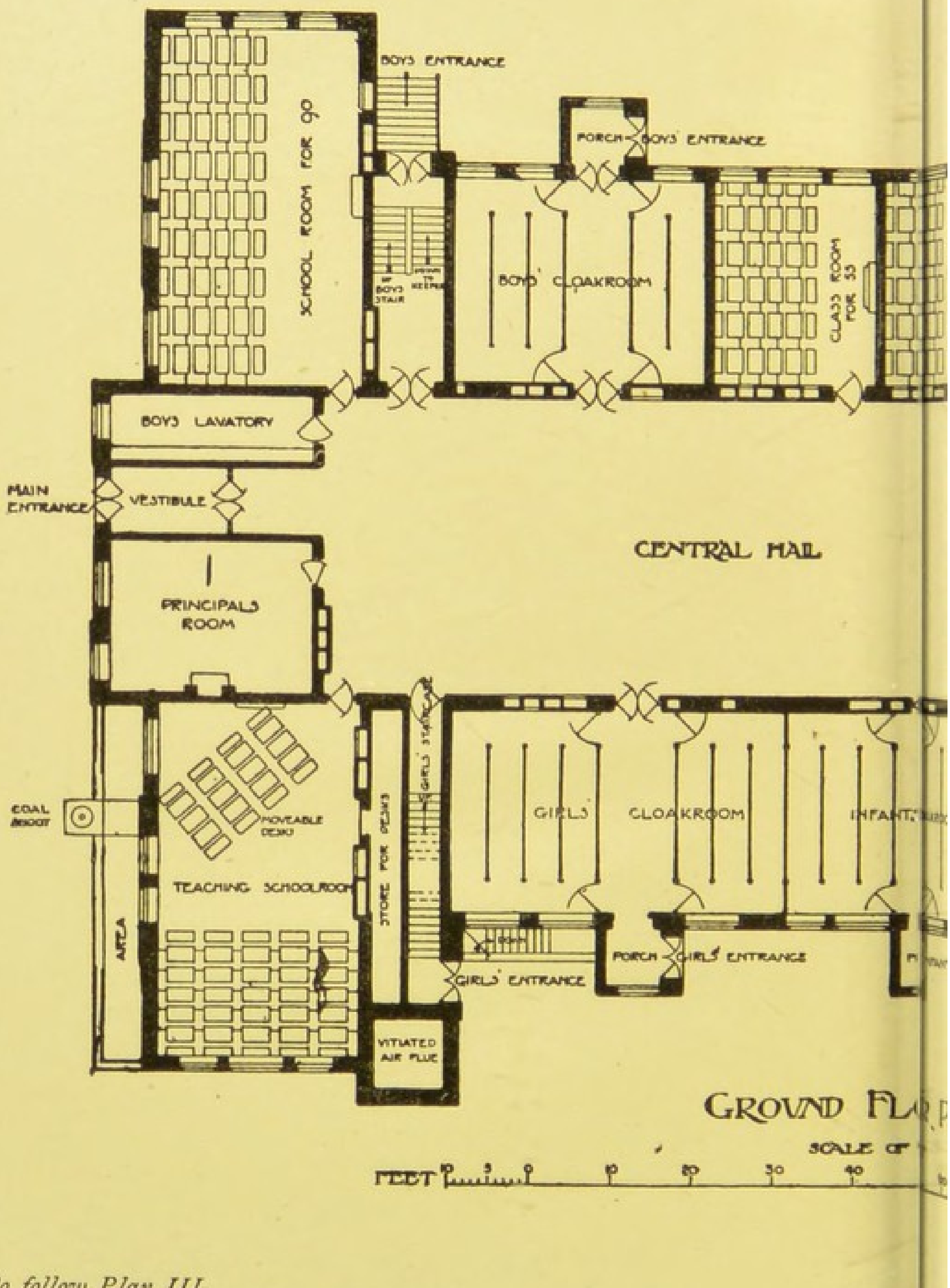
SECOND FLOOR PLAN

To follow Plan II.

PLAN III

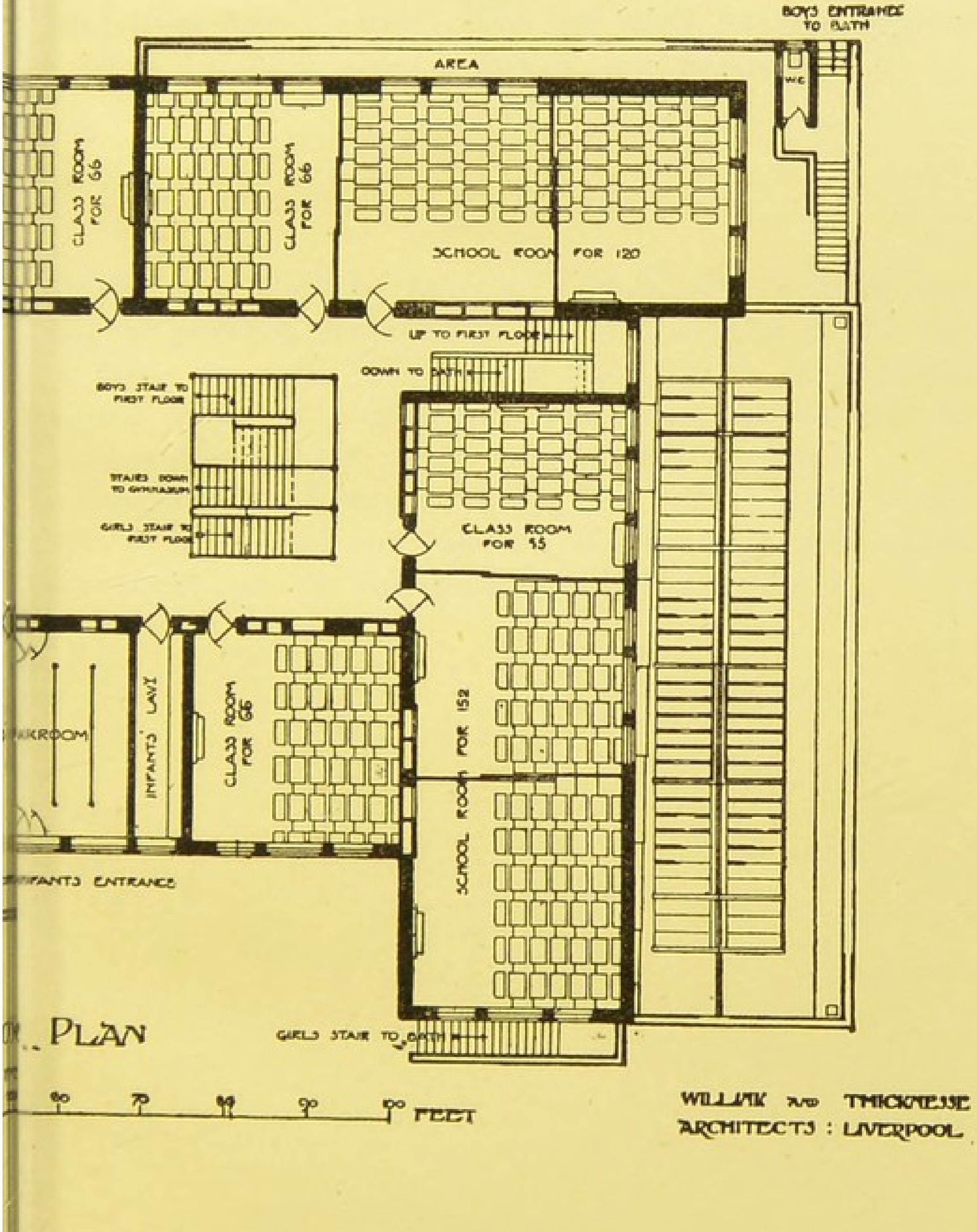


BASEMENT PLAN



To follow Plan III.

PLAN IV


BOYS ENTRANCE TO BATH
AREA
WC
CLASS ROOM FOR 66
CLASS ROOM FOR 66
SCHOOL ROOM FOR 120
UP TO FIRST FLOOR
DOWN TO BATH
BOYS STAIR TO FIRST FLOOR
STAIRS DOWN TO GYMNASIUM
GIRLS STAIR TO FIRST FLOOR
CLASS ROOM FOR 55
INFANTS' LAVY
CLASS ROOM FOR 66
SCHOOL ROOM FOR 152
INFANTS ENTRANCE
PLAN
GIRLS STAIR TO BATH
60
70
80
90
100 FEET
WILLINK AND THICKNESSE
ARCHITECTS : LIVERPOOL

Assembly room.

It is necessary, for certain functions, to assemble the whole school from time to time. The hall used for this purpose should be carefully warmed, lighted, and ventilated.

Playgrounds.

Every school should have its playground; sheltered and sunny as possible, fairly level, and well drained if the site is a damp one. In town schools the difficulty in procuring adequate space is a great one, and the pupils should be encouraged to use the public parks and playgrounds.

The Building Rules, from the Day School Code of the Board of Education are deserving of careful perusal. They are contained in the Appendix to this book, page 83.

CHAPTER III.

AIR, VENTILATION AND WARMING.

PURITY of the air is the most important of all the conditions which influence health. Impure air is a more frequent and more fruitful cause of sickness and mortality than any of the other causes which under ordinary circumstances are in operation; there are few, if any facts in the science of sanitation more definitely established than these, and whilst some forms of disease, such as typhus fever or tuberculosis require impure air as a condition necessary to their spread, almost every form of illness is accentuated, and convalescence is always delayed as a consequence of breathing impure air.

Air is liable to many impurities and may receive contamination in a great variety of ways, but it must be borne in mind that the most frequent form of contamination is that which takes place from the processes of respiration within occupied rooms, and it is this very form which most conduces to lowered vitality and ill-health, especially amongst children, and which furnishes the most ready medium for the spread of infection.

COMPOSITION OF AIR.

The average composition of the air may be given as follows:

Oxygen	20·9 per cent.	
Nitrogen	79·0 ,, ,,	
Carbonic Acid (Carbon Dioxide)	0·04 ,, ,,	(or perhaps less).

Also traces of ammonia, organic matter, ozone, salts of sodium, and, as recent researches indicate, about 1 per cent. of what was regarded as nitrogen, is an elementary gas called *argon*. There is also present a certain amount of watery vapour which varies in quantity with the temperature.

Air is a mechanical mixture and of practically uniform composition from whatever natural source it be derived; the quantity of free carbonic acid is subject to slight fluctuations; in enclosed places and in the vicinity of decomposing matter, impurities may be found, but apart from these, the uniformity of the mixture is maintained by varying temperatures and consequent winds and currents, and by the natural law of gases to diffuse; thus, if a heavy gas and a light gas are placed together in a vessel, the heavy gas below and the light above, they slowly mix even when left at rest; but, when once mixed, they show no tendency to separate, and however long the mixture is kept, the mixture at the top will be found to have the same composition as that at the bottom. The rate of diffusion of gases is inversely as the square roots of their densities.

The nitrogen in the air appears to act as a diluent of the oxygen, the latter being essential to the maintenance of combustion and of life; ozone is regarded as a concentrated form of oxygen, three volumes being condensed into two. Carbonic acid gas is one of the normal components of the atmosphere; it is formed by the action of oxygen upon tissues containing carbon; substances used as fuel contain a proportion of carbon, and this in the process of burning, combines with the oxygen of the air to form carbonic acid gas; in the processes of respiration, the oxygen of the air, conveyed by the blood, combines with the carbon in the body, as it passes through the lungs the blood gives up the carbonic acid gas, and receives a fresh supply of oxygen. It will be evident that in both cases the conversion of carbon into carbonic acid is concerned with the production of heat. Under the influence of light the green colouring-matter of plants takes up carbonic acid gas, retaining the carbon and liberating the oxygen. When carbonic acid is produced in a vessel closed at the bottom, such as a tan-pit or a brewer's vat, or poured from cracks or crevices into a well or mine it remains as a layer at the bottom, owing to its density being 1½ times that of air, only slowly mixing with the air by diffusion. Loss of life has frequently been caused by persons incautiously descending into such pits, as carbonic acid not only does not support animal life but is directly injurious.

Ammonia, except as an impurity, is present only in the minutest traces; the largest trace is present in summer, diminishing with fall of temperature and rainfall. Ammonia is a product of the decomposition of nitrogenous matter, and vegetation derives much of its nitrogen from this source.

Organic and suspended matter are present only in minute quantity in normal air; excess, such as may be found in inhabited places, is abnormal and an impurity.

Watery vapour present in the atmosphere is constantly varying in amount; the quantity passing into the air by evaporation, the quantity remaining, and the quantity condensing out in the form of rain, &c., are dependent upon temperature and pressure. Under any circumstances of temperature and pressure, a given space can only contain a given quantity of vapour, and if when the air is charged with vapour (*i.e.* contains the greatest possible amount under the circumstances) the pressure is increased, a certain quantity of that vapour will be condensed and will pass into one or other form of water; if, however, the surrounding air is not charged with vapour, evaporation will go on from any surface of water until it is so charged. Air is said to be *saturated* when the amount of vapour is at its maximum, and any increase will result in condensation; air is "dry" or "moist" in proportion as it approaches the point of saturation. Alterations in the *temperature* cause changes in the density, and consequently in the pressure; the increased density produced by fall of temperature increases the pressure. All atmospheric movements result from variations in the temperature.

IMPURITIES OF AIR AND THEIR SOURCES.

An immense number and variety of particles, organic and inorganic, of vapours and gases, pass into the atmosphere; amongst the kinds of dust are mineral matters, algæ, pollen, dried particles of debris from road and midden refuse, manure, soot, and products gaseous and particulate from factories and industrial works of all kinds. Microbes are found, sometimes in excessive numbers, and the purport of their presence is still the subject of careful investigation; moisture, nutritive material, and a certain degree of warmth are essential to their development; their numbers vary enormously in different localities and they also vary, though to a much less extent, at different seasons; in the external air they appear to increase largely during the summer and autumn months in temperate latitudes; within-doors, in closed-in places and in overcrowded rooms the greatest increase is in the winter, when the numbers are enormously increased, owing no doubt to defective ventilation at this season. As a mean of six years' observation Miquel found, during February, 155 per cubic metre of air at Mont-souris, against 2480 in the Rue de Rivoli; in July, 740 at Mont-souris, against 5205 in the Rue de Rivoli. As other examples he quotes the practical freedom from microbes of the high mountains, as against 79000 per cubic metre found in the Hôpital Hotel Dieu, Paris.

It would appear that in the open air bacteria are diluted and destroyed, whilst in any case the numbers of disease-producing microbes are relatively few excepting when local conditions are such as favour their development.

It would be beyond the scope of the present volume to enter at any detail into the contaminations of air by industrial processes and the impurities incidental to the air of factories, workshops and mines, &c. But we must notice in particular certain sources of contamination.

(*a*) *Products of Combustion.*

Impurities arising from the products of combustion are important. *Coal* is the material most commonly used as fuel, and the most common source of prejudice to health in connection with it results from smoke. The products of the combustion of coal are carbonic acid, carbonic oxide, in variable quantity as the processes of combustion are incomplete, there being very little with complete combustion; about one per cent. of the coal is reckoned to pass into the air as soot or smoke, but in wasteful misuse of coal, accompanied with excessive and unnecessary smoke probably a much larger percentage is given off. Other impurities in small quantities resulting from the burning of coal are sulphides of carbon and ammonium, and occasionally other compounds of sulphur, and water. The impurities resulting from the combustion of coke and peat resemble those of coal; wood however gives off more water and less of the sulphur compounds.

The products of the combustion of fuels pass directly into the external air, becoming freely diluted and dispersed.

Artificial lighting gives rise to impurities important from the fact that it is seldom that means are provided to convey them into the external air. Moreover in the case of *gaseous* illuminants danger may arise from leakage into occupied rooms from defective pipes or fittings; this is especially to be feared in the case of water gas, which contains a large proportion of the excessively poisonous gas, carbonic oxide. Ordinary coal gas is a mixture produced by the destructive distillation of coal, which is heated in retorts without access of air; water gas is made by passing steam over the heated fuel in a fire-brick chamber, and by subsequently enriching it with hydrocarbons; it is much cheaper and easier of manufacture than coal gas. The composition by volume of ordinary coal gas, and of a mixture of equal quantities of coal gas and carburetted water gas may be given as follows:

	Coal gas	50 % mixture of coal gas and carburetted water gas
Carbonic Acid	0·7	0·2
Heavy Hydrocarbons	6·2	8·9
Oxygen	0·2	0·0
Hydrogen	46·0	43·5
Methane	36·4	26·9
Nitrogen	4·9	2·2
Carbonic Oxide	5·6	18·3
	100·0	100·0.

The great excess of the very poisonous gas, carbonic oxide, in water gas, and proportionately in its mixtures, is evident.

Various kinds of *oil* are used as illuminants; paraffin is the commonest, and consists of 86 per cent. of carbon, and 14 per cent. of hydrogen; its products of combustion are carbonic acid and water, an ordinary lamp giving off about 0·4 of a cubic foot of carbonic acid per hour.

All of the illuminants already referred to have the effect in varying degrees of raising the temperature, abstracting oxygen from the air, and adding carbonic acid, moisture, and to a small degree, compounds of ammonia, carbonic oxide, and particles of soot.

Of recent years a very largely increased use is being made of *electricity* for illuminating purposes. Without taking other advantages into consideration, the hygienic superiority of this method over the others is very great. The incandescent carbon or platinum thread is enclosed in a small hermetically-sealed globe; there is in consequence no possibility of any contamination of the air, and the raising of the temperature by this form of lamp is too small to be of importance. The arc light is not enclosed, and is said to cause the formation of nitric acid, but even if this be the case, the amount of impurity is very much less than that from other illuminants, especially gas. Electricity is extensively employed in lighting public and private buildings and offices, hospitals, dwellings &c., and there is no illuminant so well adapted to the requirements of schools when artificial light is necessary.

(*b*) *Emanations from Sewers and Drains.*

The gaseous contents of sewers and drains are of very variable composition. If the sewer is properly constructed, well ventilated, and adequately flushed, the air in it will not vary greatly from that outside; it is in proportion to the neglect of these essentials that sewer gas becomes offensive and injurious; it is when the sewer is allowed to become a sewer of deposit—an elongated cesspool in fact—mischief from stagnating and decomposing sewage results. In these cases there is an increase in the amount of carbonic acid, the oxygen is lessened, fœtid organic vapours and particles collect, as well as varying quantities of marsh gas, sulphide of ammonium, and sulphuretted hydrogen. In closed and sealed cesspools the air is highly impure from these causes. Various micro-organisms, bacilli and moulds are found in sewer air; these however are relatively few, probably because they adhere to the moist surface of the sewer. The effect of breathing the air of rooms to which emanations from sewers and drains find access is distinctly prejudicial, especially so in the case of children; general loss of health, pallor, languor, loss of appetite and diarrhœa, headache and perhaps some degree of feverishness usually ensue and indicate that the aëration of the blood is not being properly carried out; sore-throat is not infrequently associated with the inhalation of sewage emanations. Children are more susceptible than adults; indeed amongst men working in sewers of good ventilation it is rare to find illness directly traceable to their occupation. Much depends upon the degree of dilution of the sewer gas; cases of extreme and even fatal illness have been associated with the opening of sewers and cesspools which had long been closed, the mischief apparently resulting from the generation of deleterious gases. An atmosphere contaminated with sewer gas, and passing directly into dwellings, will aggravate any form of illness which may exist there, and will always delay convalescence. There appears to be very little doubt that one of the many ways by which the specific poisons of typhoid fever and of diphtheria may find access to the body, is by means of emanations from sewage, either directly by inhalation, or indirectly by pollution of water or food. It must be carefully remembered that the lowered constitution consequent upon breathing sewage emanations predisposes the body to the reception of the poison of zymotic disease, as well as to more severe attacks of the ordinary forms of sickness. Milk and other perishable foods readily decompose if exposed to sewer gas.

(*c*) *Effects of Respiration.*

The commonest and most important impurities in the air of occupied rooms are those associated with respiration, indeed from the point of view affecting the hygiene of schools, the changes in the air brought about by respiration and emanations from the skin are to be regarded as those which most tend to prejudice health. The alterations in the gaseous constituents produced in this manner are very marked; the oxygen is considerably reduced, the proportion of carbonic acid is immensely increased, and there is a trifling change in the proportion of nitrogen; the change is as follows :—

	Ordinary Air per cent.	Expired Air per cent.
Oxygen	20·96	16·40
Nitrogen	79·00	79·19
Carbon dioxide	0·04	4·41

But other very important changes take place besides these; the expired air is warmer than before inhalation, the amount of watery vapour is increased, and it contains certain organic matters of unknown nature. It will be remembered that by the law of diffusion of gases the atmosphere of occupied rooms, so far as the gases are concerned, is maintained at the normal unless ventilation is absolutely interfered with, and if a window be opened the excess of carbonic acid will not accumulate, whilst the abstracted oxygen will be constantly replaced; but diffusion in this sense does not affect either the watery vapour or the organic matter, neither of which can be got rid of except by an adequate ventilation. The actual amount of watery vapour given off in 24 hours from the skin and lungs of each individual varies with the temperature and humidity of the surrounding atmosphere as well as with the amount of work being done; 10 ounces of water from the lungs and 20 ounces from the skin may be regarded as the average amount under average conditions.

"Five hundred children assembled in one room would in the course of two hours give off as vapour about four gallons of water, which would be visible in the clouding of windows and walls, unless the room were well ventilated" (Newsholme).

The exhaled organic matter also contributes largely to the foulness and offensive character of ill-ventilated occupied rooms. On first entering a room of this character from the fresh air the condition is at once appreciated by the sense of smell, but this appreciation is quickly dulled, and after remaining but a short time in the room the offensiveness is unnoticed; the fact that it is unnoticed no doubt explains the toleration of such a condition.

The nature of this organic matter is still uncertain; it is probably in combination with water, and particles of epithelium and fatty matters are associated with it; it presents the ordinary characters of organic matter, decolorising permanganate of potash, darkening sulphuric acid, and rendering pure water offensive, when drawn through them; it blackens on platinum and yields ammonia, and is consequently nitrogenous and oxidisable; the smell is very fœtid.

Exhaled air, then, differs in various directions from ordinary air; in close and confined rooms the exhaled air is breathed and re-breathed over and over again, each time becoming more and more charged with foulness and impurities. Foul odours, increased moisture and raised temperature contribute in a marked and important degree to the discomfort of air from which oxygen has been abstracted, which is vitiated by excess of carbonic acid, and by added volatile organic matter and dust of various kinds; it is this combination which is most favourable to the growth and development of organisms, disease-producing or otherwise.

The consequences of habitually and for prolonged periods re-breathing air fouled by respiration and by exhalations and odours from breath, skin and clothing are very pronounced; as an extreme and gross instance of overcrowding accompanied by fatal results the cases of the Black Hole of Calcutta may be quoted. In minor and ordinary degrees the earlier symptoms are dulness and lassitude, headache and loss of appetite, pallor and anæmia, the effects in the long run proving highly injurious to health. As might be expected the lungs are the organs most frequently affected, and the various forms of tuberculosis such as consumption, phthisis, or scrofula are notoriously associated with the condition, the results being especially marked when deficient exercise and poor feeding are associated with breathing the vitiated air. In former years the prevalence of consumption amongst soldiers both at home and abroad was found by the Sanitary Commissioners for the army to be due to defective ventilation of barracks and with improved ventilation came the diminution in pulmonary diseases. Contrasts even more pronounced characterise the former and present conditions of prisons. Air fouled by respiration is the cause of tuberculosis not only in man but in animals, cows for example, confined in close ill-ventilated cow-sheds, and the most marked improvement in the health of these animals has followed upon efficient lighting and ventilation of these places.

The more ready transmission of the ordinary zymotic diseases as measles, diphtheria &c., in polluted atmospheres, is due 1st to the more ready growth of the disease-producing organisms in such air, and 2nd to the predisposition brought about by the lowered constitution.

Ventilation and Warming.

The importance of pure air is so generally recognised that it is not surprising that great attention should have been paid to the subject of Ventilation, by which is understood the systematic removal from rooms or occupied places of air vitiated by any cause and in its place supplying fresh air in such quantity and in such manner as will maintain the air of the room at a certain standard without undue draught; this renewal of air must in climates like our own be effected without the unpleasant consequences of draughts which none will willingly submit to; hence the question of warming comes to be closely associated with that of ventilation.

That perfect ventilation is not easy of accomplishment is evidenced by the large numbers of buildings, especially public buildings, theatres, churches, &c., in which the ventilation is anything but successful, notwithstanding the pains which may have been taken to make it so; this may be partly owing to various causes, as popular indifference, inattention, insufficiency of the means employed, or desire for undue economy.

The various considerations involved in Ventilation may be conveniently dealt with in the following order, viz:—

(α) Amount of air necessary.

(β) The means by which this amount may be supplied.

(γ) Tests available to determine whether an adequate standard of purity is maintained.

(δ) Warming.

(*a*) *Amount of Air necessary for healthy persons.*

It will be sufficiently obvious that under exceptional conditions, associated for example with certain trades, very frequent renewal of air may be necessary and special means may be required to ensure it. But only the ordinary impurities of inhabited rooms are now considered, those evolved from respiration or transpiration, or associated with artificial light.

The index commonly used to determine the degree of vitiation of air, is the amount of carbonic acid present in it; this gas is taken as the index not because the amount present is sufficient in itself to do harm, but for two other good reasons, first, because it is present in a fairly constant ratio with other and more dangerous impurities which have already been alluded to, and secondly, because the amount of this gas present can be ascertained closely enough for all practical purposes without much difficulty.

The air of all occupied rooms must necessarily be less pure than external air, and the question to be answered is, up to what degree is impurity admissible consistent with health; in other words what is the limit of carbonic acid gas which may be allowed, and which if exceeded will result in injury to health?

The supply of fresh air should at all times be such that any observant person entering the room from the external air should not perceive the faintest trace of anything unpleasant to the senses in the way of smell or closeness. A very large number of experiments and observations have been made at military stations and elsewhere upon the connection between the closeness of the room perceptible to the senses, and the amount of carbonic acid present. Without going into details, de Chaumont's table, which is as follows, may be given:

	1. Fresh, or not differing sensibly from the outer air	2. Rather close. Organic matter becoming perceptible	3. Close. Organic matter disagreeable	4. Very close. Organic matter offensive and oppressive; limit of differentiation by the senses
Mean carbonic acid per 1000 volumes due to respiratory impurity	0·1943	0·4132	0·6708	0·9054

It may be assumed, therefore, that when the carbonic acid of an occupied room does not exceed 0·2 per 1000 vols. *from respiratory impurity*, there is no difference apparent to the senses between the atmosphere of the room and the external air, but if this amount is exceeded, the closeness and oppressiveness increase in proportion up to 0·9 vols. of carbonic acid per 1000, beyond which differentiation by the senses is no longer possible. The limit, therefore, of admissible respiratory impurity in an occupied air-space has, therefore, been fixed at that indicated by the presence of 0·2 per 1000 vols. of carbonic acid; beyond this it ought not to go. Increased warmth and moisture render the offensiveness noticeable with the lower proportions in the scale, owing perhaps to decomposition. It must, however, be carefully remembered that the carbonic acid in the room will escape, owing to diffusion, much more rapidly than the organic matter and vapour which is not affected in this way.

The next point to determine is the amount of carbonic acid given off by each occupant of the room; this depends somewhat upon the weight and activity of the person. Upon Pettenkofer's observations, 0·6 of a cubic foot of carbonic acid is given off per hour, as an average of a mixed community; children, averaging 80 lbs. weight, giving off 0·4 of a cubic foot. Upon this standard, therefore, if 0·2 per 1000 cubic feet is the limit of admissible respiratory impurity, and 0·6 cubic foot is evolved per hour, this amount must be diluted three times to maintain the requisite degree of purity; in other words, 3000 cubic feet of fresh air must be given per hour for an adult, and 2000 cubic feet for a child in order to maintain the standard which is now universally regarded as the proper one. This is the amount which is requisite in health; the necessary allowance in hospitals is much larger.

With regard to lighting, it is always desirable that the products of combustion of coal-gas should not be allowed to escape into school rooms, dormitories or other occupied places. Speaking generally, the ordinary gas burner consumes five cubic feet of coal gas per hour, generating about three cubic feet of carbonic acid, and it requires practically the same amount of fresh air supply as an adult; hence the number of gas burners must always be taken into account in estimating the amount of air required for rooms. The advantages of the electric light, which does not add impurity to the air, are very great.

It will be remembered that not only carbonic acid gas and organic and inorganic impurities, but watery vapour, exhaled or from other sources is removed in the process of ventilating the room.

(*b*) *Amount of Cubic Space necessary.*

The necessary amount of cubic space requires careful consideration. Since an adult requires 3000 cubic feet of fresh air per hour, and a child somewhat less, the cubic space must be such that this amount can be supplied without changing the air so often, or in such a manner as to cause draught and its consequent injurious effects. In churches, theatres and all such places, where people are habitually congregated for several hours at a time, the cubic space is a matter of the highest importance on this account, but nowhere is it of greater importance than in schools; no class of persons is so intolerant of draughts as those of sedentary habit or occupation.

The following table taken from Notter and Firth's work on Hygiene indicates the quantity of air per head per hour required to pass through spaces of various sizes, in order that the contained air shall be kept within the limit of admissible added respiratory impurity, *i.e.* that the added carbonic acid shall not exceed 0·2 vols. per 1000:

Amount of cubic space (=breathing space) for one person in cubic feet	Ratio per 1000 of CO_2 from respiration at the end of 1 hour, if there has been no change of air	Amount of air necessary to dilute to standard of 0·2 during the first hour	Amount necessary to dilute to the given standard every hour after the first
100	6·00	2900	3000
200	3·00	2800	3000
300	2·00	2700	3000
400	1·50	2600	3000
500	1·20	2500	3000
600	1·00	2400	3000
700	0·86	2300	3000
800	0·75	2200	3000
900	0·67	2100	3000
1000	0·60	2000	3000

The amount necessary to dilute the impurities to the accepted standard every hour after the first, is 3000 cubic feet; it is found, however that under the ordinary conditions of this climate, but especially in cooler weather, the renewal of air three times per hour is all that can be borne with comfort in ordinary rooms, a more frequent renewal than that, for example, five times per hour in a 600 cubic feet space, becomes perceptible and causes the sensation of draught.

It follows, therefore, if the estimates given be correct—which there is no reason to doubt—that for continuous occupation, the cubic space necessary per head is about 1000 cubic feet, and the air in it should be renewed three times per hour. If the air can be suitably warmed before it is introduced, so that the current shall not be objectionable, a smaller space will suffice if it is associated with a more frequent renewal. It may be mentioned that these allowances relate only to the healthy; in cases of sickness, more especially infectious sickness, and in hospitals, &c., a much larger allowance of air and space is necessary.

In schools, dormitories, barracks, public meeting places, as well as in the dwellings of people below the middle class, the ideal 1000 cubic feet of space per head for sleeping rooms is not attainable. Houses of artizans and labourers have about 200 cubic feet available; in barracks, 600 cubic feet are allowed, poor-houses and common lodging-houses have 350 to 400 cubic feet, only half of that amount being demanded in the case of children under ten. In school-rooms, the Education Department require a minimum of 80 cubic feet and 9 square feet of floor space in infant schools, and the accommodation for elder children is subject to a minimum of 10 square feet being provided; wasted space is not considered.

Cubic space cannot of course take the place of change of air; the table quoted indicates that in the largest air space, the air requires renewal after a limited time just as in a small one.

(*c*) *Supply of Fresh Air.*

The *Source* of the air supplied must in all cases be a pure one, and contamination during the course of supply must be avoided; warming or cooling may be necessary according to season, and the attainment of uniformity of diffusion through the room must be kept in view. Means for the abstraction of foul air are properly provided near the top of the room.

The Forces concerned in ventilation, are diffusion (see p. 17), winds, and the changes arising from varying temperatures; by *natural ventilation* is understood that these forces act alone, without mechanical apparatus; by *artificial ventilation* is understood that the action of natural forces is modified by mechanical means.

Winds may be the most powerful ventilating agent, either by directly blowing through the room, or by means of *aspiration*, as when blowing over the chimneys a current of air is then caused up the chimneys at right angles to the course of the wind.

The uncertainty of the force of the wind prevents reliance being placed upon it.

Varying temperatures cause changes in the weight or density of volumes of air and consequently give rise to movement; it is to this cause that winds are due, but the same changes play an important part in the ventilation of ordinary rooms—if the air of a room be warmed it will expand and some of it will escape, and what remains will be lighter than the air outside, which will find its way in until the weight of air inside and out is equalised again.

All methods of ventilation aim at admitting enough fresh air to remove all closeness, without causing draughts; in warm, summer weather, windows placed in opposite sides of the room and open at the top may be relied on for the purpose, but under ordinary conditions, special arrangements of inlet or outlet shafts or openings are necessary; with long shafts there is considerable loss of velocity of the current owing to friction, and bends and turns also have the effect of checking the force of the current, a turn of a right angle diminishing it by one half. Hence angles should be avoided as much as possible in the course of the shaft and the shaft itself, with the object of lessening friction, should be circular rather than rectangular.

Natural ventilation is effected in the simplest manner by open windows, a method, however, which is only available in warm weather. Special inlets and outlets which are ordinarily provided, best ensure distribution if numerous and small, say 48 to 60 square inches, rather than few and large.

Inlet tubes should be short, easily cleaned, and, if warmed, placed low down; if the air is not warmed the current is best admitted at a height of 9 or 10 feet, and directed upwards to avoid draughts. In towns the air can be *filtered* by a piece of muslin drawn across the opening, which effectually prevents the entrance of blacks and dirt. Hinckes Bird's simple device for natural ventilation is to raise the lower sash of the window a few inches, and fit in a block of wood below it, so that fresh air is admitted through the opening between the upper and lower sashes only, and the force of the current is broken and directed upwards. Other simple inlets may be mentioned, such as Ellison's bricks, perforated with conical holes, the small end outside; Tobin's tubes; louvres; Sherringham valves; Cooper's discs, &c.

Outlets should be placed high up, if there are no means of heating the air passing through them; they should be straight, smooth, enclosed in walls to prevent the air being cooled, and covered above in a manner which will aid the aspirating power of the wind, check down-draughts, and exclude rain. The reliability of outlets is increased with artificial warmth; the ordinary chimney with open fire will meet ordinary requirements, and this may be more fully utilised by the construction of shafts around it, their openings being near the top of the room. Arnott's valve is an outlet valve, it is usually placed high up in the wall and is constructed to swing towards the chimney, closing against down-draught, the flaps are of talc or metal.

Artificial ventilation. Heat, steam-jets, fans, pumps, &c., are the means commonly employed in artificial ventilation. When the fresh air is driven in so as to force out the foul air, the method is known as *propulsion* or *plenum*; if ventilation is effected by drawing the foul air out, the method is *extraction* or *vacuum*.

The common chimney is the most familiar example of extraction by heat, the current up it being 6 to 9 feet per second, all other openings in the room being inlets; if the inlets are insufficient, down-draughts are caused. Lighted gas, suitably placed in a shaft in the ceiling, may be made a very efficient means of extraction. Fans may be used either for extraction or propulsion; the Blackman air-propeller is considered one of the most efficient.

Both methods, extraction and propulsion have advantages and disadvantages; with extraction the amount of current varies with the degree of heat; in the case of large buildings, the rooms nearest the shaft will have a strong current, whilst those at a distance from it will have little or none; the possible reversal of the current with this method must not be lost sight of. With propulsion there is more certainty in amount, and greater ease with which that amount can be supplied, moreover the purity of the intake can be assured. There is, however, usually greater cost, and possibility of breakdown to be remembered, and careful attention to detail is always necessary with this system.

Schedule VII. of the Code of Regulations of the Education Department contains the following rules to be observed in planning Public Elementary Schools :—

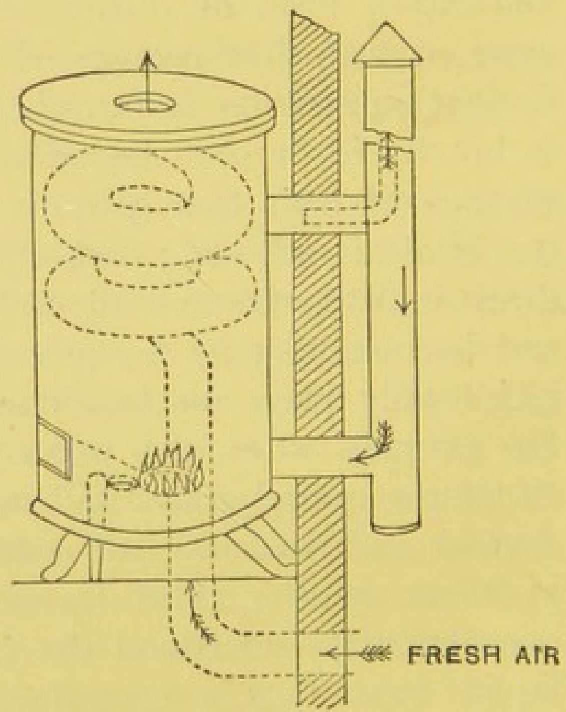
"Apart from open windows and doors, there should be provision for copious inlet of fresh air; also for outlet of foul air at the highest point of the room; the best way of providing the latter is to build to each room a separate air chimney carried up in the same stack with smoke flues. An outlet should have motive power by heat or exhaust, otherwise it will frequently act as a cold inlet. The principal point in all ventilation is to prevent stagnant air. Particular expedients are only subsidiary to this main direction. Inlets are best placed in corners of rooms furthest from doors and fireplaces, and should be arranged to discharge upwards into the rooms. Inlets should provide a minimum of 2½ square inches per child, and outlets a minimum of 2 inches. All inlets and outlets should be in communication with the external air.

Rooms should, in addition, be flushed with fresh air about every two hours. A sunny aspect is especially valuable for children, and important in its effects on ventilation and health."

Warming.

Warming is closely associated with ventilation. There are three ways in which heat is distributed, viz. :—(α) by *radiation*, in which the heat given off by the warming object, e.g. burning coal in an open grate, is propagated in straight lines, with equal intensity in all directions, but with an effect which diminishes as the square of the distance increases; this method is no doubt wasteful, but at the same time it is the natural one and the most pleasant, being typified in the warmth of sunshine; the open grate and the sun warm in the same extravagant but agreeable fashion. (β) *Conduction* is another well-known form of distribution of heat; it consists of the more or less slow passage of heat through certain solids; a familiar illustration is furnished when a silver spoon is used in hot liquid, it soon becomes warm throughout by the conveyance of heat from particle to particle of the spoon until the whole is affected; similarly if one end of a metal bar be thrust into the fire and allowed to become red hot, the other end becomes hot by the process of conduction. Conduction incidentally plays an important part in warming rooms, as for example when the ironwork, or other solid conducting structures around grates and stoves become hot by this means. *Liquids* and *gases* are bad conductors, but heat is distributed in them in the third manner, namely by *convection*. By convection is understood the fact that the particles of gas or liquid expand as a consequence of being heated, become lighter, and rise, their place being taken by colder and consequently heavier ones; if a vessel containing water be heated, and a few fragments of cochineal dropped into it to indicate the currents, it will be seen by appropriately placed thermometers that the warm particles of water ascend in the centre, while the cold ones descend by the sides. The atmosphere like all other gases readily expands by heat, consequently convection is very marked, and convection currents are important adjuncts in warming.

Ordinary dwelling rooms in this country are almost invariably warmed by open fires, a method to be commended as not only cheerful but healthy on account of the ventilation ensured by it. In the case of large rooms such as school-rooms this means cannot be regarded as efficient since about 75 °/ₒ of the available heat from the combustion of fuel is with the ordinary open fire-place lost up the chimney. Various measures however are taken to construct grates so that combustion shall be slow and fuel economised, the points aimed at are (1) to use fire-brick instead of iron, (2) the fire-place should be narrow, the back leaning slightly forward over the fire, (3) beneath the fire the space should be closed in front by a close fitting shield. Suitably placed central stoves with open grates such as Boyd's can be sometimes used, the flues from which pass under the floors. In halls and vestibules stoves are sometimes employed to warm the fresh air as it passes in from without; George's Calorigen stove is upon this principle, which is sufficiently explained by the diagram. Many adaptations of this principle are in use. Stoves which do not provide means for the inlet of fresh air as



George's "Calorigen" Gas Stove.
Fig. 7.

well as for the removal of the products of combustion should be excluded, and it is unnecessary to say that any stove which is liable to become over-heated should be condemned.

Hot-water pipes constitute one of the simplest and best means of warming schools; the pipes are usually from 2 to 4 inches in diameter and are connected with a boiler usually placed in the basement; they are arranged in a double row to allow the water circulating.

The temperature in school-rooms should be kept at about 56° to 60° Fahr.; if the corridors, lobbies etc. are also warmed by pipes this degree is more easily maintained. Warming by means of hot-water pipes can with great advantage be supplemented by open grates, which can be used occasionally, and their flues are always available for ventilating purposes.

Fig. 8 indicates the method of warming and ventilation of a large Council School. The fresh-air inlet is shown on the left (A), the air is warmed at (B), filtered at (C), and following the direction of the arrows, passes through the class-rooms and is extracted at the shaft (K), connected with the boiler-house (L).

Lighting is dealt with in connection with *structure* and *arrangement* of school furniture in Part II.

NOTE. Mr Bailey, of Owens College, Manchester, has supplied the following figures illustrative of tests carried out in connection with Ventilation of School and other public buildings:

Class-room in Public Elementary Schools in Manchester in June and July gave a range of 11 *to* 15 *parts* CO_2 in 10,000.

The Chemical Laboratory at University College, Nottingham, 7 *parts* CO_2.

A Committee Room of the same College (27 jets of gas burning), 42.

A Theatre at Leeds, gallery, 14.

Chancery Court, London, 20.

Standard Theatre, London, E., 32.

Air of normal standard indoors may be taken to show 6 parts.

Expired air, at temp. 98° Fahr., 470 parts.

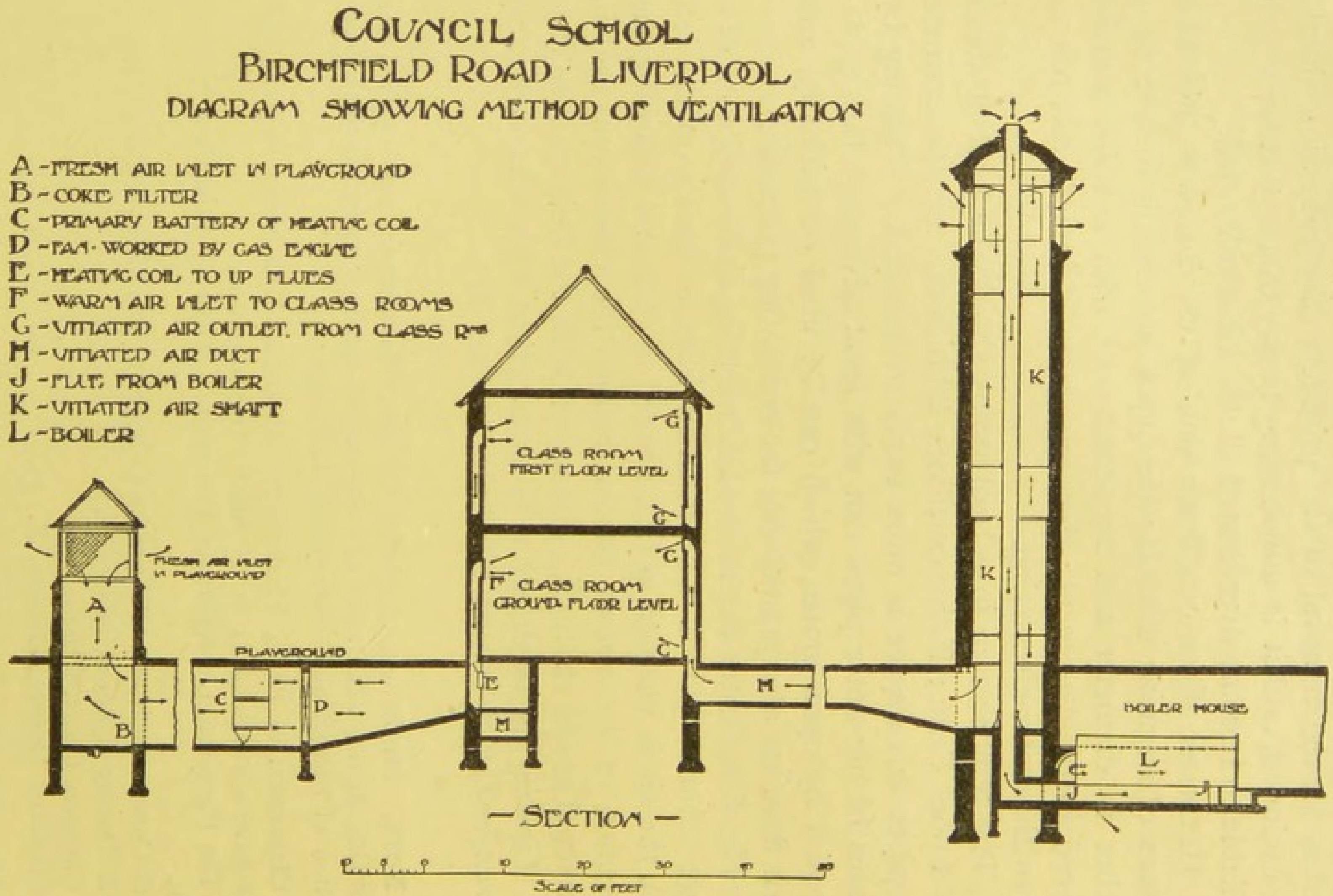

COUNCIL SCHOOL
BIRCHFIELD ROAD · LIVERPOOL
DIAGRAM SHOWING METHOD OF VENTILATION
A - FRESH AIR INLET IN PLAYGROUND
B - COKE FILTER
C - PRIMARY BATTERY OF HEATING COIL
D - FAN · WORKED BY GAS ENGINE
E - HEATING COIL TO UP FLUES
F - WARM AIR INLET TO CLASS ROOMS
G - VITIATED AIR OUTLET, FROM CLASS Rms
M - VITIATED AIR DUCT
J - FLUE FROM BOILER
K - VITIATED AIR SHAFT
L - BOILER
FRESH AIR INLET IN PLAYGROUND
PLAYGROUND
CLASS ROOM FIRST FLOOR LEVEL
CLASS ROOM GROUND FLOOR LEVEL
BOILER HOUSE
— SECTION —
SCALE OF FEET

Fig. 8.

CHAPTER IV.

FOOD AND CLOTHING: SOME ESSENTIAL FACTS FOR THE GUIDANCE OF THE TEACHER.

1. *Food and Diet.* Foods are substances which are capable of undergoing such changes in the digestive organs as will render them capable of absorption into the circulation, and of serving one or other of the following purposes, viz. :—

(*a*) of renewing the tissues and the organs of the body,

(*b*) of supplying material for the maintenance of their functions.

In other words they are either tissue producers or force producers, but most of the ordinary articles of diet contain both materials, although in unequal proportions, and ordinary articles are therefore to a certain extent contributory not only to the growth, maintenance, repair, and functional activity of the tissues, but also to the production of heat and force. Water also enters largely into the compositions of all foods, and it is essential to their assimilation; a certain quantity of salts is also present in foods. Besides foods proper, certain food accessories are in constant use, such as tea, coffee, alcohol, condiments, &c. Organic food-stuffs admit of a division into the nitrogenous, and the non-nitrogenous. The nitrogenous, as the name implies, contain nitrogen; their function is mainly that of providing for growth, maintenance, and repair, and only in a minor degree do they contribute to the production of heat and force. As a common illustration of the various kinds of nitrogenous food-stuffs may be mentioned (1) egg albumen, (2) myosin, the chief constituent of meat, (3) casein, from milk in cheese, (4) legumin, from peas, beans, &c., (5) gluten, in cereals, wheat, bread, (6) peptones, which include the foregoing after they are rendered diffusible and non-coagulable by heat, by the gastric juices. The non-nitrogenous food-stuffs include the fats or hydro-carbons, and also the starches and sugars or carbohydrates. These contain no nitrogen, and are used up in the production of heat and force, or in the formation of fat in the body. Water and the inorganic salts are essentials in all diets.

It is obvious, therefore, that a variety of the ordinary food-stuffs is necessary to maintain health and life, and the actual diets taken by an individual include very complex mixtures. Actual diets and dietaries vary in accordance with the age and sex of the individual, with the climate and temperature, with rest and work, as well as with individual tastes and idiosyncrasies.

Standard diets have been compiled for the use of schools, hospitals, and so forth, but it is abundantly plain that what is enough in the case of one child would be too much for another, and *vice versâ*. Roughly speaking, the average diet of an adult in 24 hours would comprise 4 to 4½ ozs. of nitrogenous food (meat), 3 ozs. of fat, 15 ozs. of sugars and starches, &c. and 1¼ ozs. of salts. The average child would probably take about three-fifths of that amount, but the fats and the starches would be increased somewhat in cold climates, and this estimate does not include the food accessories.

It must be remembered that during childhood, growth and development of the nervous, muscular, and bony tissues, call for an adequate food supply, and this would indicate an addition to what is wanted merely to maintain the equilibrium of the body. Milk, which is considered by some as the type of a perfect food for children, contains :—

Casein............	4·0%
Fat	3·7%
Sugar	4·8%
Salts	0·7%
Water	86·8%

The probability is that milk is too dilute a food for average children of the school age.

A most important point in connection with foods is their digestibility. It is perfectly obvious that good food, unless prepared in such a way as to be digestible and attractive, loses much of its usefulness. For example most people have a practical acquaintance with the relative digestibility of tough meat and tender meat. A point of equal importance is that the meals should be suitably divided; excess at any time is bad. Sleep diminishes digestion, therefore late and heavy suppers should be avoided, and the reason why they cause sleeplessness is that the digestive system is given work to do at a time when it also wants sleep. It must also be remembered that active mental work immediately after a meal will retard digestion. Alcohol should never be given to children excepting as a medicine and under the advice of a medical man.

A fixed theoretical standard of nutrition is of doubtful value.

The routine medical inspection of school children reveals the fact that mal-nutrition is one of the commonest physical defects from which they suffer; frequently it arises from insufficiency of food, frequently from food which is unsuitable or rendered so by improper preparation; other causes such as defective teeth, insufficient rest—the child being "employed" out of school hours—incipient tuberculosis, adenoids, or other ailments may exist, and the condition is one which calls for much careful investigation on the part of the school doctor or school nurse, in which, not infrequently, the teacher also can assist.

2. *Clothing*. The object of clothing is to protect the body against heat or against cold; in other words to maintain an equable and uniform temperature of the body, the normal being 98·4 degrees Fahrenheit.

Clothing, whilst it prevents radiation and conduction of heat, should not interfere with the evaporation of perspiration, and hence the materials and the make of the garments require consideration.

First with regard to the *Materials*, those most commonly used are cotton, linen, wool, silk, leather and india-rubber, all possessing certain microscopic and chemical characters.

Cotton in its microscopic characters consists of minute riband-like fibres. The fibre is exceedingly hard, and in an article of dress wears well, does not shrink in washing, and is very non-absorbent of water, and is cheap and durable. It is very absorbent of odours. It conducts heat less rapidly than linen, but much more rapidly than wool.

Linen has fine cylindrical fibres with little swellings at regular intervals; it conducts heat very readily and hence feels cold to the touch, as for example linen sheets; it absorbs water slightly better than cotton, with which it may be classed as an article of clothing. Cambric and lawn are fine varieties.

Wool, a modification of hair, consists of round fibres which break up into fibrillæ when old and worn; it is a bad conductor of heat, and a great absorber of water, which penetrates into, and distends the fibres themselves and also lies between them, hence it is greatly superior to cotton and linen as an article of clothing. Evaporation of perspiration during exercise reduces the heat generated by the exercise; evaporation however continues after the exercise, and the vapour from the body is condensed in a woollen garment and the large amount of heat which became latent when the water was vaporised is given out again. The non-conducting character of wool makes it warmer as an article of clothing. It should always be worn next the skin, but it is needless to point out that in summer the woollen garment should be an exceedingly thin one; the disadvantage of wool is the way in which the soft fibre shrinks, hardens, and becomes less absorbent after frequent washing.

Leather should be well tanned and supple; coats of sheep-skin and other skins are exceedingly warm and are of use in intensely cold and windy climates; the use of *india-rubber* as a protection from wet is good; it should not be used except as a temporary protection against wind and rain.

Silk consists of minute filaments and is the strongest and most tenacious of textile fabrics; it approaches wool, rather than linen or cotton in its conducting and absorbing capacities.

Clothing should never fit so tightly as to constrict; loosely fitting clothes are more comfortable and warmer, as they imprison the air. Tight gloves will produce chilblains. Braces should be worn rather than belts or garters. Young children should be properly covered in cold weather; bare arms, chests, and legs should be avoided. Children should never be allowed to sit in damp clothes. Frequent changes of underclothing are necessary, and things worn by day should never be slept in at night.

Boots should have thick, damp-proof soles, low heels, and should fit comfortably.

In many parts of the country clogs are commonly worn; they have the merit of protecting from damp, but care is necessary that they fit well. The practice in many schools attended by children whose poverty deprives them of water-tight boots, of providing felt slippers to be worn during school hours is very commendable.

With a view to help parents to add to the comfort of the children some such circular as the following has been found helpful in urban districts:

SOME SIMPLE HEALTH RULES FOR SCHOOL CHILDREN.

The following few rules will, it is hoped, be found serviceable to parents of school children:

Fresh Air.

This is as necessary at night as it is in the day time, and the bedroom window should always be kept open at the top during the night time, unless some special circumstance, such as bad weather, prevents it.

Food.

1. Oatmeal in the form of porridge is especially suitable for children.

2. Cow's milk should always be taken, not machine-skimmed condensed milk, as the latter has been deprived of much of its nourishing value. Milk puddings and bread and milk are suitable for children.

3. Some meat or fish should be given to children every day.

4. Tea is harmful to children; alcohol in any form even more so.

5. Sweets, especially soft sweets, such as toffee or chocolates, should be sparingly taken.

Care of the Teeth.

1. Every child from the age of four should have a tooth-brush, and should use it twice a day, but certainly before going to bed. Camphorated chalk or precipitated chalk forms a good tooth powder. It will, of course, be necessary for the mother to attend to the brushing of the teeth of the younger children, but she should personally see that the tooth-brush is

used until the children have got into the habit of using it for themselves. Much future pain and discomfort will be avoided by its use, and some teeth will be saved from decaying.

2. No biscuits or sweets should be given after the teeth have been brushed at night time.

3. All badly-decayed teeth should be removed, and teeth of the second set commencing to decay should be stopped by a dentist.

SQUINT, or "TURN OF THE EYE," is always due to defective eyesight, and it is very important that it should be attended to as soon as it is noticed.

MOUTH BREATHING.

Children who constantly keep their mouths open, and who snore at night, probably suffer from growths at the back of the nose, and should receive medical attention.

CLOTHING.

1. This should be warm in texture, and should fit loosely on the body.

2. Woollen or flannel undergarments are the warmest, and help to prevent chills.

3. No child should go to bed wearing any of the garments worn during the day-time.

4. More clothing is required in cold than in hot weather.

5. Girls should never be allowed to wear stiff corsets nor tight garments round the chest or waist, as this interferes with the proper growth and with breathing.

6. Stockings should be kept up by the use of suspenders. Tight garters are very harmful.

7. Boots should be watertight, and high or narrow heels should be especially avoided.

Cleanliness.

1. No child should have nits (eggs of lice) in the hair. The only really satisfactory method of getting rid of nits is to cut the hair short where the nits are found.

2. To avoid having the hair infected, boys' hair should be kept quite short, and girls' hair should be worn in plaits.

3. Parents should impress upon their children the danger of putting on other children's caps or hats.

Sleep.

It is very important that children should have more sleep than they generally do nowadays. Children of five to seven should go to bed about 6 o'clock, eight to ten about 7 o'clock, eleven to thirteen not later than 8.30 o'clock, these rules being but slightly relaxed in the summer time. Late hours are responsible for much subsequent ill-health.

Measles and Whooping-cough.

These diseases are very fatal to infants and young children, and the longer an attack can be put off, the less likely is it to be dangerous. Some children altogether escape having these diseases. No child, therefore, should be taken into or allowed to enter a house in which these or other infectious diseases are being treated.

CHAPTER V.

SICKNESS.

APART from the general hygiene of the scholar, the Head Teacher of a school has to take special account of the kinds of sickness which are liable to occur in epidemic form.

A memorandum relating to the closure of schools or the exclusion of scholars with a view to the prevention of the spread of infectious diseases has been issued jointly by the Local Government Board and the Board of Education. It calls attention to Code requirements and amplifies points of special importance.

SCHOOL CLOSURE.

Article 57 of the Code is as follows:

> *Article* 57. If the Sanitary Authority of the district in which the school is situated, or any two members thereof, acting on the advice of the Medical Officer of Health, require either the closure of the school or any department thereof, or the exclusion of certain children for a specified time, with a view to preventing the spread of disease or any danger to health likely to arise from the condition of the school, such requirement must at once be complied with.

As regards the Grant, provision is made by Article 45 (*b*) where a school is compulsorily closed or is closed under the advice or with the approval of the School Medical Officer, or for any other unavoidable cause. It runs as follows:

> *Article* 45 (*b*). If the requisite number of meetings has not been held owing to a closure of the school under

Article 57, or under the advice or with the approval of the School Medical Officer, or for any other unavoidable cause, the grant will be paid in full, provided that the requirements of this Article are satisfied after an allowance of nine meetings has been made for each week of such closure.

Exclusion of Children.

If the Sanitary Authority or two members thereof, acting on the advice of the Medical Officer of Health, require the exclusion of certain children for a specified time in order to prevent the spread of disease those children must be excluded (Article 57). Thus the Medical Officer of Health can initiate a compulsory process whether for closing the school or for excluding scholars, though he can only do so through the Sanitary Authority or two members thereof.

The exclusion of children is also provided for on the authorisation of the School Medical Officer by Article 53 (*b*) of the Code, which is as follows:

> *Article* 53 (*b*). Where the Board (of Education) are satisfied (i) that proper arrangements have been made by the Local Education Authority for enabling the School Medical Officer to ascertain and certify cases in which the exclusion of children from school is desirable, and (ii) that the School Medical Officer has authorised the exclusion of certain children from the school
>
> (1) on the ground that their exclusion is desirable to prevent the spread of disease, or
>
> (2) on the ground that their uncleanly or verminous condition is detrimental to the other scholars, or
>
> (3) on the ground that, owing to their state of health or their physical or mental defects, they are incapable of receiving proper benefit from the instruction in the school,

the exclusion of such children shall be deemed for the purposes of this Code to be exclusion on reasonable grounds.

Efficiency in the prevention of the spread of infection implies active co-operation not only between the Medical Officer of Health and the School Medical Officer, but also between these officers and the school teachers, school nurses, and attendance officers. This general need can be met by each Local Education Authority making regulations as to the duties of each of their officers to send forthwith to the Medical Officer of Health and to the School Medical Officer, information regarding any children suspected to be suffering from infectious illness, and to exclude such children temporarily. This point is emphasised in the following recommendation quoted from Circular 596 issued by the Board of Education on 19th of August, 1908:

> He (the School Medical Officer) must so organise his machinery that both he and the Sanitary Authority shall receive immediate information of any such occurrence (of infectious disease) whether the disease is notifiable or not, by duplicate notices or otherwise, so that the matter may be dealt with effectively and without confusion at the earliest possible moment. Definite regulations should be made for this purpose.

Instructions to Teachers and Parents.

It is in connection with investigations into these diseases that the co-operation of teachers and parents is needed, as well as of the School Medical Officer whenever the latter can help in this work. Infection is often spread in school by the attendance of children suffering from initial and unrecognised symptoms, or attending school in the convalescent stage, or throughout the course of a mild attack of an infectious disease. The school teacher and school attendance officer should inform both the Medical Officer of Health and the School Medical Officer of any children who have recently been kept at home with illness of a suspicious character, or concerning whom circumstances suggest the possibility of infection. This information probably will have come to the teacher and to the attendance officers from direct communication with parents. In some instances the attendance officers and in others the teachers may obtain the earliest information; and the system of intimations to the medical officers should be so arranged as to secure the simultaneous conveyance to the Medical Officer of Health and to the School Medical Officer of such information.

Information as to the Non-notifiable Diseases.

Measles, whooping-cough, mumps, chicken-pox and infectious diseases other than scarlet fever and diphtheria, which prevail among school children are seldom added by Sanitary Authorities to the schedule of compulsorily notifiable diseases. Even in districts in which any of these diseases are notifiable, the parents commonly either do not consult a doctor, or they call him in after secondary infection of other children has already occurred. Hence the Medical Officer of Health is dependent for information on parents, teachers, and attendance officers; and if the rapid spread of these diseases in school and the need for exclusion from school on a large scale or for school closure are to be avoided, school officers and parents should furnish this information to the Medical Officer of Health.

Intimations as to Cases of Doubtful Nature.

Apart from systematic and prompt intimation to the medical officers by teachers and attendance officers of all cases of the non-notifiable infectious diseases ascertained by them, further intimations should be sent by them of the absence from school of any child on the suspicion that it is suffering from an infectious disease; and absence of several children of one family from school at the same time, no matter what name be given to the complaint that keeps them at home, should also be reported.

The frequent and thorough washing of class-rooms and cloak-rooms is an efficient means of removing both dust and infection. Dry sweeping on the other hand tends to scatter dust.

Pulmonary Tuberculosis.

Pulmonary tuberculosis in a recognisable form is seldom a large factor in school life. Where it is known to exist, either through the medical inspection of children or apart from this, the affected scholar should be excluded from school in his own interest, and in that of the school, if the patient has cough with or without expectoration.

Exclusion of Scholars.

It will be seen that the ailments which may lead to the closure of the school, or the exclusion of the scholars therefrom, are not limited to diseases scheduled under the Infectious Disease (Notification) Act. In fact quite apart from actual illness amongst the scholars, there is a phrase "or in danger to health likely to arise from the condition of the school."

The diseases on account of which it is most usually necessary to exclude scholars, or close schools, are those which spread directly from person to person, such as Scarlet Fever, Measles, Diphtheria, Whooping Cough, Small Pox, Typhus Fever, and it is also very commonly necessary to exclude pupils coming from homes in which Typhoid Fever, or certain forms of Choleraic Diarrhœa exist. One reason, in the case of Typhoid Fever, being the risk of contamination of the closets by a child in an incipient stage of the illness.

In all forms of acute illnesses, which may possibly develop into Infectious Disease, it is desirable to exclude scholars coming from houses where sickness is until it is clearly ascertained that the disease is not an infectious one. It must be remembered that in their early phases some forms of infectious sickness are frequently obscure and difficult to diagnose, consequently it is better that the error should be on the side of safety, and the child excluded if the circumstances of illness at home are doubtful.

Very frequently teachers will be the first persons who have the opportunity to notice symptoms of illness of a pupil. A change in the normal disposition of the child, abnormal irritability, drowsiness, or inattention, are commonly associated with impending illness; hot and dry skin, accompanied perhaps with shivering; shrunken and dusky, or flushed appearance of the face; complaint of headache, sore-throat, diarrhœa or pain, should be carefully observed by the teacher, and the pupil should temporarily be taken from the class for medical examination if necessary. These observations are specially necessary during times of prevalence of infectious sickness, the onset of which is commonly attended by one or more of the symptoms alluded to; those first named are practically common to them all, but during times of prevalence of Scarlet Fever or Diphtheria, every case of sore-throat is to be looked upon with suspicion, and children with rashes on the skin should be promptly separated from the class.

The importance of attention to these matters will be more apparent when it is remembered that when an infectious disease has been contracted, a period of incubation ensues, of varying duration, before any symptom of illness is manifested by the infected person. Hence, when a child has been exposed to infection it is unsafe for that child to mix with others until it is evidenced by expiration of the period of incubation that the child has not been affected.

The period of incubation and the average duration of infectivity of the commoner forms of infectious disease are as follows, but it is desirable that exclusion from school should not be limited to minimum periods, but continued for 14 days after disinfection has been completely carried out by a competent authority, or until, of course, the child is strong enough to resume school work.

	Average incubation period	Average duration of infection from commencement of illness	
Scarlet fever	4 days	5 to 8 weeks	
Diphtheria	4 ,,	3 ,,	
Measles	12 ,,	3 ,,	
Whooping cough	14 ,,	7 ,,	
Typhus fever	10 ,,	5 ,,	
Typhoid ,,		5 ,,	
Rötheln	8 ,,	3 ,,	
Mumps	14 to 21 ,,	4 ,,	
Smallpox	12 ,,	4 to 12 ,,	varying as the disease has been modified by vaccination
Chickenpox	12 ,,	9 ,,	

Ringworm, scabies, and ophthalmia may last indefinitely unless properly dealt with, and no child with any trace of these diseases should be admitted to school.

With reference to the grounds upon which scholars should be excluded from school, it must be admitted,

(1) That all children suffering from an infectious disorder should be excluded from school so long as they are likely to retain any infection; this condition is one which may involve exclusion for some time after the patient is apparently convalescent.

(2) In general practice it is equally necessary that children coming from houses, any inmate of which is suffering from infectious sickness, should also be excluded, because in the great majority of instances, if not in all of them, it is impossible to effectually isolate a case of infectious sickness in an ordinary household, especially within the homes of children of the class who attend the public elementary schools.

Hardship really is minimised by a careful application of the powers to exclude individual scholars, because unless this is attended to it is quite possible that disease may rapidly spread to an extent which would render it necessary to close the school altogether.

It must not be forgotten that the Sanitary Authority of every town and of most rural districts has provided hospitals for the isolation of those suffering from infectious disease, and if the patient is removed to hospital, and the house, &c., disinfected, attendance at school may be resumed by children living in the house much sooner than if the patient remains at home throughout the entire illness.

The closing of schools may seriously interfere with the educational work of the locality, and is a step which should only be taken after the most careful consideration of the circumstances, and upon evidence that extension of disease will be checked by it.

The character of the evidence that the school is the centre of infection must be carefully weighed, and the nature of the action to be taken will necessarily vary under different conditions. If, for example, a serious and formidable form of disease is found to be spreading amongst children living at such distances apart as to render it improbable that they had any other means of communication than that involved by attendance at school, grounds would be furnished for the suspicion either that some coming from an infected house were disseminating the disease, or possibly that a child actually in an infectious condition was attending the school. Localised outbreaks of typhus fever, for example, a most formidable and dangerous disease, have been definitely traced to these causes, and it must be remembered also that even if other possible opportunities for infection exist, such as would arise in playing together or going to one another's houses, it must be borne in mind that the relationships are less intimate than when in school.

It is extremely difficult, if not impossible, to lay down definite rules as to when, and for how long a time, schools should be closed. The nature of the disease, its character, the numbers of the pupils affected, will all be factors in determining the point, as well as the nature of proof that the sources of infection are actually at the school.

It is plain, for example, that if 10 % of the children attending a school are absent on account of typhus fever, the aspect is more grave than if the same number of children are absent from measles, and the more formidable character of the one form of disease would call for more stringent action than in the case of the other; yet in either case it would be necessary to adopt as rigorous means as possible to exclude scholars from infected houses in the first instance, and it would probably be found in that way that the disease would be checked without resorting to closure of the school.

Much depends upon the amount and the promptness of the information which the Medical Officer of Health is able to gain in regard to the circumstances of the school children and their homes: and the promptness with which action can be taken.

Closure of schools is less likely to be efficacious in checking diseases such as measles in a densely populated district than in a sparsely populated one, because the opportunities for intercommunication in other ways are much greater in the densely populated district than in the rural one, where children live at greater distances and are less likely to meet together apart from schoolroom meetings.

The existence of infectious disease in a locality is by no means *per se* to be looked upon as a ground for closing the schools, and again still less is the existence of isolated cases of sickness amongst the pupils.

What applies to public elementary schools also applies to Sunday Schools and private schools. Although these latter establishments are not subject to the same regulation by the Sanitary Authority as the others, yet the Public Health Act does make certain provisions which are applicable to schools of every kind, and the managers of these establishments are as a rule perfectly willing to act upon the suggestions which the Sanitary Authority may find it necessary to offer.

When it does become expedient to close schools it is desirable that the time specified should be a minimum, because if it appears necessary a notice extending the period can be given before the expiration of the time originally stated.

It will be of interest to describe the details of the practice current in an English city, taking our illustration from the City of Liverpool.

The object aimed at is of course to give the earliest possible information to the Head Master, or Head Mistress, or Principal, when sickness exists at the homes of the scholars.

Usually the first intimation is received by the Medical Officer of Health, under the terms of the Notification Act, which requires that notice be given to the Medical Officer of Health of the occurrence of Infectious Disease by,

(*a*) the head of the family to which the patient belongs, and in his default,

(*b*) by the nearest relatives present in the building and in attendance on the patient, and in their default,

(*c*) by every person in charge of, or in attendance on, the patient, and in default of any such person,

(*d*) by the occupier of the building (as soon as he becomes aware that the patient is suffering from an Infectious Disease).

(*e*) Every Medical Practitioner attending on or called in to visit the patient is required forthwith, on becoming aware that the patient is suffering from an Infectious Disease, to send a Certificate to the Medical Officer of Health stating the name of the patient, the situation of the building, and the Infectious Disease from which, in the opinion of the Practitioner, the patient is suffering.

The Infectious Diseases (Notification) Act, however, does not include measles and whooping cough, both of which are liable to spread extensively amongst children of school age; these will be subsequently alluded to.

When notification of infectious sickness is received by the Medical Officer of Health from the medical attendant under the terms of the Infectious Diseases (Notification) Act, the address of the patient and the nature of the illness are entered in a register specially made for the purpose and which passes each day to the District Sanitary Inspectors' office. There it is examined by each of the District Inspectors, who takes note of such addresses as are on his own district, which he initials, and he becomes responsible for ascertaining and reporting the names of any children of school age who may be living at the address in question, the school they attend, and the various matters which require to be dealt with in connection with an infected house. It is part of the Inspector's duty to warn the parents or those in charge that the children must be kept from school until fourteen days after the necessary disinfection has been carried out; he leaves a postcard, addressed to the Medical Officer of Health to be filled up and forwarded by the parent or other responsible person as soon as the doctor in attendance states that the disinfection may be carried out.

Case of..

No. of House...*Street.*

Date for Disinfection..

Signature...

On returning to the central office next morning each inspector copies from his daily work book on to a sheet the date of his visit, nature of disease, address and names of children, and school they attend, in accordance with the subjoined form :

Date 191...		Disease	Address		Names of Children	Schools where Children attend	REMARKS
			No.	Street			

This information is duly entered in a permanent register under corresponding headings.

Intimation is sent by postcard the same day to the Head-master of the School the children attend if it is a Public Elementary School (or to the Principal in the case of a Private School).

The permanent register in which the names have been entered is then passed on to the Clerk to the School Board, who causes the various entries to be copied by his staff into a book having appropriate headings, as follows :

DATE		STREET	NAME

No.	SCHOOL	SICKNESS			DISINFECTION			Date when School was notified of Disinfection		
		Inspector notified of Sickness		Disease	Date of Disinfection	Inspector notified of Disinfection				
		Date	Initial			Date	Initial			

There are four of these books, to correspond with the four districts into which the city is divided for school purposes.

An intimation on the subjoined form is then given to the School Visitor warning him that the children from the address indicated thereon are prohibited from attending school until further notice is sent to him.

SICKNESS. Date,..1912

Disease..*District*..............................

Street..

Name..

Name..

School..

MUST NOT ATTEND THE SCHOOL.

At the expiration of a fortnight from the date of disinfection the School Visitor is notified to visit the house, and if no sickness of any kind has occurred in the interval he reports accordingly, and the following day intimation is sent by post-card to the Head Teacher of the School to re-admit the children.

Information is received by the Medical Officer of Health of diseases not included under the Notification Act from School Visitors, teachers, parents, and others, who are supplied with printed postcards suitable for the purpose, and each District Sanitary Inspector initials the address situated in his district, and reports the names of the children, &c., in a similar manner to that followed in the case of diseases included under the Notification Act.

It must be borne in mind that the methods now described are directed to the suppression of infectious disease, and although the child may be free from infection, and therefore, so far as the risk of infection is concerned, may with perfect safety return to school, yet it must be remembered that the child may not be sufficiently recovered physically to undertake at once the full work and discipline which attendance at school entails.

The permission of the Health Department to return to school therefore implies nothing further than freedom from infection.

Care of the Teeth.

A great amount of suffering and ill-health are caused directly or indirectly by inattention to the prevention and treatment of dental decay. Indifference and want of knowledge, as well as the absence of reasonable facilities, may explain this; many parents consider that attention to the first teeth is quite unnecessary as they will drop out in due course. A school dentist is a necessary officer; it is found that he gains the confidence of the children in a remarkable manner and very little trouble is experienced, a result no doubt due to the painless methods adopted. It is most important that children should be taught the proper use of the tooth-brush and the importance of cleaning the teeth.

CHAPTER VI.

PERSONAL ASPECT OF INFECTION.

It is sufficiently evident that no child in indifferent health, or suffering from illness of any kind, should be allowed to attend school, but in the case of *infectious* sickness the reasons for its exclusion do not apply only to the *sick* child, but to the rest of the scholars. It is, therefore, of paramount importance that children suffering from infectious sickness should be at once excluded, and *serious* responsibility rests upon those in authority to effect this exclusion.

It may be well, therefore, to describe briefly the more prominent symptoms of those forms of infectious sickness commonly met with amongst children in this country.

In all forms of infectious sickness a period of *latency* precedes the commencement of the illness, that is to say, after the germs of infection have entered the body, the patient remains in apparently perfect health for a certain length of time which varies with the nature of the illness.

Thus, a child who on being exposed to scarlet fever contracts that disease, will show no sign of illness whatever until about four days later, whilst a child which has been exposed to measles will show no sign of illness for about 12 days. As soon as this period of latency is over, symptoms of illness manifest themselves: the child is usually fretful, and peevish; there may be shivering, vomiting, and headache, together with loss of appetite, whilst the hands feel hot to the touch, and the face is usually flushed, because the temperature is raised. In very young children, convulsions frequently precede the other symptoms.

These conditions are more or less the same in the commencement of any illness, and any child in which such symptoms appear, should be at once removed from the school.

The *specific symptoms* usually to be observed in the commoner forms of sickness are as follows.

Whooping Cough. In this form of disease the period of latency is about a fortnight. The commencement of the illness then closely resembles a severe cold, accompanied by feverishness, and a troublesome and persistent cough, which may last a fortnight. The cough soon assumes a paroxysmal character beginning with a deep inspiration followed by a rapid succession of short coughs, without the possibility of any inspiration, the patient consequently appears for the moment to be bordering upon suffocation, when a long whistling or whooping inspiration occurs, which gives the name to the illness. This may be repeated at longer or shorter intervals, and upon this the severity of the disease depends. The disease is infectious, and amongst young children most distressing and fatal. Extreme care should be taken to exclude from school all children with the characteristic whoop, and also children coming from infected houses.

Mumps. The latent period of mumps varies between 14 and 21 days. The symptoms characteristic of mumps are pain and tenderness at the back of the lower jaw, followed by swelling there. The aching, tenderness, and swelling increase for two or three days, sometimes on one side, sometimes on both sides, considerably altering the appearance of the face. The swelling remains for about six days and is attended with general symptoms of ill-health: after that time it gradually disappears, and sometimes the skin peels off over the swollen parts. The disease is not a serious one, but is attended by considerable discomfort, and frequently occurs in widespread outbreaks.

Measles. The incubation period of this disease is about 12 days. The characteristic symptoms which measles superadds to those common to infectious sickness are those which accompany a severe cold, discharge from the nose, running from the eyes, hoarseness. On the fourth day inclusive from the commencement, a purplish bluish rash appears, first about the forehead and scalp, then on the face and neck, and gradually extends over the body. It lasts 4 or 5 days, and its disappearance is followed by the skin peeling off in fine particles. The severity of the disease varies greatly but it is excessively fatal to young children, usually on account of bronchitis or inflammation of the lungs, which complicates it.

Scarlet Fever. This disease has a short period of latency, usually 4 days. The illness then is usually sudden, and accompanied by vomiting, sore-throat, quick pulse, feverishness. The rash appears on the second day, first on the chest, and very quickly afterwards on the arms, abdomen and thighs, from which it may spread all over the body. The tongue becomes brightly red, with swollen papillæ, which gives it something the appearance of a strawberry. When the fever abates, and the rash disappears, the skin peels off, usually in flakes, which are especially large in the case of the hands and feet. Convalescence is usually protracted, and infection remains for a considerable time.

Diphtheria. The period of latency of diphtheria is short, averaging about 3 or 4 days. The child becomes dull, pallid, and moping, chills and shivering occur, and the child complains of sore-throat. The throat if examined will be seen to be deep red, somewhat swollen, and after a day or so whitish patches may be seen on it, and it is these which give the name to the disease, from the Greek word "διφθέρα, *diphthera*," *leather*. The disease is excessively infectious and very fatal, and great care is necessary in dealing with it, both in regard to the sick child, as well as to prevent the spread of infection.

It is not necessary to enter into details in regard to the more formidable diseases of typhus and small-pox, since the constitutional disturbances associated with their commencement would prevent children from attending school.

Typhoid Fever, or *Enteric Fever*. The commencement of this disease is usually insidious, with feeling of general lassitude and malaise, aching in the limbs, loss of appetite, signs of disturbance of the stomach and bowels, and tendency to diarrhœa. Chills, shivering and flushes of heat are among the early symptoms. With the progress of the disease these symptoms increasing in severity develop ultimately into the grave characteristics of this form of illness.

It is obviously of great importance to the patient to be quietly isolated at as early a stage as possible; it is equally important in the interests of the other scholars that this should be done, for the infection lies in the dejecta and in anything such as clothing, linen &c., which directly or indirectly may be soiled with them; the latrines used by the sick child may be the means of infecting healthy children. This form of illness, perhaps more than any other, owing to the obscurity of the early symptoms, illustrates the necessity for keeping from school children who are at all out of sorts or suffering from vague and indefinite illness.

Chicken-pox is a very infectious disease characterised by a small blister-like eruption appearing in successive crops, which dry into scabs in the course of two or three days. It is communicable by means of the air, and also by clothing, books &c., which have been infected. The commencement of the illness is usually unattended with symptoms more severe than slight feverishness and general malaise; minute red spots appear within 24 hours and these speedily develop into the vesicular eruption already described which is usually most abundant on the back.

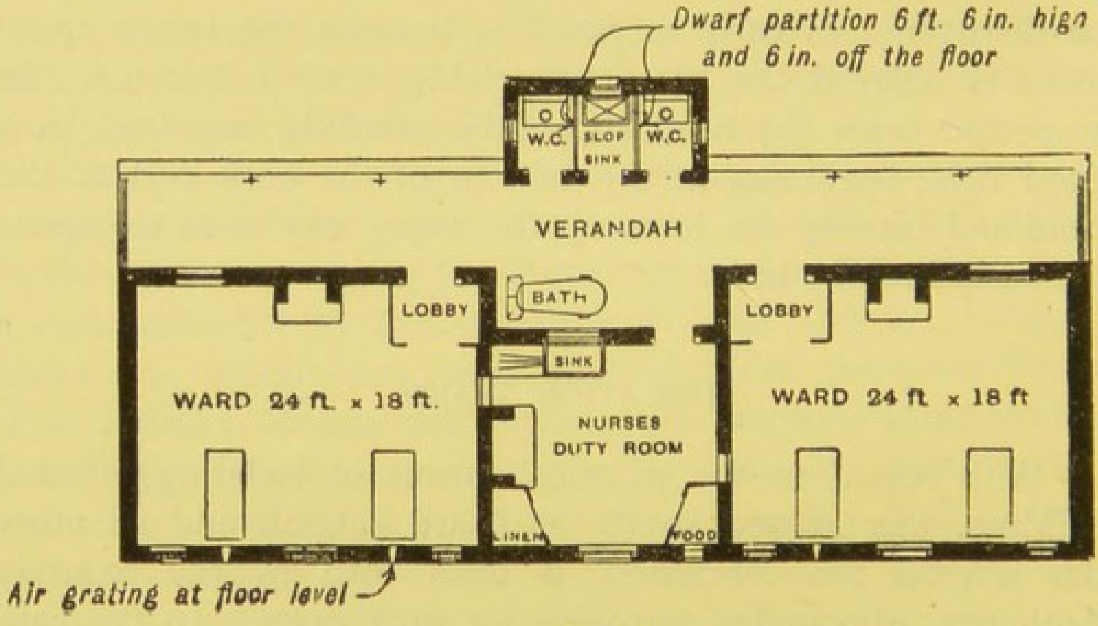
The malady usually lasts ten days or a fortnight, but it often happens that children remain weak and out of sorts for some weeks after an attack.

Ringworm. This is a readily communicable disease, parasitic in character, and is caused by a microscopic fungus which after a time insinuates itself into the hair follicles and between the fibres of the hairs, and therefore soon gets beyond the reach of remedies applied only to the surface; hence the need for preventive measures. It may easily be communicated from one child to another by caps, towels, brushes and combs, &c., and the lower animals, cats, dogs, rabbits, &c., may also impart it. Any part of the body is liable to be attacked, but the scalp is the most frequent seat, and here it is most difficult to get rid of, especially in the case of ill-nourished, or strumous children.

The disease usually appears as a small ring of scurfy scales, or minute reddish pimples at the circumference of a slightly raised and scaly spot; these dry up and fine branny scales take their place; the ring rapidly extends and becomes very characteristic in appearance; most of the hairs have broken off and look like stubble. Itching is one of the earliest symptoms. It is important that the disease should be discovered as early as possible, because the longer treatment is delayed the more intractable does it become. In suspected cases the head should be carefully examined in a good light, beginning at the bottom of the back part of the head and turning the hairs up the wrong way so as to expose the scalp little by little.

Isolation Ward.

With regard to the practical means of isolating infected children, this matter, so far as board schools and all other day schools are concerned, is dealt with by the Sanitary Authority, who makes provision for such cases. In the case of boarding schools, however, the circumstances frequently are different. If the school is situated in or near a town where an isolation hospital is provided, no better course can be pursued than having the patient removed to such an institution. In these days there are few, if any, towns without a hospital of the kind, but when the school is situated in the country it may be necessary to provide a small isolation hospital. Most purposes will be served by a one storey building, such as shown on the plan, divided into two wards with one or perhaps two beds in each. Into one or other of these, doubtful or suspicious cases of illness can be isolated for observation, or they can remain to be treated throughout the whole of the illness. Its construction, drainage, water-supply, ventilation and lighting will be carried out upon the ordinary principles. The building itself should be placed in such a position that it shall be effectually cut off from the rest of the school buildings and grounds, and it will be required to be so administered that the persons in charge shall have no direct contact with other inmates of the school. The plan is one suggested by the Local Government Board as a suitable ward block or unit for a small community.



PLAN

CHAPTER VII.

MEDICAL INSPECTION OF SCHOOL CHILDREN; SCHOOL NURSE; FEMALE HEALTH VISITORS; SCHOOL ATTENDANCE OF CHILDREN BELOW FIVE YEARS OF AGE.

Medical Inspection of School Children.

The medical inspection of school children is not only of great interest to school teachers, but its successful accomplishment is largely facilitated by their co-operation. The Education (Administrative Provisions) Act, 1907, imposed upon local education authorities the duty to provide for the medical inspection of children immediately before, or at the time of, or as soon as possible after their admission to a public elementary school, and on such other occasions as the Board of Education may direct; it also empowers the local authority to arrange for attention to be paid to the health and physical condition of the children educated in public elementary schools.

It will be noted that the inspection and supervision are not limited to those children who are apparently, or who are suspected to be, delicate or ailing, but include all children.

The Board of Education realised that this systematic inspection of school children constitutes an important part of school hygiene, a subject already closely linked up with general sanitary administration. Various circulars, issued by both the Board of Education and by the Local Government Board made it quite evident that the desire of both bodies was that in the work of inspection the co-operation of existing machinery in treatment and in sanitation should be availed of as far as possible, and all duplication and over-lapping avoided.

In pursuance of this policy of unification it has been found helpful by practically all local education authorities to associate the work of medical inspection as closely as possible with the department of the medical officer of health, and in a large majority of cases that officer either himself supervises or carries out the work.

At the present time the medical inspection takes place (α) shortly after the child enters the school, and (β) usually about one year before leaving, the respective ages being (α) from three to six years, and (β) from 12 to 14 years; the entrance inspection (α) can be more usefully made at the later than the earlier age, whilst obviously the earlier the examination of the "leavers" (β) the greater is the likelihood that any defects found will be remedied; when the child has left school, pressure can no longer be brought to bear upon negligent parents. Under the scheme of the Board of Education an intermediate examination is included, the result of which will be to increase the opportunities for effective attention to any defects which may be found.

As the work of medical inspection of school children is now developing in intimate relationship with general hygiene, it opens up many avenues for special inquiries, *e.g.* into parental circumstances, home conditions, industrial occupations and so forth, which lead to results beneficial alike to the children and the community generally. So far as the scholars themselves are concerned it has resulted in the satisfactory remedying of a very large proportion of the ailments discovered, whilst all of them have received attention of some kind; many of these ailments are of a kind to interfere seriously with the efforts of the teacher; deafness and defective vision, for example, whilst others, such as ringworm, being of a communicable nature are liable not only to cause much trouble by their spread but ultimately to result in the exclusion of many scholars for protracted periods.

The discovery of more serious physical defects such as unsuspected tuberculosis, heart disease and so forth, has resulted in the affected children being suitably cared for.

The medical inspections will in due course enable the medical history of each scholar in respect of infectious diseases to be recorded; and the knowledge thus secured will in the future be valuable in determining whether in particular cases children need to be excluded from school or whether classes or departments need to be closed when outbreaks of infectious disease occur. It is anticipated that this information will be valuable especially in dealing with outbreaks of measles and whooping-cough.

It will be plain that suitable provision should be available in every school for a room in which the medical examination of the scholars can be carried on under the most favourable conditions.

The School Nurse.

The usual function of the school nurse is to attend to, or to show parents how to attend to the minor injuries and ailments of children including cuts, bruises, chilblains, etc.; more serious condition should be referred for medical supervision. If her duties enable her to follow up cases of parental neglect by visiting the homes of the neglected children much good results. Not infrequently she renders valuable assistance in the work of medical inspection, a great deal of the time of the doctor being saved by the services which the nurse is able to render. The duties of school nurse may be summarised in the following regulations, which of course may be modified to meet varying conditions:—

Duties of School Nurse.

1. At each school at which she may attend, a Nurse will examine all such children as, in the opinion of the Head Teacher, require attention. If the teacher is in any doubt as to which of the children require attention, the Nurse at the request of the Head Teacher may assist in the selection of the children.

2. The Nurse shall examine all such children, and shall ascertain if:—

(*a*) Clothing is deficient.

(*b*) Conditions as to cleanliness; head, many nits and/or verminous.

(*c*) Body and Clothing dirty and/or verminous.

(*d*) Any infectious or other complaints present or requiring medical attention. The presence of ringworm or scabies should especially be searched for.

(*e*) Any cuts, bruises, sores, or other minor ailments present.

3. In the case of minor ailments such as cuts, bruises, sores, broken chilblains, etc., the Nurse shall apply suitable dressings as a temporary measure, and she shall, when she considers it necessary, refer the case to the District Nurse, or to the parents, to secure proper medical treatment, giving such instructions as may be necessary, either verbal or on a form to be provided by the Committee. On her next visit she shall ascertain whether these cases have been treated, and, if there is evidence of neglect on the part of the parents, report the case to the School Medical Officer. She shall enter in a book kept for the purpose the name of each child treated along with the conditions requiring treatment.

4. When the child ought in the opinion of the Nurse to have medical attention, she shall give the child for the parents a note to this effect on a form to be provided by the Education Committee, and in the case of any infectious complaint shall forthwith report the case to the Head Teacher and to the Medical Officer of Health, on a form to be provided by the Education Committee. If within a reasonable time the parents fail to obtain medical advice, the Nurse shall report the case, whatever its nature, to the School Medical Officer on a form to be provided by the Committee.

5. Where the clothing is found to be deficient, or the head or body is found to be with many nits, or verminous,

notices shall be sent to the parents on a form to be provided by the Committee, and if not remedied in a reasonable time, the case shall be reported to the School Medical Officer.

6. In the case of suspected ringworm, broken hair stumps shall be sent to the School Medical Department in a manner to be arranged (giving the date, the name and address of the child, and the school attended) for microscopical examination, and the case reported to the teacher.

7. Cases in which the Nurse suspects gross neglect shall be reported to the Medical Officer of Health.

8. The Nurses may be occasionally required to attend at a school when the School Medical Officer is conducting an inspection.

9. The Nurses will act under the directions and supervision of the Medical Officer of the Local Education Authority.

In administration it will of course be found that certain schools require the attention of the School Nurse far more frequently than others; in schools in which the proportion of neglected children is large her attendance is necessary either continuously or at short intervals. It is equally plain that few, if any, local Education Authorities will have a superabundance of School Nurses, and it will therefore be a matter for local administrators to determine whether the nurse's time is most effectively used by visiting the schools on her list frequently, for short periods, or spending say a week or a fortnight at a time at each school in its turn, an arrangement which must necessarily result in long absences. The difficulty in the latter method is that relapses from cleanliness, especially in schools in the poorer districts of cities, are very apt to occur if the School Nurse is absent for any protracted period.

Female Health Visitors.

Many Local Education Authorities avail themselves of the female sanitary staff in the work of medical inspection, leaving the School Nurse to follow her more usual duties already indicated. The Female Health Visitor can render the same assistance to the doctor which the nurse is able to give, and she can subsequently follow to the home every child where such a procedure is necessary. In some large towns the Female Sanitary Inspectors regularly assist the School Medical Officer at the schools.

The town is divided into districts, and the female Inspector who is attached to each district is placed at the disposal of the School Medical Officers whilst they have been inspecting schools which are situated in her district.

The large number of visits to the homes resulting from the inspections at the schools contributes in no small degree to a higher level of cleanliness and parental attention.

The work of the female Inspectors in relation to school children may be classified under the following heads:

i. Assisting the School Medical Officers at the schools and investigating the condition of cases at the routine inspections and of certain special cases as to cleanliness, etc.

ii. Visiting the homes of children who at the inspections are found to be verminous or dirty, or who are reported by the School Nurses as persistently neglected.

iii. At intervals these Inspectors can pay visits to the schools in order to see in school the children referred to for the purpose of noting improvement; they also see other children whom the teachers are anxious for them to inspect.

iv. Visit the parents at the request of the School Medical Officers, to urge the necessity of paying attention to various defects or for the purpose of giving advice to the parents.

v. Visits can be paid to the homes of school children suffering from various communicable conditions, including ringworm, itch, ophthalmia, and impetigo. These visits are part of the routine duties of a female Health Visitor or Sanitary Inspector, and are paid for the purpose of urging the parents to obtain treatment.

School Attendance of Children Below Five Years of Age.

Considerable discussion has centred upon the question of making provision in the Public Elementary Schools for children below five years of age, but much of the divergence of opinion upon the subject is due to misconception of the objects aimed at in making such provision. It will be generally conceded that, given good home surroundings, infants from three to five years of age are better off at home with their mothers than confined in ill-ventilated class rooms where their aggregation is a fruitful source of infection, and where real dangers of premature mental strain and interference with physical development may exist; but these do not represent the alternative conditions. The various aspects of this unusually complex and important subject have received very careful consideration by a Consultative Committee of the Board of Education, whose general conclusions, from which few if any will dissent, cannot be better expressed than in their own words.

"The Consultative Committee are of opinion that the best training for children between three and five years of age is that which they get from their mothers in their own homes, provided always that there exist in such homes adequate opportunities for the necessary maternal care and training.

"When the mother does her duty by her children; when she knows how to care for them properly and to make the best use of her narrow means; when her employment does not keep her away from home; when the home itself is clean, well-lighted, well-ventilated, and not over-cramped, and when the little children are within easy reach of some safe place to play in out-of-doors; in such circumstances the home affords advantages for the early stages of education which cannot be reproduced by any school or public institution. There is in the natural relationship between mother and child, and in the other influences of good home life, a moral and educational power which it is of high national importance to preserve and to strengthen, and which educational policy should be careful not to impair."

It is when all, or some of these conditions are wanting, and because their absence results in neglect and suffering and injury to large numbers of infants, that suitable places should be provided for them in the daytime. The Consultative Committee lay stress upon certain essentials of the Nursery School; they emphasise the necessity for light, air, sunshine; easy exits, ample playgrounds, good offices and sufficient bathing arrangements. The curriculum should encourage games and free play in the open air; cleanly habits, kindly discipline; short organized lessons, excluding formal lessons in reading, writing, etc. The infants should be allowed plenty of rest, to sleep when sleepy, preferably in the open air.

With regard to the teacher, the "Committee deprecate very strongly the idea which appears to be prevalent that any teacher is good enough for infants. They hold, on the contrary, that the care of these young children presents difficulties at least equal to those which arise in teaching the older ones, and that infant teachers should be selected with scrupulous care."

A specially trained and qualified Nurse is an equally essential member of the staff of the Nursery School.

With regard to the danger of infection the Committee recognise the supreme importance of the prompt exclusion of children who show any symptoms of illness, and they wisely refer to the undesirability of too much zeal in endeavouring to secure a regular attendance.

Finally they deprecate in the plainest manner any undue pressure of infants, and disapprove the old systems which have led teachers or inspectors to countenance it in the past.

The need for providing schools for infants below five years of age is fully recognised in France, Belgium, Germany and elsewhere, administrative details varying in different countries.

CHAPTER VIII.

ACCIDENTS AND EMERGENCIES.

It is never desirable that a teacher should accept the responsibility of treating illness or injuries, but as medical assistance is not always at hand either in the playgrounds or the schoolroom to meet every emergency it is clearly of advantage that he should know what to do pending the arrival of the doctor. It cannot be too strongly emphasised as a first principle, that every injury needs rest for its repair; indeed the common symptom of pain when an injured part is moved or touched is merely a reminder to keep it quiet.

Bruises and *contusions* should be immediately treated by the local application of cold; a handkerchief wetted, and kept wet with cold water, or the application of an ice bag, or an evaporating spirit lotion, or a lotion of acetate of lead, will lessen the swelling and minimise the subsequent discoloration. In every case, the more promptly the cold is applied the better. The appearance of a bruise, as for example a "black eye," is due to the fact that minute capillary blood-vessels in or beneath the skin have been ruptured, and that some blood has escaped into the tissues; this blood gives rise during its absorption and disappearance, to the rainbowlike hues of the discoloration, and the object of the cold dressing is to limit the actual escape of blood. In injuries involving abrasion or breach of the surface of the skin, the injured part should be carefully washed free from dirt, and a dressing of wet lint applied.

Severe injuries sometimes arise from laceration, skin and subcutaneous tissue being torn, but the amount of bleeding in these cases is usually slight, and is no index to the seriousness of the wound.

Clean cuts should have the edges brought carefully together, and a piece of clean dry lint placed upon them and kept in position by a carefully adjusted bandage. A piece of sticking-plaster will do excellently for small cuts; the edges of the plaster should be nicked before it is applied. Bleeding from cuts or punctured wounds may be easily arrested by pressure; a pad may be made of a folded piece of lint or firmly folded handkerchief and pressed firmly over the wound.

Hæmorrhage (bleeding) results from division or rupture of a blood-vessel, either an artery, a vein, or capillary vessel; arterial bleeding—resulting *e.g.* from the severance of a small artery by a fall on the head—is distinguished from venous or capillary by the bright colour and freer flow, which comes in spurts corresponding to the heart-beats. Each form, either the arterial jets, or the continuous venous flow, can always be temporarily and usually permanently stopped by pressure upon the wound in the manner indicated, but if the hæmorrhage is at all copious the pressure must be firmly persevered with till the doctor comes. The slighter forms are often arrested by cold alone.

Nose bleeding occurring by itself is seldom of serious importance in children in good health. In order to check it regard must be had to position; the patient's head should never be bent down over a basin; he should sit down, with the head thrown back, with a towel spread in front like a bib to prevent the clothes, previously loosened, from being soiled, and he should avoid frequently blowing and wiping the nose. Cold may be applied to the nose and to the nape of the neck.

Bites of animals cause irregular wounds, jagged and contused, which are often difficult to heal. Wet lint, or a wet handkerchief or other fomentations may be applied to relieve pain. If there is excessive bleeding it must be arrested in the manner indicated, but some bleeding may be advantageous.

Stings of insects are often exceedingly painful; a poultice will relieve this. Usually oil or glycerine or sal volatile may be applied with advantage.

Foreign bodies in the eye or ear may sometimes be lifted out; a probe should never be used except by the skilled person, and if difficulty is met, the doctor had better be referred to.

Fractured limbs. Fractures are not usually difficult to detect. Apart from the pain on attempting movement, there is usually more or less bending or twisting of the injured limb; this deformity arises from the displacement of the bone, and is also caused by the weight of the parts previously supported by the bone.

The aim in treatment is to keep the parts at rest, as nearly in the natural position as possible, and to prevent further displacement, above all to prevent the ends of the broken bone being thrust through the skin. If the leg is broken the patient should be carried home with the greatest care. The sleeve or trouser should be cut up and not pulled off.

Splints are used to support the limb and prevent displacement. They must be so applied that there shall be no pressure at the seat of injury, and in all cases must be carefully padded. They are usually of wood but temporarily other contrivances may be used so as to keep the parts immovable, *e.g.* pasteboard, thatch, or bundles of unbroken straw; umbrellas have served the purpose.

Slings and bandages may be usefully made with handkerchiefs and pinned where necessary; the accompanying figures explain the way in which handkerchiefs may be applied.

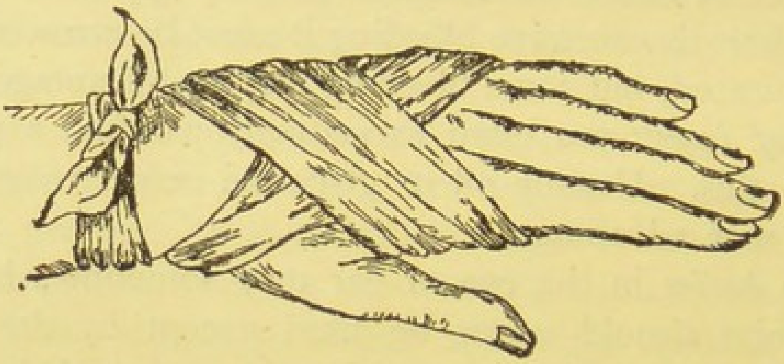
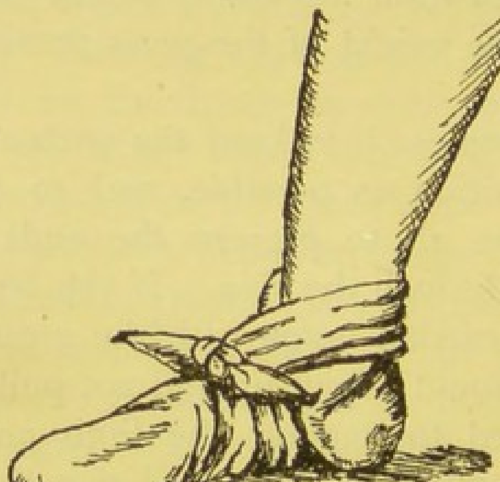


Figure-of-eight for the hand.

Fig. 9.

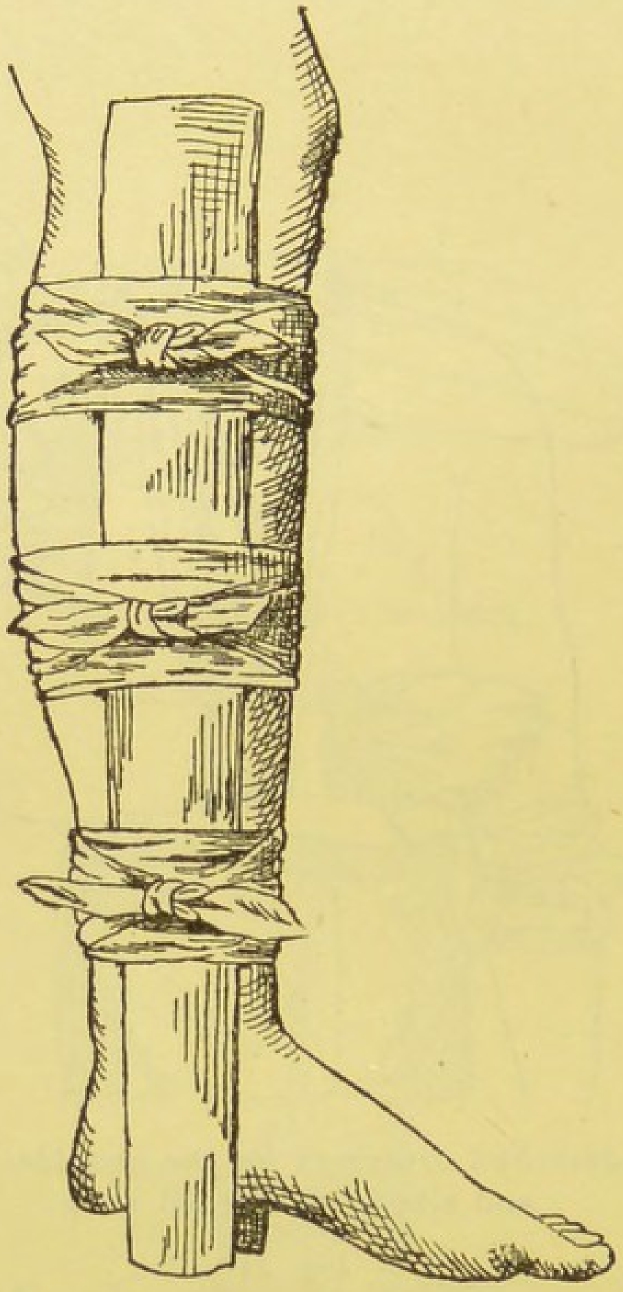


Handkerchief dressing for the foot.

Fig. 10.

Handkerchief dressings for the shoulder, hand and elbow; and small sling.

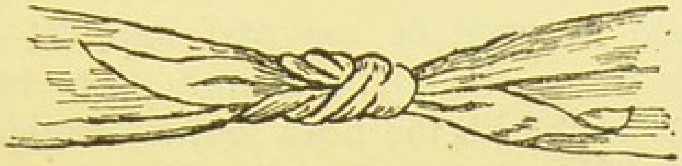
Fig. 11.



Provisional splints for fracture of the leg.

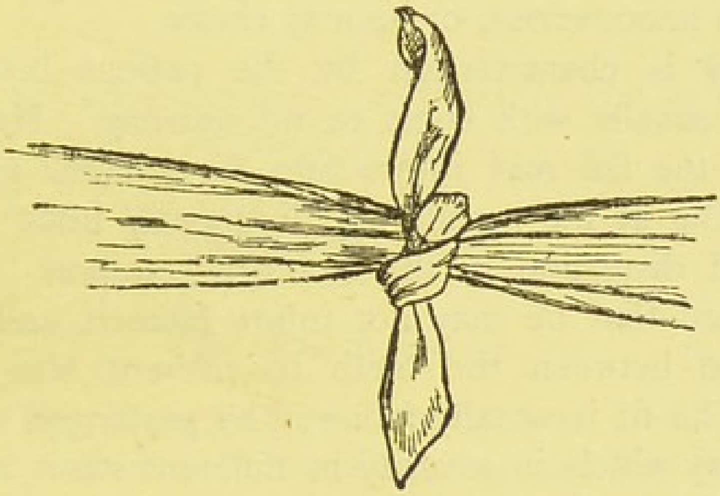
Fig. 12.

Care must be taken that a reef knot, and not a "granny" knot is tied.



Square-knot.

Fig. 13.



Granny-knot.

Fig. 14.

In very young children the bone is sometimes bent, and does not actually fracture, giving rise to a condition known as a "green-stick fracture."

Sprains result from a sudden wrench or twist by which the capsule or ligaments of a joint, or certain sheathing structures in its neighbourhood are stretched or torn. Pain, swelling and inflammation result, and the first aid consists in applying cold and in ensuring absolute rest for the injured part.

Burns and scalds should be treated with oil; there is no better application than a piece of lint well soaked in a mixture of equal parts of olive oil and lime-water; a little cotton-wool should be placed over this and kept in position by a light bandage.

Fits of various kinds may occur in school.

Fainting may occur in close and ill-ventilated rooms. The patient should at once be removed into the open air, or windows and doors should be thrown open, he should be placed on his back with the head low, his clothing should be loosened, and persons should not be allowed to crowd round him. Cold water may be sprinkled on his face and neck and chest, but no attempt should be made to make him drink whilst he is unconscious, or he may choke.

Epilepsy is characterised by the patient becoming unconscious, usually with short or no warning. He falls with a cry, and the fall may injure him, he remains unconscious, often frothing at the mouth, and frequently bites his tongue. Squint and distortion of the face are common. He should be so placed that he may not injure himself, and a piece of cork placed between the teeth to prevent him biting the tongue. The fit is usually followed by prolonged sleep. The seizures vary widely in severity in different cases, and are apt to recur. The epileptic must be regarded as an invalid.

Hysteria is more frequent in girls than boys; the fits are preceded or accompanied by emotional excitement, weeping or laughter, cries and screams; the patient falls on to the sofa, or gently and without injury to the floor, where convulsive movements more or less extensive are continued. The patient should be removed from the school.

Care of the Teeth. Observations of recent years have very conclusively shown that imperfect dental efficiency is frequently responsible for general derangement of health.

Most of the damage is done in childhood, especially between the ages of 7 and 14 years, and a great opportunity for doing good rests with those who have the supervision of children at these ages.

The fact that dental surgeons have been appointed not only to the great public schools, but to many public elementary schools, indicates the importance attached to the care of the teeth.

APPENDIX I.

BOARD OF EDUCATION. ABSTRACT OF BUILDING REGULATIONS.

Prefatory Note.

(1) *New Buildings.*

The chief aim of these Regulations is to secure that buildings newly erected for use as Public Elementary Schools shall be satisfactory for their special purpose.

They are intended to assist Local Education Authorities, School Managers, and their Architects, in providing schools which shall be compact, properly sub-divided for class teaching, conveniently arranged for effective supervision by the Head Teacher and for the movement of the children from the entrance to the class-rooms or from one class-room to another, and, as regards the several rooms, properly fitted for the instruction to be given in those rooms. The Regulations are framed with a view to the combination of economy with efficiency.

The Board will be prepared to consider other arrangements of the various parts of the building, provided there is good reason to suppose that an efficient building for teaching purposes will thereby be forthcoming.

The extent of the site, the solidity of the fabric, the lighting, warming, drainage, ventilation, cloak-rooms and sanitary arrangements, and the adequacy of the entrances and staircases in view of the use of the building by a large number of children, have an important bearing on the health and safety of the scholars.

(2) *Existing Buildings.*

These Regulations do not constitute a standard by which existing premises can be judged; and they are plainly unsuitable for any rigid application to proposals for enlarging or otherwise improving existing buildings. Such cases must be dealt with individually as they arise, having reasonable regard to the principles set forth in these Regulations.

PART I.

PRINCIPLES TO BE OBSERVED IN PLANNING AND FITTING UP NEW BUILDINGS FOR PUBLIC ELEMENTARY SCHOOLS.

SECTION 1. GENERAL.

The principal factors to be considered are the respective numbers of boys and girls for whom it has been determined that provision is necessary. The distribution of these scholars in respect of age is also very important in its bearing on organisation, and consequently on planning; the type of building required will probably depend to some extent on the manner in which the Local Education Authority have exercised their discretion as to the exclusion of children who are under five years of age; and the nature of the accommodation required in the upper departments of ordinary public elementary schools will be affected if higher elementary schools are provided in the locality.

It must be remembered that a Head Teacher can seldom undertake effectively the responsibility for more than five to six hundred scholars, including the supervision of the teaching staff required for that number. This, therefore, is the greatest number of scholars for whom provision can wisely be made in one and the same department, remembering that each department must have its own Head Teacher, who is responsible for the general control and supervision of the instruction and discipline of that department (Article 8 of the Code).

The number of departments on any one site will depend upon the total number of scholars for whom provision is required, but it will be very seldom that more than three departments (or four, if one of them is for boys and girls of seven to nine or ten years of age) could properly occupy parts of one and the same building. When a school comprising departments for boys, girls and infants is attended by all the children of the area for which it is available, it is not unusual to find that the average attendance in each department is much the same; and this fact will be a guide in planning a building for these conditions. But it is desirable to have a certain margin of places in the infants' department in order to meet the greater variability of the attendance at different seasons.

It is important to remember that the number of places provided in any room depends not merely on its area, but also on the lighting, the shape of the room (especially in relation to the kind of desk proposed), and the position of the doors and fireplaces, which should be arranged so as to allow the whole of one side of any room to be left free for the groups of desks.

For large departments containing from 350 to 600 places the most suitable plan is that of a Central Hall with the class-rooms grouped round it; as a rule such a department would require from seven to ten class-rooms. Smaller departments may be planned conveniently with the class-rooms opening from a corridor, and a similar plan may be adopted even for larger departments. For small schools a school-room with one or more class-rooms will be sufficient. There should always be at least one class-room, except in special cases.

Where the site is sufficiently large, open, and fairly level, the most economical plan is that in which all the rooms are on the ground floor, and this arrangement is preferable on educational grounds. It is desirable that a building for use as a public elementary school should be on not more than two floors. A building on three floors is open to many objections, though it may be necessary in special circumstances, as, for example, on a site where land is very costly, or where it is otherwise impossible to get adequate area for playgrounds.

SECTION 2. CENTRAL HALLS.

When there is a Central Hall it should have a floor-space of not more than 4 square feet for each scholar for whom the school is recognised; about 3½ square feet for each scholar will be sufficient. The Hall must be fully lighted, warmed, and ventilated.

Section 3. Corridors.

Large schools not built with a Central Hall must be provided with a wide Corridor giving access to the rooms ; and two or three of the rooms ought to be divided from one another by movable partitions only, so that on occasions one large room may be available.

A Corridor should be fully and directly lighted and ventilated, and from 8 to 12 feet wide, according to the size of the school.

Section 4. School-Rooms.

Where a school-room is the principal room in a school which has neither Central Hall nor Corridor it should never be designed for more than 100 children, and a room of even smaller size is desirable. The width should vary according to the kind and arrangement of the desks.

No school-room lighted from one side only can be approved. The gable ends should be fully utilised for windows, and there should be no superfluous windows opposite the teacher.

When a school consists of a single room, that room should not contain more than 600 square feet of floor-space.

Section 5. Class-Rooms.

The number of class-rooms should be sufficient for the size and circumstances of the school.

(*a*) The class-rooms should not be passage-rooms from one part of the building to another, nor from the school-rooms to the playground or yard. Both school-rooms and class-rooms must have independent entrances. The rooms should be arranged so that each can be easily cleared without disturbing the work proceeding in any other room.

(*b*) A class-room should not be planned to accommodate more than from 50 to 60 children ; but in special cases somewhat larger rooms may be approved. In the absence of supplementary light the measurement from the window-wall in a room 14 feet high should not exceed 24 feet 8 inches. Except in very small schools class-rooms should not be planned for less than 24 scholars.

(*c*) The proportions of class-rooms should vary with the kind and arrangement of the desks ; but a long and narrow room should always be avoided, and a room approximating to a square is most satisfactory.

SECTION 6. DESKS.

Seats and desks should be provided for all the children, graduated according to their ages, and placed at right angles to the window-wall. The seats should be fitted with backs.

An allowance of 18 inches per scholar at each desk and seat will suffice (except in the case of the dual desk), and the length of each group should therefore be some multiple of 18 inches, with gangways of 18 inches between the groups and at the walls. In the case of the dual desk the usual length is 3 feet 4 inches, and the gangways 1 foot 4 inches.

(*a*) In an ordinary class-room five rows of long desks or six rows of dual desks are best ; but in a school-room or room providing for more than 60 children, there should not be more than four rows of long desks or five rows of dual desks.

If a school-room is 18 feet wide, three rows of long desks or four of dual desks may be used ; if the width is 22 feet, the rows may be four and five respectively.

Long desks should be so arranged that the teacher can pass between the rows. Where dual desks are used this is not necessary, as the gangways give sufficient access ; but the teacher should be able to pass behind the back row.

(*b*) The desks should be very slightly inclined. An angle of 15° is sufficient. The objection to the flat desk is that it has a tendency to make the children stoop. A raised ledge in front of a desk interferes with the arm in writing. The edge of the desk when used for writing should be vertically over the edge of the seat.

(*c*) Single desks are not necessary in an ordinary public elementary school.

SECTION 7. ACCOMMODATION.

No Central Hall or Corridor, and no class-room for Cookery, Laundry Work, Handicraft, Drawing or Science, will be counted towards the accommodation.

When the building to be erected is for the use of older scholars, the plans of the school-room (if any) and class-rooms must show an average of not less than 10 square feet of floor-space for each place proposed to be provided.

Section 8. Infants' Schools.

Infants should not, except in very small schools, be taught in the same room with older children, as the methods of instruction suitable for infants necessarily disturb the discipline and instruction of the other scholars. Access to the infants' room should never be through the older children's school-room.

(*a*) It is desirable that the partition between an infants' room and any other school-room or class-room should be impervious to sound, and there should be no habitual means of direct communication other than an ordinary door.

(*b*) An infants' school and playground should always be on the ground floor.

(*c*) No infants' class-room should accommodate, as a rule, more than 60 infants.

(*d*) A space in which the children can march and exercise should be provided. A corridor intended for this purpose should not be less than 12 feet wide.

(*e*) The babies' room should always have an open fire, and should be maintained at a temperature of not less than 60 degrees.

(*f*) In infants' schools an allowance of 16 inches per child at long desks will be sufficient. Dual desks should be 3 feet long.

Sections 9 and 10 deal respectively with special rooms for Cooking, Handicrafts, &c., and with Higher Elementary Schools.

Section 11. Teachers' Rooms.

In large Schools there should be provided for the use of the Teachers a small room or rooms with suitable lavatory accommodation. A store-room for books and other School material should adjoin the Teachers' room.

Section 12. Teacher's House.

The residence (if any be provided) for the master or mistress should contain a parlour, a kitchen, a scullery, and three bedrooms, and the smallest dimensions which the Board can approve are :

For the parlour	14 ft. by 12 ft.	of superficial area	9 ft. } in height to wall-plate.
,, ,, kitchen	22 ft. by 12 ft.		9 ft. }
,, one of the bedrooms...	14 ft. by 12 ft.		8 ft. if ceiled at wall-plate; or 7 ft. to wall plate, and 9 ft. to ceiling.
,, two other bedrooms ...	12 ft. by 8 ft.		

(*a*) The residence must be so planned that no room is a passage room, and that the chimneys are not all on the external walls.

(*b*) There must be no internal communication between the residence and the school.

(*c*) Windows should be carried up as nearly to the ceiling as practicable.

(*d*) There must be a separate and distinct yard with offices.

(*e*) No dwelling house should be built as part of the school-house.

PART II.

RULES AS TO THE HYGIENIC AND SANITARY CONDITIONS OF THE PREMISES, THE CONSTRUCTION OF THE FABRIC, AND THE SAFETY OF THE SCHOLARS IN CASES OF EMERGENCY.

1. Sites and Playgrounds.

In planning a school care must be taken to secure that there shall be an open airy playground proportioned to the size and needs of the school, and the site should, if possible, have a building frontage suitable to its area. As far as the site permits the building should not be placed near to a noisy street or main thoroughfare ; where this is unavoidable the class-rooms should be placed on the opposite side to the street. A site open to the sun is especially valuable for the children, and important in its effects on ventilation and health, and the class-rooms should be so arranged as to ensure the admission of direct sunlight during some part of the day. The minimum size of site is, in the absence of exceptional circumstances, a quarter of an acre for every 250 children, irrespective of the space required for a teacher's or caretaker's house, or for a Cookery or other Centre. If the school is of more than one storey this area may be proportionately reduced; but a minimum unbuilt-on or open space of 30 square feet per child should be preserved.

(*a*) Except in the case of very small schools, playgrounds should be separate for boys and girls, and should, where practicable, have separate entrances from the road or street.

(*b*) All playgrounds should be fairly square, properly levelled, drained, and enclosed. A portion should be covered, having one side against the boundary wall. A covered-way should never connect the offices with the main building; buttresses, corners, and recesses should be avoided.

(*c*) An infants' school should have its playground on the same level as the school, and a sunny aspect is of special importance.

2. Walls, Floors and Roofs.

The walls of every room used for teaching, if ceiled at the level of the wall plate, must be at least 12 feet high from the level of the floor to the ceiling; if the area of the room exceeds 360 square feet the height must be not less than 13 feet, and, if it exceed 600 square feet then the height must be at least 14 feet.

(*a*) The walls of every room used for teaching, if ceiled to the rafters and collar beam, must be at least 11 feet high from the floor to the wall plate, and at least 14 feet to the ceiling across the collar beam.

(*b*) Great care should be taken to render the roofs impervious to cold and heat.

(*c*) Roofs open to the apex are very undesirable. They can be permitted only where the roofs are specially impervious to heat and cold, and where apex-ventilation is provided. Iron tie-rods are least unsightly when placed horizontally.

(*d*) In the case of a school of more than one storey special care must be taken to render the floors as far as possible sound-proof.

(*e*) The whole of the external walls of the school and residence (if any) should be solid. If of brick, the thickness must be at least one brick and a half; and, if of stone, at least 20 inches; where hollow walls are proposed, one wall must be 9 inches thick and the cavity 2 inches.

(*f*) The Board are only prepared to sanction the erection of schools of a lighter construction, *e.g.*, in iron and wood, or other suitable material, in very special circumstances, as for example in colliery districts where, owing to mining operations, there is no site available upon which a building of the ordinary solid type can be safely erected; or where the population is not of a stationary character, as, for example, during the progress of a large piece of engineering work, or in the neighbourhood of a mine likely to be soon worked out; or where temporary accommodation is required during the building of a new school, or the reconstruction of an old one.

Where such buildings are proposed special care must be taken to ensure the comfort of the children with regard to warmth and ventilation.

(*g*) All walls, not excepting fence walls, should have a damp-proof course just above the ground line.

(*h*) The vegetable soil within the area of the building should be removed, the whole space covered by a layer of concrete not less than 6 inches thick, and air bricks inserted in *opposite* walls to ensure a through current of air under floors for ventilation to joists.

(*i*) Timber should be protected from the mortar and cement by asphalt or tar.

3. Entrances.

Entrances should be separate for each department and each sex. In large schools more than one entrance to each department is desirable. (*See also* Rule 4.) Entrance doors should open outwards as well as inwards. A porch should be external to the school-room. An external door, having outside steps, requires a landing between the door and the threshold.

4. Staircases.

There must be separate staircases for boys and girls and each department should have its own staircases.

Every staircase must be fire-proof, and external to the halls, corridors, or rooms. Triangular steps or "winders" must not be used. Each step should be about 13 inches broad and not more than 5½ to 6 inches high. The flights should be short, and the landings unbroken by steps. The number of staircases must be sufficient not only for daily use, but also for rapid exit in case of fire or panic. For any upper floor accommodating more than 250 a second staircase is essential.

5. Cloak-Rooms and Lavatories.

Cloak-rooms should not be passages, and should be external to the school-rooms and class-rooms. Cloak-rooms should be amply lighted from the end, and should not be placed against the gable wall which should be fully utilised for windows giving light to the rooms used for teaching. There should be separate ingress and egress so that the children can enter and leave the cloak-room without confusion or crowding. There should be gangways at least 4 feet wide between the hanging rails. Hat pegs should be 12 inches apart, numbered, and of two tiers. The lineal hanging space necessary to provide a separate peg for each child is thus 6 inches. The hat pegs should not be directly one above the other.

Cloak-rooms should be fitted with doors so that when desirable they can be locked up.

Thorough ventilation and disconnection are essential, so that smells are not carried into the school. Ample space is needed immediately outside a cloak-room.

Lavatory basins are needed. Girls' schools require a larger number than boys' or infants'.

A lock-up slop sink, water-tap, and cupboard are desirable for the caretaker.

6. Lighting.

Every part and corner of a school should be well lighted. The light should, as far as possible, and especially in class-rooms, be admitted from the left side of the scholars. All other windows in class-rooms should be regarded as supplementary or for ventilation. Where left light is impossible, right light is next best. Windows full in the eyes of scholars cannot be approved. Unless the top of the windows be more than 14 feet above the floor the plan should shew no space more than 24 feet from the window-wall in any room used for teaching.

(*a*) Windows should never be provided for the sake merely of external effect. All kinds of glazing which diminish the light and are troublesome to keep clean and in repair must be avoided. A large portion of each window should be made to open for ventilation and for cleaning.

(*b*) The sills of the main lighting windows should be placed not more than 4 feet above the floor; the tops of the windows should as a rule reach nearly to the ceiling; the upper portion should be made to swing. The ordinary rules respecting hospitals should here be remembered. Large spaces between the window heads and ceiling are productive of foul rooms.

(*c*) Skylights are objectionable. They cannot be approved in school-rooms or class-rooms. They will only be allowed in Central Halls having ridge or apex ventilation.

(*d*) The colouring of the walls and ceilings and of all fittings in the rooms should be carefully considered as affecting the light. This point and the size and position of the windows are especially important in their bearing on the eyesight of the children.

(*e*) The windows should be properly distributed over the walls of the class-rooms so that every desk shall be sufficiently lighted. The glass line of the window furthest from the teacher should be on a line with the back of the last row of desks.

7. Ventilation.

The chief point in all ventilation is to prevent stagnant air; particular expedients are only subsidiary to this main principle.

There must be ample provision for the continuous inflow of fresh air, and also for the outflow of foul air. The best way of providing the latter is to build to each room a separate air chimney carried up in the same stack with smoke flues. An outlet should be by a warm flue or exhaust, otherwise it will frequently act as a cold inlet. Inlets are best placed in corners of rooms furthest from doors and fireplaces, and should be arranged to discharge upwards into the room. Gratings in floors should never be provided. Outlets in ceilings must not open into a false roof but must be properly connected with some form of extract ventilator.

The size of the inlets and outlets must be carefully adapted to the method of ventilation proposed. A much larger area is required when no motive force is provided.

It is as well that the windows should have both the top and bottom panes arranged to open inwards as hoppers.

Besides being continuously ventilated by the means above described, rooms should as often as possible be flushed with fresh air admitted through open windows and doors. Sunshine is of particular importance in its effects on ventilation and also on the health of children.

Although lighting from the left hand is considered so important, ventilation demands also the provision of a small swing window as far from the lighting as possible, and near the ceiling.

8. Warming.

The heat should be moderate and evenly distributed, so as to maintain a temperature of from 56 degrees to 60 degrees. When a corridor or lobby is warmed, the rooms are more evenly dealt with and are less liable to cold draughts. Where schools are wholly warmed by hot water, the principle of direct radiation is recommended. In such cases open fireplaces in addition are useful for extra warming on occasions, and their flues for ventilation always.

(*a*) A common stove, with a pipe through the wall or roof, can under no circumstances be allowed. Stoves are only approved when:

- (i) provided with proper chimneys (as in the case of open fires);
- (ii) of such a pattern that they cannot become red hot, or otherwise contaminate the air;
- (iii) supplied with fresh air, direct from the outside, by a flue of not less than 72 inches superficial; and
- (iv) not of such a size or shape as to interfere with the floor-space necessary for teaching purposes.

(*b*) A thermometer should always be kept hung in each room.

(*c*) Fireplaces and stoves should be protected by fireguards.

(*d*) If a room is warmed by an open fire the fireplace should be placed, if possible, in the corner of the room in order to leave space for the teacher's desk and black-board.

9. Sanitary Arrangements.

Water-closets within the main school building are not desirable, and are only required for women teachers. All others should be at a short distance and completely disconnected from the school. Privies should be fully 20 feet distant.

(*a*) The latrines and the approaches to them must be wholly separate for boys and girls. In the case of a mixed school this rule especially affects the planning. Boys and girls should not use the same passages or corridors; where such an arrangement is unavoidable, there must be complete supervision from the class-rooms by sheets of clear glass.

(*b*) Each closet must be not less in the clear than 2 feet 3 inches wide, nor more than 3 feet, fully lighted and ventilated, and supplied with a door. The doors should be at least 3 inches short at the bottom and at least 6 inches short at the top. More than one seat is not allowed in any closet.

(*c*) The children must not be obliged to pass in front of the teacher's residence in order to reach their latrines.

(*d*) The following table shows approximately the number of closets needed:

—	For Girls	For Boys	For Infants	For Girls and Infants
Under 30 children	2	1	2	2
" 50 "	3	2	3	3
" 70 "	4	2	3	4
" 100 "	5	3	4	5
" 150 "	6	3	5	6
" 200 "	8	4	6	7
" 300 "	12	5	8	8

There should be urinals in the proportion of 10 feet per 100 boys; urinals are required for infant boys. If the numbers in the school are not very large, offices common to girls and infants can be approved; a proper proportion of the closets must then be made of a suitable height for infants.

(*e*) Earth or ash closets of an approved type may be employed in rural districts, but drains for the disposal of slop and surface water are necessary. Cesspits and privies should only be used where unavoidable, and should be at a distance of at least 20 feet from the school.

10. Water Supply.

In all schools adequate and wholesome drinking water must be available for the scholars.

In cases where it is not taken from the mains of an Authority or Company authorised to supply water, care must be taken to ascertain that the water proposed to be used is adequate in quantity, is of suitable character, and is not liable to pollution in any way, as *e.g.*, by surface drainage, or by leakage from sewers, drains, cesspools, or other receptacles.

Where water pipes are used they should be so laid or fixed as to be properly protected from frost, and so that in the event of their becoming unsound the water conveyed in such pipes will not be liable to become fouled, or to escape without observation.

There should be no direct communication between any pipe or cistern from which water is drawn for domestic purposes, and any water closet or urinal.

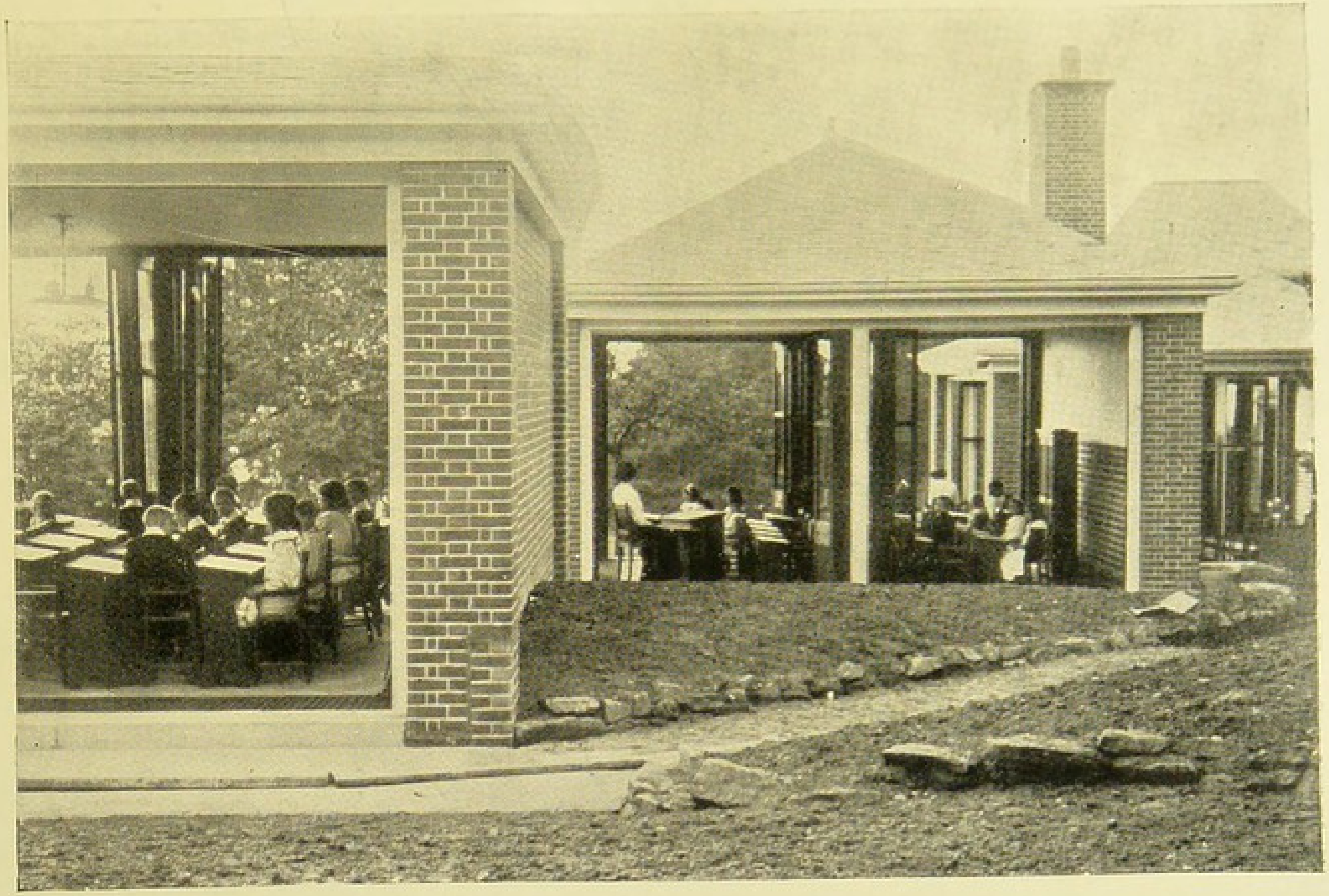
All water closets and urinals should be provided with proper service cisterns, which, together with the outlet therefrom, should be capable of providing a sufficient flush.

Any cistern to be used for the storage of water should be watertight and be properly covered and ventilated, and should be placed in such a position that the interior thereof may be readily inspected and cleansed.

"Open-air" or "Recovery Schools."

Many delicate children are threatened with or even actually infected with quiescent phthisis, or with other forms of tuberculosis. Such children cannot attend an ordinary Elementary School without injury; for them abundance of fresh air, sunlight, rest, and special attention are needed, and the object of the "open-air" school is to provide these. Modified courses of instruction under such conditions are distinctly advantageous to the child's prospects of recovery.

The illustration is reproduced by kind permission of the Society of Medical Officers of Health from Dr G. A. Auden's *Annual Report* to the Birmingham Education Committee for 1911.



Uffculme Open Air School, Birmingham.

APPENDIX II.

The following memoranda relating to Measles and Whooping-cough are illustrative of informative leaflets in use in many towns for circulation amongst the poorer classes :—

MEASLES.

Measles is an extremely catching and very dangerous disease. A large number of children lose their lives through it every year, from want of proper care and attention.

SYMPTOMS.

Measles usually begins with running at the eyes and nose, sneezing and coughing. This is followed in a few days by a blotchy red rash on the face and body. When measles is in the neighbourhood you should be very suspicious if a child has a bad cold, and a careful watch should be kept for three or four days to see if the rash comes out.

Usually about twelve days elapse before a child who has been exposed to the disease shows the first symptoms, namely, those of a cold.

TREATMENT.

In every case, even though it seems mild, the doctor should be called in. The patients should be warmly clothed and kept in bed so long as they remain feverish. The room in which they should remain until they have quite recovered should be warm but well ventilated. It is very dangerous to take the children out of doors or into draughty passages or cold rooms before they have recovered.

A child commencing or thought to be commencing with measles should be kept away from school at once, and the teacher should be informed of the reason.

To Prevent Spread.

Keep the patient apart from all other children for at least two weeks from the beginning of the illness. Never allow any child, especially a baby in arms, to be taken into any house in which there is a case of measles, and do not allow a child to play with another who has not yet recovered from the disease. Do not allow any other children to come into your house if you have a case of measles. It is quite wrong to suppose that every child must have measles some time, and that the sooner it is over the better. The longer you can put off the disease the less is the likelihood of a dangerous attack, and many children escape the disease entirely. The younger the child the greater the danger.

Measles and Whooping Cough destroy more lives than all the other infectious diseases put together.

WHOOPING COUGH.

Whooping cough is a very infectious as well as an exceedingly dangerous and distressing disease of early childhood and of infancy. Many children lose their lives through want of proper attention and nursing.

Symptoms.

The disease usually begins like a feverish cold, and is infectious from the start. The cough soon comes on in paroxysms, which threaten almost to suffocate the child, who frequently vomits. The whoop may come on later.

Treatment.

The doctor should be called in, even in what appear to be mild cases. The patient should be warmly clothed and kept in bed until the severity of the attack has worn off. The room should be kept warm and well ventilated.

To Prevent Spread.

As whooping cough is catching, keep all other children away from the patient for five weeks from the beginning of the whooping, and do not let the child return to school till quite recovered.

When whooping cough is in the neighbourhood, look upon all colds with suspicion. Never allow any child, especially a baby in arms, to be taken into any house in which there is a case of whooping cough, and do not allow any child to play with another who has not yet recovered from the disease. At the same time do not allow any other children to come into your house if you have a case of whooping cough.

On recovery, the child's clothes and bed linen, etc., should be washed, and what cannot be washed should be well aired in the yard or garden, whilst the windows should be thrown open and the room well flushed with fresh air.

The longer the disease can be put off, the less likely is it to be fatal.

A child commencing, or thought to be commencing, with whooping cough should be kept away from school at once, but the teacher should be informed of the reason.

Measles and Whooping Cough destroy more lives than all the other infectious diseases put together.

APPENDIX III.

Illustrative Memorandum for the Use of Teachers.

Any special circumstance, such as deficient house accommodation, numbers infected, persistence of symptoms, etc., will necessitate a modification of these arrangements. Where a doctor is in attendance his views must be ascertained.

PUBLIC HEALTH DEPARTMENT.

Memorandum to Head Teachers of Elementary Schools.

The Medical Officer of Health begs to draw the attention of the Head Teachers to the following instructions which have been given to the Sanitary Staff relating to the exclusion from School of Children suffering from the following diseases or coming from an infected house.

Disease	Exclusion of Patient	Exclusion of other children in the house	
	Period of Exclusion	Children Involved	Period of Exclusion
Diphtheria and Scarlet Fever	Until 10 days following release from Isolation.	All Children to be excluded.	Until 10 days following the disinfection of the premises.
Measles...	For Three Weeks from the commencement of Illness.	All Children under 7 to be excluded, as well as Children between 7 and 10 years of age who have not had the disease.	Until sixteen days after the occurrence of the last case in the house.
Chicken Pox...	Ditto.	Ditto.	Until sixteen days after the occurrence of the last case in the house.
Mumps......	Ditto.	All Children under 7 to be excluded, as well as Children over 7 years of age who have not had the disease.	Until sixteen days after the occurrence of the last case in the house.
Whooping Cough...	For at least Six Weeks from the commencement of the Illness.	All Children under 7 years of age who have not had the disease to be excluded.	Ditto. Exceptional cases must receive special attention.

As the Medical Officer is desirous of having the information respecting cases of infectious disease as complete as possible, he will be glad if, when the teachers notify him of such diseases, they will, as in the past, draw his attention specially to those cases which have been detected in School.

N.B.—It must be borne in mind that the patient may be too debilitated to return to school, notwithstanding that infection has disappeared.

PART II.

THE CHILD.

CHAPTER IX.

INTRODUCTORY—GENERAL CONSIDERATIONS.

When a child passes from its home to the school it is brought under a new set of influences, and the responsibilities of the parent are transferred to the teacher. In the case of boarding-schools the teacher obviously directs and colours the whole life of his pupil so far as one human being can modify the development of another by means of surroundings and customs, precept and example.—In the matter of mental training nothing less is demanded, else why send the child to school? The lifelong influence exercised by successful headmasters over the minds and conduct of their pupils is universally admitted and admired, but it is not so generally conceded that a man's physical health may in like manner be largely dependent on the wise or ignorant regulation of his school-life. For nine months in the year, during the period of formation, when mind and body are most impressionable, the parent fades into the background, the teacher becomes all important, and on him rests the grave responsibility of preparing a fellow-creature for the struggle of life.

In the case of day schools the transference of authority is less obvious but practically scarcely less complete. The responsibility may seem to be shared between the parent and teacher but in reality the parent has very little say in the management of the daily life. The child is directly under the control of the teacher the greater part of the day (perhaps from 9 a.m. to 4 p.m.), but the school influence extends into the home. Meal times are regulated, not by the wants of the household, but by the school, so also is the time allowed for freedom in the open air, and bed-time depends less on sleepiness than the time needed for the preparation of home lessons. Who is not familiar with the spectacle of the "revival of learning" on the part of parents assisting with grammar and dictionary in order to abridge the labour of translation and pack their offspring off to bed in reasonable time? Having chosen a school the parent must abide by his choice. His individuality is swamped by the crowd of other parents, his demands are neutralized by counter demands or by the requirements of school organization. If the head-teacher be not weakly pliant (and no worse disqualification could be named) he becomes scarcely less autocratic (so far as the question of health is concerned) than the head of a great public school. We may take it the responsibility of every teacher is grave, personal, and cannot be shirked. A frank acceptation is the only practical policy.

The paramount duty of the teacher towards health is to promote it. Current public opinion tends to exonerate him who does no harm, but with a national system of education, adopted as an inalienable duty of the State, this narrow and pernicious view is doomed to speedy effacement. The primitive notion that the mind is something independent of the body is rapidly being discredited and replaced by the view that the brain is the organ of thought, and therefore a healthy brain is the first necessity for a successful career. Public opinion in the immediate future is likely to ask the schoolmaster for strong healthy brains rather than for a superficial acquaintance with specific subjects that scarcely outlive the date of an examination.

It is to be hoped that in the immediate future Government grants will be awarded partly on the condition of the physical health of the children. Payment by results would then be an unmixed benefit.

The teacher called upon to study and apply the laws of health may at the onset be discouraged by the difficulties to be encountered. But he need not be alarmed. The laws of health are very like the laws of the land, exceedingly easy to obey, though prodigiously difficult to investigate and master in detail. Most citizens contrive to pass their lives without committing legal offences without any knowledge of the law but simply by the exercise of common-sense; though judges of great erudition and experience are scarcely able to decide on questions that continually arise. So common-sense will carry a teacher over the difficulties without any particular acquaintance with the intricate details of public health or the intimate physiology of the vital organs. Thus the essentials of a healthy life have been known, from such time as the memory of man runneth not to the contrary, to be wholesome food, pure air and water, exercise, and sufficient rest to compensate for fatigue. Science adds very little, but is able to determine by analysis and the microscope the impurities that may exist in food, air, and water, and to shew why fatigue is prejudicial. We are all convinced of the value of fresh air, and we know it is to be found on a hill side or the deck of a ship, but not in a school-room, even the best arranged. Science confirms our empirical experience and explains to us that the atmosphere of the mountain and the sea is comparatively pure, but that the air in the school-room is laden with carbonic acid, bodily emanations, microbes from the nose, lungs, or the skin, ready to pass from one child to another and set up disease. But every one who has watched growing children knows that they do not flourish as they should if kept long in school, but if brought up mostly in the open air they do. Science does not tell us the fact, merely tells us the reason why. We need not wait for Science to do right.

The teacher then has only to regard his charges as young animals requiring to be trained, and to place before himself a sufficiently high standard of physical perfection. He must study the signs of health, he must study the signs of failure, not from books or hearsay, but from the living subject. He must study the senses and their organs in relation to school-work, especially noting where injury is most easily inflicted, as for example in the case of the eye and excessive book-work, or in the case of the nose and throat and the rebreathing of polluted air. He must study the differences between the child, the adolescent, and the adult. He must study the peculiarities of the growth and development of individual children and be prepared to vary his routine to suit the necessities of each case. He must remember that health and strength are but slowly built up, that the influences that tell against even a fairly good development in modern town life are very numerous and very powerful and difficult to withstand. Artificial ills require artificial antidotes. For instance, natural life in the country affords sufficient open air exercise, but the shut up, indoor life led by the middle classes in towns can only be effectually counteracted by the systematic exercise taken of set purpose. The country schoolmaster may afford to neglect what the town schoolmaster must supervise with unremitting attention.

Part of the purpose of the following pages is to shew that it is the teacher's duty to take an active and not merely a passive part in relation to health and physical development. To impress upon all guardians of the young that though health is an affair of many circumstances (*e.g.* ancestry) that may be beyond our personal control, it is within the power of any one of moderate intelligence to understand the grounds upon which modern hygiene is founded and to shape the conduct of the school (or the nursery) accordingly. Observation, sympathy and common-sense are the most needed qualities, but they must be accompanied by an intellectual freedom sufficiently vigorous to withstand authority tradition and prejudice. Every school-custom, the time-table, the lessons, should be examined and tested at first-hand in relation to health. Nothing should be taken for granted or because it appeared to do well in the past, or because it suits another school or another set of circumstances. It is your own town and its particular degree of smokiness or airiness, the feeble or healthy class of the parents, your own street, your own school and your own scholars that are to be considered and nobody else. Health starts from the home and should be improved in school because the teacher ought to possess more profound convictions and more experience than most parents.

The Doctor should be the adviser and supporter of the schoolmaster. The relations of the teacher to the medical man are generally allowed to begin with the appearance of sickness or accident. This is wrong. The prevention of disease, the avoidance of the causes of predisposition and the right conduct of health are now considered the noblest province in the great arena of medical science. It is better never to be ill than to require to be cured, and schools might advantageously take example from the Chinese, who are willing to pay for health but who refuse to pay for being rid of disease.

At present the relationship of the doctor to the school varies greatly in its intimacy. In some of the great schools the medical officer holds a definite position and visits regularly whether wanted or not. He is allowed some voice in the management, though seldom as much as might be desirable. The close association of Dr Clement Dukes with Rugby has been very advantageous to that great school and his experience has added considerably to our knowledge of the public school boy. Other public schools and private adventure schools for the wealthier classes have benefited by the results of his work, and other schools have found it expedient to have medical men in similar close relationship. But among poorer schools and especially in girls' schools, where health is often entirely neglected, such an arrangement is rare. But every school should be provided with a doctor who should periodically examine and advise on all the conditions pertaining to health. Where a medical supervision does not exist it should be instituted if within the power of the teacher.

The doctor in the second degree of relationship holds a regular appointment to the school but only appears when summoned. That he should see every accident and every suspected case of illness goes without saying. He acts as guide on questions of isolation and quarantine. When there is a determination on the part of teacher and medical man to work together even this degree of relationship may be made very serviceable.

In the day-school the teacher has for the most part to fall back upon the family medical attendant. He can only notify the parents that the child needs a doctor and receive from them a certificate that the child is fit to return to school. Useful hints on the questions of time-table, compulsory games and the existence of organic disease or hereditary proclivities may often be obtained by private communication. But the relationship, though satisfactory for the individual patient is not sufficiently close to be useful to the whole school.

Finally, in general questions concerning buildings, sanitary arrangements, epidemics, and so forth, the teacher may have recourse to the medical officer of health for his district, and a demand for such assistance should never be neglected, for it will never be refused. In brief, the duty of the teacher in regard to the doctor is to provide himself to the best of his ability with an adviser on all questions of physical health, and to throw the whole responsibility of illness on to the medical man. Having done so, if he remain in charge of the child, he should obey orders with the precision and promptness of a soldier.

CHAPTER X.

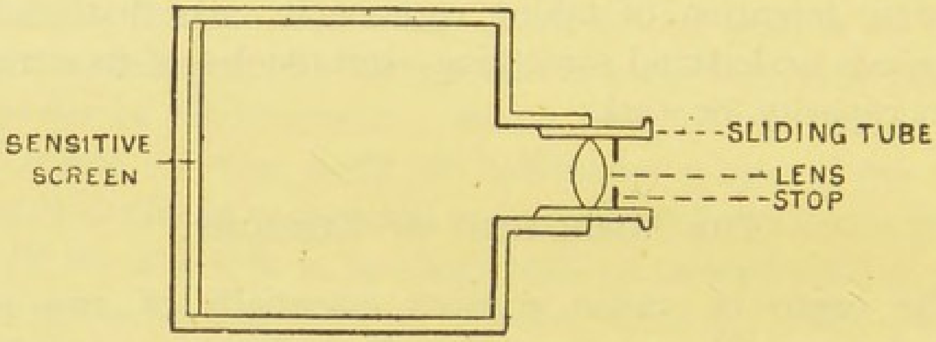
THE CARE OF THE EYE.

THE eye is an optical instrument of great complexity and extreme delicacy of structure. It is therefore, like all complicated mechanism, peculiarly liable to injury or disarrangement from slight causes. No other organ of the body is so easily injured by inappropriate or excessive work and no organ has less power of readjustment. By an irony of circumstance no other organ of the body is habitually subjected to such excessive strain in proportion to its power of resistance or put to work for which it is so ill-adapted or treated with so little regard to the perfection of its function, none suffers so severely from the strain of modern education. And yet it would seem reasonable that the organ of the master-sense should be sedulously cared for, and that part of the aim of education should be to render it strong and healthy and fitted to withstand the strain that may be thrown upon it in after-school life. Under a rational system of teaching vision should improve and not deteriorate. A child should leave school with a greater power of seeing than when he entered, and with immensely greater power of interpreting and estimating what he sees. To demand so much would be in the present state of affairs considered beyond the reach of practical effort by the most daring of reformers, though we may perhaps be permitted to consider that something of the sort may not be wholly a dream of an impossible ideal. Now, all we dare ask is that actual injury should not be inflicted on children's eyes during the period of school-life. Even this modest request will necessitate considerable reforms in routine teaching and great alteration in the ideas and requirements of ambitious parents. For it must be remembered that teacher and parent play into one another's hands in the policy of asking for small profits and quick returns—in asking for results that can be estimated in the immediate present—the place in class, the passing of examinations, the running of children for advertisement, or for mere vanity and show—which with the concomitant hurry, fuss and cram are responsible for many of the ills suffered by school-children. To begin with we must respect the eye at least as much as we should an expensive instrument purchased from an optician. We must set out with the deliberate intention of taking care of it. To that end we must needs understand something—not much—of its structure and its capacity for work.

The Mechanism of Eyesight.

The organ of vision consists essentially of two parts. One—the eyeball—employed in the refraction of light so that its vibrations may become appreciable by the nervous system and used by "the mind": the other situate within the skull, a most complicated structure forming a considerable part of the back of the brain and having intimate connection not only with the eye, but with other centres governing the senses and the limbs. It is for this the eye exists. It supplies information of the outer world and it is on the integrity of its structure that the brain depends for the correctness of its visual impressions. A faulty or imperfect eye gives faulty or erroneous information and deprives its possessor of an amount of knowledge commensurate with the amount of its defect. Persons with bad sight (from whatever cause) have often most erroneous notions of common objects, trees, mountains, cathedrals and haystacks appearing much the same, and they not unfrequently make mistakes that lead to trouble in ordinary life. An accurate eye is part of the stock in trade of a well-informed brain. It is therefore one of the first duties of a teacher to see that the eye is sound and not to allow slight defects to increase and become troublesome. A little knowledge of principles aided by common-sense is all that is needed to attain this desirable end.

In principle *the eye is an optical instrument like the photographic camera* now in everybody's hands. If you understand one you understand the other. A quarter of an hour may be well spent in taking a camera to pieces and examining its parts.



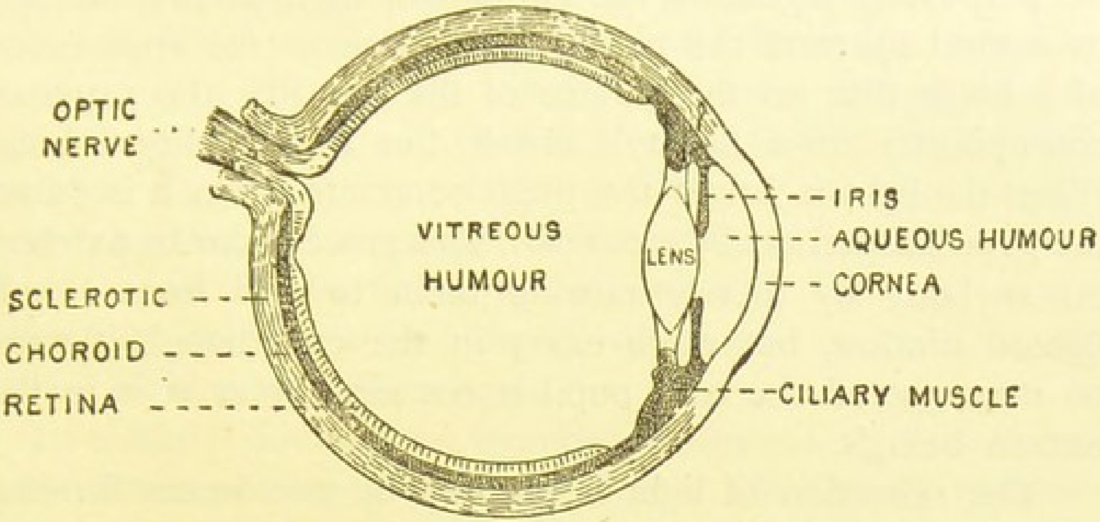
Camera reduced to its simplest expression.

Fig. 15.

It consists of a box, painted black inside to prevent cross-reflexions, and having fitted into one side a lens capable of being adjusted so as to focus rays of light on to a sensitive screen at the back of the box.

The lens can be slid to and fro so as to focus different objects according as they may be situated near to or at a distance. The screen, a thin film soaked in a salt of silver which remains stable in the dark but which changes to a darker and darker brown according as it is exposed to a duller or brighter light. So the ordinary photographs are taken.

THE HUMAN CAMERA.



Horizontal Section of the Human Camera.

Fig. 16.

The eye is a globular chamber with its walls composed of tough fibrous tissue of the nature of gristle. A portion of this [the sclerotic] is visible between the eyelids and is familiarly known as the white of the eye. The greater part is opaque, but in front it is modified, becomes transparent, and is called the cornea. The coat of the eye then is composed of two parts, the greater designed to keep out the light, the lesser especially arranged for its transmission.

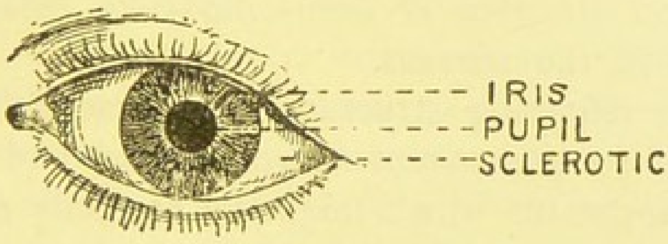


Fig. 17.

Through the cornea, like the face of a watch covered by its glass, is seen the iris. This is the coloured part of the eye. When we say a person is blue-eyed or hazel-eyed or black-eyed, we mean that the iris is of certain light or dark tints for which custom has provided names. It is a diaphragm or stop for the purpose of regulating the amount of light passing through its central aperture the pupil. This presents the appearance of a black disc on the surface of the iris, like the patch of court-plaister on a beauty's cheek, but is in reality a hole. When the light is bright the pupil contracts, when it is duller the pupil proportionally expands. This process can be watched on anybody by merely moving them to and from a well lighted window, but more easily in the cat, though it must be remembered the cat's pupil is not circular as it is in the human being's.

The refraction of light is effected by two lenses forming together a compound lens:

1. The cornea (already mentioned) is placed in front of the iris. It has a shorter curvature than the body of the globe and is concavo-convex. It is unable to alter its curvature and therefore is always of the same focal length.

2. The crystalline lens placed behind the iris. It is biconvex, and is capable of being made more convex (and consequently of a shorter focus) when required for the purpose of viewing a near object.

The eyeball is kept in shape and its contents in position by two humours. That in front, between the cornea and the lens, is fluid and named the *aqueous*, that filling the main body behind the lens is semi-solid (like calves' foot jelly) and is named the *vitreous*.

All the refracting structures are practically transparent (though not so transparent as good glass) and together constitute an apparatus which might be correctly named a water camera.

In order properly to receive the images projected by the lenses the eye has two linings:

1. The choroid immediately lines the sclerotic. It is composed of innumerable blood-vessels arranged in a most

complicated network. It is continuous with the iris. Its inner surface is overlaid with a layer, like a tessellated pavement, of pigment cells. So is provided the necessary dark surface to prevent cross reflexions. In a few very fair people (called albinoes) the pigment is absent and great disturbance is caused by excess of light. 2. Lining the choroid and most intimately connected with it is the sensitive screen, the retina. Some idea of the delicacy of the structure under consideration may be found by remembering that it is about $\frac{1}{80}$th of an inch thick (and about half that at its central spot) yet it is divided into seven layers.

Its essential elements are innumerable microscopic structures of two forms closely packed together. They stand perpendicularly to the plane of the retina. They are of two kinds, (1) straight cylindrical rods, (2) cones, not truly conical but rather resembling hock-bottles. From these proceed (3) fine nerve-filaments which serve (like telegraph wires) to connect the retina (the receiver) with the visual centre in the brain (the transmitter). The bundle of the optic nerve leaves the back of the eyeball by a hole rather to the inner side. One group of the fibres passes to the *same* side, the other passes to the *opposite* side of the brain, so that each eye is connected with both sides of the body.

The retina is increasingly sensitive to light towards its centre. By the outer circumference we perceive large objects and are thus able to keep ourselves informed of our surroundings, but it is by the centre only that we see fine objects. Thus a man while walking may read a paragraph in a book by dint of his central vision and steer himself through a crowd of passers-by at the same time, or perceive the inequalities of the ground by his circumferential vision. The art of reading is performed by the central spot alone. When the goodness or badness of vision is spoken of in relation to school-life central vision is implied, and the fitness or unfitness of the eye for reading is the first point to be considered.

Defects of the Eye.

Refraction.

So far we have spoken of the eye as a perfectly formed instrument exactly adapted to perform its functions. If we purchased a hundred cameras from a good firm we might rely on all being equally good. One would probably be a facsimile of the other ninety-nine. But Nature is not mathematically exact, she turns out her work half finished and is at the mercy of a hundred evil influences that may mar her best projections in the course of development. Consequently the eyes met with in actual life vary considerably from the standard and are often either very ill-adapted for reading or incapable of seeing at a distance, but not fitted to either one or the other at requirement. The first condition of vision is obviously an accurate focus.

The Standard Eye.

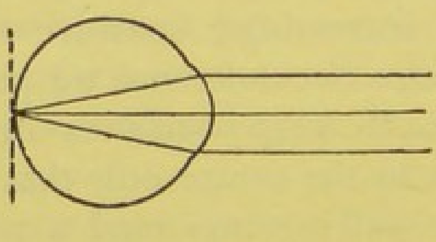


Fig. 18.

1. In the well-adjusted eye the focal length of the lenses exactly corresponds with the axis of the eyeball. Parallel rays of light are therefore focussed on the retina and a clear image formed. These eyes are adapted for parallel rays of light without using any exertion.

THE FLAT EYE. (Hypermetropia.)

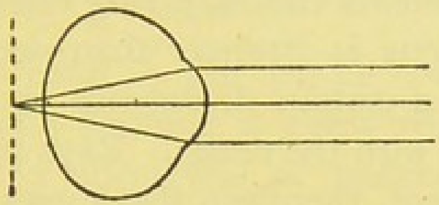


Fig. 19.

2. In a 2nd class the axis of the eye is shorter than its focal length and parallel rays of light are brought to a focus at a point *behind* the retina. In such eyes the converging pencil of light falls on the retina as a circle not as a point, and the image formed is fainter and less defined than it would be at the focus. These eyes are not adapted for parallel rays except by dint of exertion. As the lens is too weak for its position it requires rays to have a given degree of convergence in order that the focus might correspond with the retina. But convergent rays do not exist in nature and must be supplied artificially by a spectacle-lens. The majority of eyes met with in early school-life belong to this class. A more detailed description is given under the headings "The Eye in Childhood," p. 125, *et seq.*, and "Eye-Strain," p. 130, *et seq.* Here it is sufficient to recognize the nature of the defect.

THE ELONGATED EYE or Short-sighted Eye. (Myopia.)

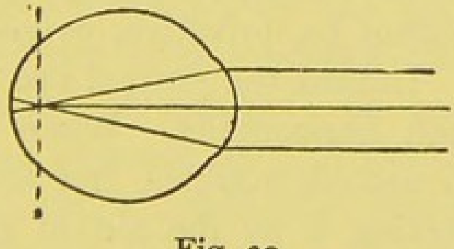


Fig. 20.

3. The over-focussed or "Short-sighted" eye. The axis of the eyeball may be longer than its focus. In that case

parallel rays of light are brought to a point in front of the retina. Continuing past the focus it is obvious they diverge and fall on the retina as circles, giving rise to blurred and faint images. As the lens is stronger than necessary it is obvious it requires rays of a certain divergence in order that the focus should correspond with the retina. Rays proceeding from near objects are divergent, therefore these eyes can focus (without exertion) objects at a given distance, but not beyond. Or the necessary divergence may be given to parallel rays by the use of concave spectacle-lenses. A great proportion of the eyes met with in the middle and later periods of school-life belong to this class. A more detailed description is given pp. 133, *et seq.*

4. *The double-focussed or astigmatic eye.* Combined with the foregoing defects due to a discrepancy between the focal length and the axis there is yet another set due to unequal curvature of the cornea. To understand this, look at your face in the convexity of the bowl of a spoon—if held vertically the face is lengthened, if horizontally it is widened. Supposing the cornea instead of being cut out of a spherical glass like a watch-glass, were a segment of a glass medicine-spoon, it is obvious the rays passing through the long diameter would be focussed at a greater distance than those passing through the transverse diameter. Therefore an eye might be under-focussed in one direction and over-focussed in another, and as rays of light cannot be brought to a focus at *one* point, as with an equally curved lens, the condition has been called astigmatism (α, privative, στίγμα, a point). This defect is frequent. Indeed the normal eye tends to be a little flatter vertically than horizontally. When this defect exists it may give rise to untold troubles, but fortunately we have the means of correcting it by the aid of glasses.

It is obvious that the vision of these eyes must vary considerably according to the difference in their refraction.

We have therefore to consider the question of

The Standard of Vision.

1. *Distance.* Vision is not to be estimated by taking objects haphazard and forming a guess whether the sight is good or bad from a successful or unsuccessful naming of anything that may happen to be seen. Mental quickness, familiarity and practice may help out a poor sight. A sailor with comparatively poor sight will see a vessel and recognise her rig when a landsman with good eyes can barely make her out on the horizon. A definite standard has been adopted and has been accepted for practical purposes by the civilized world.

It is founded on the fact that the retina cannot distinguish objects unless they are of a certain magnitude and a certain distance apart. We estimate the size of objects by the angles enclosed by two lines drawn from the extremity of the object through the optical centre of the eye on to the retina. Our impressions of size therefore depend partly on the actual dimensions of the object and partly on its distance from the eye. The apparent diminution of objects by distance is the most familiar effect of perspective. The lamp-posts near at hand appear enormously taller than those at the end of a street.

Fig. 21 makes this evident. The lines drawn from the extremities of the object *AB* through the optical centre *c* encloses the angle subtended by the arc *a*, *b*. But if an object of the same size is at a greater distance at *XY*, then the arc *yx* subtended is smaller. In order that an object placed at the same distance as *XY* should seem as large as *AB* it would require to have the dimension *PQ*. As a familiar illustration of this fact a threepenny bit held at arm's length will cover the moon's disk, which has an actual diameter of more than 2000 miles. Letters have been adopted as the most convenient and widely needed standard. It has been determined that letters are plainly visible when seen

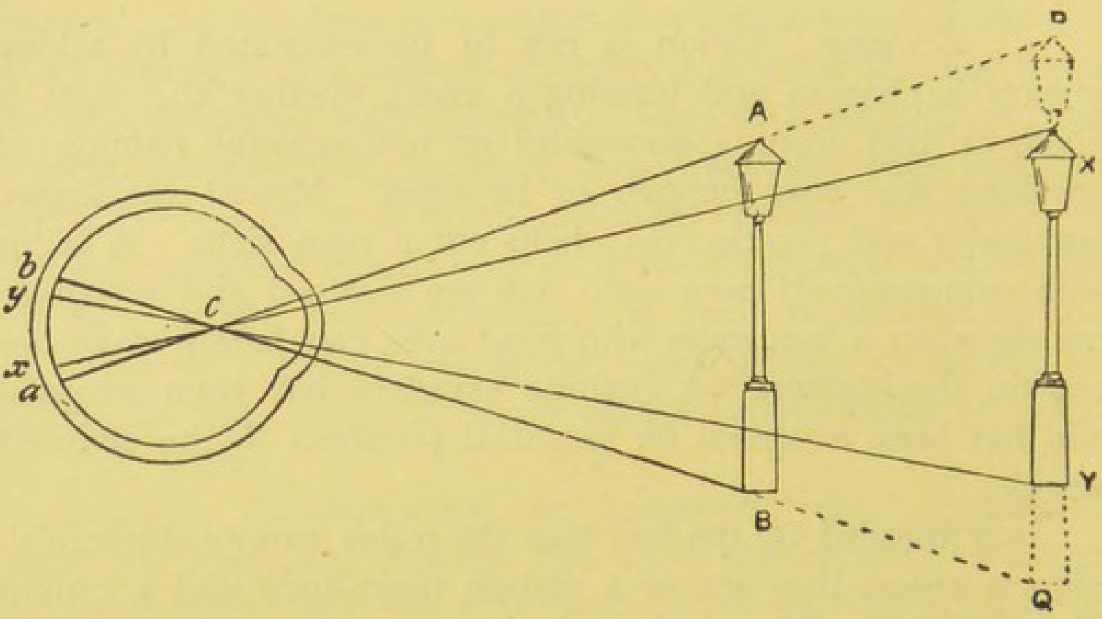


Fig. 21.

under an angle of not less than 5 minutes and their details of not less than 1 minute. Dr Snellen has arranged a table of test-types, having letters constructed to fulfil these conditions.

Testing the Vision of School-Children.

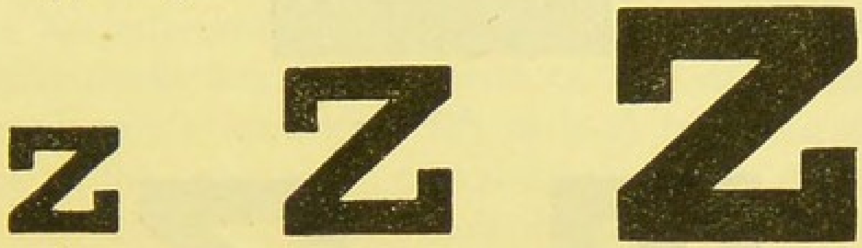
Test-types.

The types in general use are adapted for use at 20 feet and beyond. Some are made for small rooms, but nothing less than 20 feet should be employed in schools.

The letters range upwards from 20 to 30, 40, 50, 70, 100, 200 feet, or if preferred 6, 9, 12, 18, 24, 36, 60 metres. The acuteness of vision is determined by finding the smallest type that can be read at 20 feet or 6 metres.

If 20 type at 20 feet be taken to represent standard or normal vision, then it is obvious that if only a larger type can be read the vision is below normal.

The acuteness of vision is therefore conveniently and uniformly expressed by stating the distance as the numerator and the type read as the denominator of a fraction. Thus if at the distance 20 feet the type read is 20, then vision is $\frac{20}{20}$ or 1. But if at the distance 20 feet the type read is 50, the vision is $\frac{20}{50}$ or $\frac{2}{5}$ths of normal.



20 feet. 6 metres. | 30 feet. 9 metres. | 40 feet. 12 metres.

Test letters—actual size.

To TEST THE VISION the card is hung in a good light.

The child is stationed *exactly* at 20 feet from the card and must be so placed as not to be dazzled by any light falling into the eyes.

A good selection of 20 type should be available so that the letters are not learned by heart.

A child's vision ought to be *above* the standard, but against that may be put the want of familiarity with letters among the juniors, so that if 20 is smartly read the child should be passed. (See p. 130 in relation to eye-strain.) If the child fails to read 20, the examination may be continued till the smallest type distinguishable is found and the result noted. But the business of the teacher is only with the standard. If that is not easily read it is his duty to refer the child for a skilled examination and advice.

RULE.

Every child on entering a school should be examined as to his capability of reading 20 type at 20 feet easily. Children already in the school should be examined at least twice a year to ascertain if any failure is occurring; any defect should be reported to the parents.

D–60

E

D–36

T Z

D–24

N V L

D–18

P C F A

D–12

L N T Z E

D–9

O N Z F V T

D–6

F N Y L V T Z

Test card (reduced) to shew general arrangement of letters.

The small figures (D—6) indicate the necessary distance in metres for each type in a full-sized card (*v.* p. 118).

2. Vision near at hand.

Reading and Writing.

So far we have regarded the eye as a camera adapted for distance, but unfortunately literary work has to be accomplished by reading books held in the hand or laid on a desk at a distance of only a few inches (24 or less) from the eye, and therefore at the expense of considerably greater exertion.

To see objects distinctly their images must be focussed accurately on the retina. Hence if we wish to compare the figures on a church clock a hundred yards off with those on our watch-dial at ten inches—the rays from one being parallel, the other divergent—some power of adjustment must obviously be possessed by the eye. If parallel rays are brought to a focus on the retina divergent rays would be focussed behind it and therefore either the eyeball must be lengthened (as the photographer does with his camera) or the lens must be given a shorter focus by becoming more convex. It has been proved that the latter process actually takes place. In focussing near objects the crystalline lens is rendered more convex, the greater change taking place in the curve of the front surface.

This power of altering the focal length to meet requirements is called the

Accommodation of the Eye.

When the crystalline lens is at its flattest the eye is said to be accommodated for its *far point.*

When the lens is at its greatest convexity it is said to be accommodated for its *near point.* In the former case the eye works without exertion, in the latter under exertion proportionate to the amount of accommodation exercised. Remember then that reading, writing, sewing and all *near work is only accomplished by dint of exertion.*

What increase in convexity does the lens undergo in focussing? By paralyzing the accommodation by means of certain drugs (and in other ways) it has been proved experimentally that in order to accommodate to a given distance—say 10 inches—a standard eye requires an increase of convexity equivalent to the addition of a 10-inch lens.

In the under-focussed eye the amount of accommodation needed is of course greater. Such an eye we have already learned requires to increase the convexity of its lens in order to focus clearly distant objects. In reading the amount required for distance is added to that required for the near work. Not a few of these eyes require to exercise considerable accommodation for distance. Let us suppose it equal to a 10-inch lens. Then the amount required to read at 10 inches would be equal to a lens of 10 inch focus already in action added to another of 10 inch focus for the near point—that is to say to a single lens of 5 inch focus. The enormous addition to the exertion necessary is obvious. The importance of this fact in school-life cannot be overestimated.

In the short-sighted (or over-focussed) eye it is obvious the amount required would be less in proportion.

In children the power of accommodation is enormous. In infancy the near point lies at about 3 inches. All through life the power steadily diminishes with age. Old people either hold a newspaper at arm's length or supplement their accommodation with spectacles. During school-life the *excess* of accommodation-power enables improper work to be done and irreparable damage is thereby frequently inflicted.

The change in convexity is accomplished by the action of a muscle placed immediately behind the iris and corresponding with the margin of the lens. Like muscles in other parts of the body when in action it becomes tense and hard, it uses up more blood and nerve-force. If much exercised it gains strength and size, if not exercised it dwindles. It is found to be larger in the flat-eye and smaller in the short-sighted eye than in the standard. It is liable to fatigue, and if the fatigue is pushed beyond a certain point instead of being strengthened by exercise it is enfeebled. It is especially liable to strain and spasm, *i.e.* it is not able to relax from a position taken up. As if a man lifting a too heavy weight by bending his arm should be unable to straighten the arm when there were no weights to be lifted. In the young lenses are sometimes focussed to read print and cannot be relaxed when flattening is required for looking at a distance. Children are not unfrequently attacked in this way and appear to be short-sighted[1]. Distant vision can however be recovered by proper treatment. Genuine short-sight is of course either a permanent or, still worse, a progressive condition. But spasm of accommodation is often the beginning of permanent short-sight and should not be neglected for a single day.

Convergence.

It is obvious that in order to fix a small object like a letter at a definite short distance (say 10 inches) not only must the focus of the lens be adjusted but the axes of vision must be rendered convergent. In reading therefore the eyes are turned inward. Simple inspection of anyone reading will demonstrate that the inward movement is considerable as the book is approached towards the eye. During the act of reading a very remarkable thing takes place, not only is the convergence maintained but the side to side movements necessary to pass from one end of the line to the other are accomplished. These complicated movements are effected by six muscles which pull on the eyeball and move it in the required directions.

[1] School-work is often less to blame for this serious affection than the reading habit. Some severe cases have been observed to follow reading exciting but badly printed literature. Without investigation the school-master might have been blamed for the occurrence.

If the eye turned on a pivot no harm could result from any excess in convergence. But it is enclosed in a fibrous socket supported on a cushion of fat, and the muscles in acting pull and press on the eyeball and tend to modify its form injuriously. The power of convergence varies considerably in different individuals. In some it is performed with ease but in others owing to the shape of the eyeball or a want of exact balance of the power of the respective muscles the slightest over-exertion is followed by headache, neuralgia, aching of the eyeballs or various degrees of squint.

Summary.

1. The acuteness of vision is measured by types calculated to be viewed under an angle of 5 minutes.

2. The formula for noting the acuteness of vision is $\frac{d}{D}$ of which the numerator d = distance and the denominator D = type read $\frac{20}{20}$, $\frac{20}{30}$ &c.

3. The standard of good vision is the capacity to read 20 type at 20 feet.

4. When vision does not reach the standard the child should be referred for expert examination.

5. Reading and writing are effected by muscular exertion causing an increased convexity of the lens.

6. The amount of increased convexity (and therefore of exertion) required for a given distance varies according to the type of eye. It reaches its maximum and is sometimes excessive in the flat eye.

7. The excessive power of accommodation possessed by children is a source of danger as it enables improper work to be undertaken. Increased convexity of the lens sometimes cannot be relaxed at requirement.

The Eye in Childhood.

For a machine to work at its greatest efficiency it must be perfect. An imperfect or badly finished machine not only does its work badly but wears itself out prematurely. If the child's eye were perfect there might be a reasonable hope that school-work might be accomplished without much trouble.

But nature is not mathematically correct, and the eye at birth is very immature—it is not at all fit for near work.

This follows the law of other organs. At birth, for instance, the heart is not properly divided and cannot separate aerated from carbonized blood. If by chance the development of the infant heart is arrested life is generally limited to a few years. The stomach—that vital organ—cannot digest certain common foods; teeth are absent and within the first few years only a makeshift set is provided, and the general helplessness of the infant is due less to weakness as might be supposed than to undevelopment of various structures and nervous centres.

The heart is normally developed in a few weeks, the stomach in a certain number of months, and so forth, till every organ and member is perfected. The eye requires years for its full development.

Now the eye in infancy is not the standard eye, but the flat eye. All examinations of new-born children made under scientific conditions shew that the eye is always short in the axis; frequently to a remarkable degree. Under favourable conditions the eye by manhood tends to become approximately spherical and the length of the axis coincides with the focal length. Among the hill tribes of India, we are told, the standard eye is the rule. Vision is therefore perfect. Certainly among the population of large towns, and probably among the rural population of this country, the equable and perfect development of the eye is not the rule. A considerable proportion remain flat during life (arrested development), another considerable proportion passes into the category of the short-sighted (over development). The aim of those having care of children should be to promote the just development towards the standard. The achievement of this object may be taken to imply more than mere care of the eye, it may mean a thorough understanding of the means whereby the physical development of the whole body is promoted. The perfect eye is to be regarded not merely as a good thing in itself but as a sign of well-conducted and symmetrical growth of the whole body. But examination of any school in this country—especially of any school frequented by the poorer classes of town-dwellers—will shew a remarkable absence of physical symmetry. Look at the bow-legs, the knock-knees, flat-feet, ill-made noses, lop-sided or malformed skulls and then say if it seems likely that the eyes should be optically perfect. Examinations of a vast number of eyes in school-children in the various civilized countries of Europe and America have invariably shewn an enormous preponderance of the immature, or flat, eye both before and in the earlier ages of school-life.

The standard or accurately focussed eye only exists in a minority.

In the later years the proportion of flat eyes steadily diminishes. But this cannot be taken as the result of healthy development as a very remarkable circumstance has been observed. A considerable proportion of these eyes have passed over into the class of the elongated (or short-sighted) eyes.

So that if an examination of a given school be made it may be predicted that in the junior classes the under-focussed eye will largely predominate; that in the senior classes there will be fewer under-focussed eyes, and that with every year they will be replaced by an increasing number of short-sighted eyes. The number of well-developed standard eyes only shews a slow increase. Or if an examination be made of a number of children of a given age and these children are followed up, exactly the same course of events will be noted. Slight variations in the proportion have been made by different reporters but the main facts have been so repeatedly ascertained that they may be taken as definitely proved. Just as certainly as that the children in the lower classes are the shorter children and those in the upper classes are the taller, so certain is it that the two extreme types of eyes are found in the lower and higher forms. A tall child or so may be found dotted about in the lower classes and so may a few short-sighted eyes, but the overwhelming majority are under-focussed—the flat eye preponderates. The detection of under-focussing presents considerable difficulties and requires some skill and great patience, as in children it is often entirely masked and indeed the opposite condition simulated (see p. 122). Whenever the proportion appears under the mark the thoroughness of the examination may be suspected.

Fig. 22 shews graphically the kind of proportion of the different classes of eyes met with at different ages[1].

A represents the refraction of 100 children in the lower classes, average age being 8½ years.

Column 1**H** shews the amount of (Hypermetropia) Flat eyes, 88·11 %.

Column 2**E** shews the amount of (Emmetropia) Standard eyes, 7·01 %.

Column 3**M** shews the amount of (Myopia) Short-sighted eyes, 4·27 %.

B represents the refraction of the eye in 100 scholars of an average age 17·5.

[1] The actual figures are taken from Dr Risley, as the examinations were conducted with scientific precision and are recent, but they differ only in small degrees from the results of other observers. Statistics are easily multiplied but they are deceptive unless the precautions taken in collection are known and unless the readers understand the value of the evidence they embody.

Column 4H shews the amount of Hypermetropia fallen to 66·84 %.

Column 5E shews the amount of Emmetropia increased to 12·28 %.

Column 6M shews the amount of Myopia increased to 19·33 %.

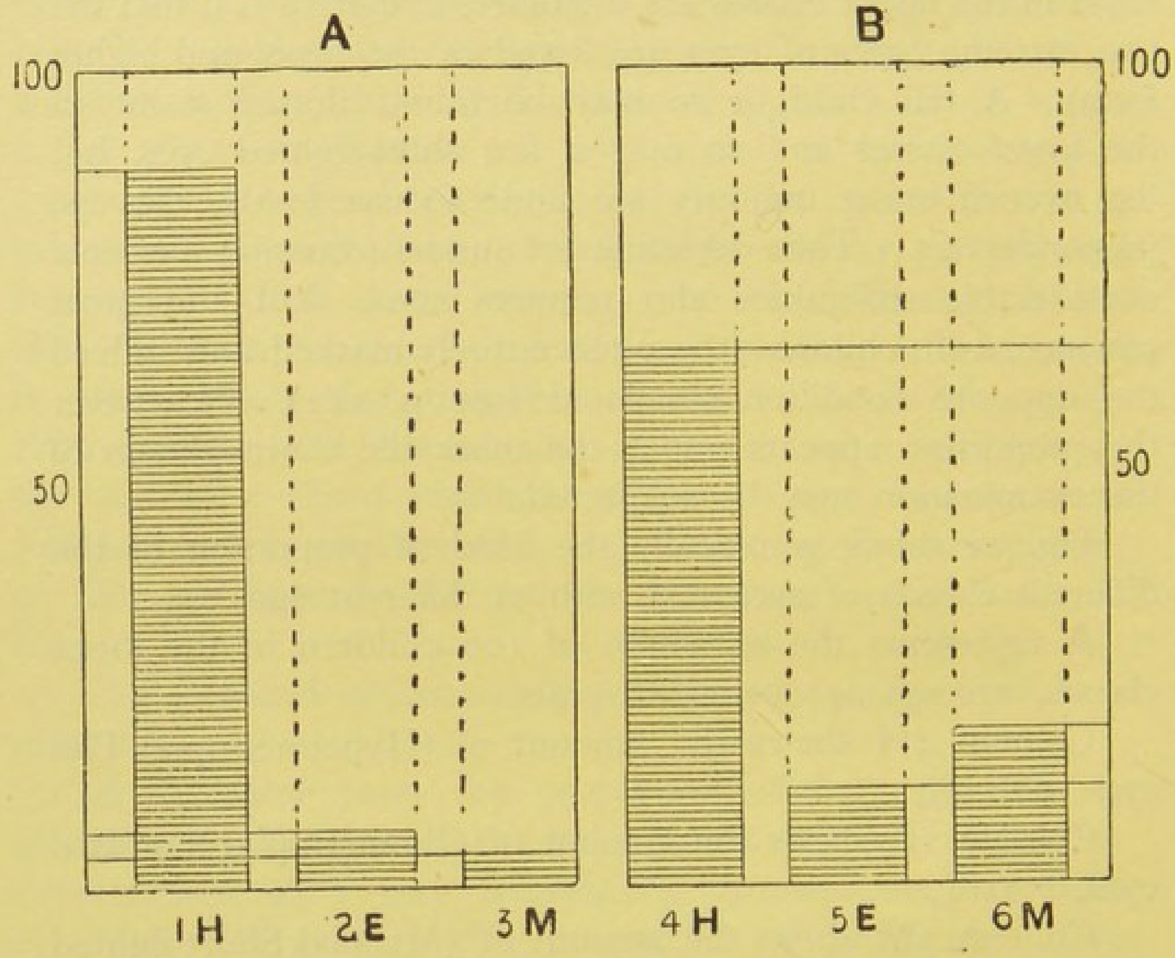


Fig. 22.

From this it is seen that the proportion of Hypermetropia falls considerably from infancy to adolescence, that the eyes are transferred for the most part to the short-sighted class, comparatively few attaining the ideal development during the period of school-life. The full development of the eye and the establishment of the stability of its tissues correspond with other parts of the body.

Summary.

1. The eye in infancy is an incomplete eye, being (a) under-focussed, and (β) constructed of growing tissues.

2. It is not well adapted for distant vision, but it is altogether unfitted for near-work.

3. Development proceeds at an uncertain rate, is never completed in some cases, in others is accompanied by injurious changes leading to short sight.

4. The proportion of under-focussed eyes may appear to be less than it really is owing to the great difficulties of a thorough examination.

5. The inaptitude of the eye for near-work and the instability of its tissues give rise to the evils to be described under the title of eye-strain.

6. The settlement of the ultimate form of the eye only precedes the full growth of the body by a few years.

The Characteristics of the Healthy Eye.

It is clear and bright. The white is not suffused or red.

The edges of lids have the aspect of healthy skin, there is no sign of inflammation, rawness, crusts, styes, or scales at the roots of the eyelashes. The eyelashes do not tend to fall out. There is no watering on facing bright light or moderate winds, or in reading small print. Strong light is faced without flinching and no discomfort is experienced in opening the eyes after sleep.

The vision reaches the standard and reading can be (though it ought not to be) maintained for hours without fatigue, pain or headache.

Every teacher should be capable of ascertaining if these conditions are fulfilled in his pupils. It is not his business to discover *what* is wrong but merely to know when something is not right and to refer the child for a competent opinion.

Eye-Strain.

Symptoms of eye-strain may arise whenever there is any impediment to the distinct vision of near objects, and are more especially liable to occur when the defect can be remedied by an undue exertion of the muscles of the eyeball. In other words small defects give rise to more pronounced symptoms than great defects. The explanation of this apparent paradox is simple. When a defect is so great that it cannot be overcome the eye does not attempt the job, no exertion is made and consequently no symptoms occur. Thus a dense white scar on the front of one eye may altogether obscure small print. As the eye does not see, it makes no attempt to see. Reading is then done by the other eye alone and with comfort. But supposing the film is so thin that letters can be read by dint of holding the book a little closer to the eyes, then both eyes endeavour to act in concert and under unfavourable conditions, and various pains and aches or even permanent injury may result. In the same way if no reasonable amount of muscular exertion will overcome a given high degree of focal error then the eye is content with not seeing at all or seeing with a blurr and no ill arises. But low degrees are easily overcome by slight exertion which though easy in itself may by constant and prolonged application give rise to pain or permanent disablement.

Any focal maladjustment or impairment may give rise to eye-strain, but by far the most frequent cause is the undevelopment of the eye, and the symptoms accompanying that condition may therefore be here considered.

The Flat Eye.

The vision of these eyes *may* be perfect, and distant vision may be maintained indefinitely without fatigue as by standard eyes.

But in near vision certain peculiarities are shewn. Small print may be read with ease in a mere test experiment, but prolonged reading—the amount varying from a few lines to many pages—gives rise to symptoms of fatigue.

Letters begin to dance or wobble. Mistakes are made in easy and familiar words, finally the words run together into a grey mass and nothing is distinguishable. A short rest, a closure of the lids, a rub with the knuckles and the task can be resumed, to be ended in the same way generally after a shorter period. This tendency of certain children to read well at the beginning of a paragraph and to blunder towards the end is well known to teachers, but is generally attributed to a "want of attention." An unlucky guess, as it is obvious that the blundering is due to too much attention and not to too little. Children who are markedly slow in learning to read are frequently found to have this defect. Mental deficiency sometimes exists but it is comparatively rare—in the vast majority of cases the eyes and the eyes only are at fault. Children seldom call attention to this defect of vision (or to any other subjective sensation that does not amount to actual pain) because in their inexperience they assume that whatever is is right. Ignorance is not always bliss. But if under the circumstances a determined push is made with reading and writing the tired nerves resent the strain and pain results. Aching of the eyes occurs, often not at the time of exertion, but hours after or even the next day, as the inexperienced rider feels his stiffness not in the saddle but next day on his office-stool. Or the pain may be reflected by a nerve, and radiate a considerable distance from the eye, constituting a "neuralgia." In these cases the eyes are frequently not even suspected but all sorts of nostrums are prescribed and teeth are extracted with lamentable zeal before having recourse to the true remedies, rest and glasses.

General headaches varying from slight malaise to downright disabling "sick headaches" are frequent. Children undoubtedly suffer from headaches from various causes but those from eye-strain far outnumber those from all other causes put together.

Overstrain may be detected by various outward signs. BLINKING and WINKING. The eyelids are rapidly and repeatedly closed, especially on exposure to light, as in facing a window or while regarding objects attentively. In slight cases this blinking will subside after a day or two in the country. In more severe cases it persists even after long rests and careful optical treatment. The twitching is at first generally confined to the eyelids, but sometimes spreads to other muscles of the face—the angles of the mouth and nose, the cheeks moving spasmodically, and even down the side of the neck. The movements are occasionally grotesque and are supposed to be tricks—but tricks in childhood have but a short vogue and tend to be quickly changed for something new, whereas these spasms tend to get worse instead of better if work is persevered in. The resemblance to St Vitus's dance is sometimes so close as to lead even professional men astray.

Accompanying the foregoing symptoms, or separately, we may see signs of CONGESTION, or inflammation. The whites of the eyes become red and suffused, tears are frequent and copious. There is a general aspect of having "caught cold" or a look of having been crying.

REDNESS and SORENESS of the edges of the lids. Small crusts or fine scales form at the roots of the eyelashes, which are sometimes shed. Styes occur with frequency.

Finally these children SQUINT. No squinter should be allowed in a school without a medical certificate.

In observing cases of eye-strain we cannot fail to note that out of a number of children with focal defects only a certain number are inconvenienced, the remainder though equally under-focussed do not suffer. From this we infer that pain is the resultant of a combination of two circumstances, one the structural imperfection of the eyes, the other a want of fortitude in the nervous system. Remarkable variation in the sensibility to pain is shewn in different individuals, and as a rule it may be said that it varies according as the physical health has been neglected or cultivated. The intellectual worker with muscles undeveloped and a brain overworked will suffer torments from trifles that a navvy would scarcely feel. And therefore in all cases of eye-strain where pain is a marked symptom we must be on our guard against a nervous system overtasked by work or growth, or an inherited neurotic or other degenerate constitution. The great majority of these cases can be relieved by properly adjusted glasses and work comfortably alongside their unspectacled school-fellows, but there remains a small body of unfortunates whom no glass relieves. In spite of the most skilful treatment and assiduous care their pangs continue. They should be packed off to the country. They often do admirably if allowed to run wild for six months or so in a farm. Or they should be sent for a voyage. But on no account should they be allowed to continue at school.

The foregoing symptoms are characteristic of the flat eye but may arise in other varieties of defective focus or impaired vision.

Short Sight.

Short sight is by far the most important condition of the eye connected with school-life, partly on account of its far-reaching consequences and partly because educational methods are directly responsible for its inception.

A short-sighted person sees clearly at a definite finite distance, it may be a few feet or only a few inches, but everything beyond this point is hazy or ill defined.

A child should be suspected of short sight when it reads a book easily but makes mistakes over the wall diagrams or the work on the blackboard.

No suspicion of the early stages of short sight may be excited by observation of the child's power of seeing natural objects. For the recognition of the vast majority of things a sharp outline is not necessary, though for the recognition of a letter (or precise form) it is of primary importance.

A haystack or a sail or a house are equally recognizable with a blurred or with a sharp outline.

It is therefore often supposed because two persons can see a haystack or a sail distant some half a mile off that both are equally "long sighted"—is not half a mile half a mile? Even letters may be deciphered provided the blur does not wholly obfuscate the open spaces. Thus the short sight of many children may escape detection of rough and ready observation.

But if a child reads small print easily at a certain distance from the eye (*e.g.* a book held in the hand) and cannot read the distant type (20 at 20 feet) he may be suspected of becoming short sighted.

Slight degrees of short sight may be considered no disadvantage (or perhaps even desirable) for many urban occupations. But the advantage ends with the slight degrees. No apology can be made for the pronounced degrees—Men otherwise fitted are inexorably rejected for the Royal Navy, they are less rigorously excluded for the mercantile marine and the Army, they are handicapped as emigrants. They are more or less dependent on spectacles throughout life.

The troubles of the Short-sighted.

In addition to the inconvenience caused by the limitation of the range of vision short sight may imply a certain amount of internal mischief, pain, and ultimate destruction of sight.

The short sight as met with in schools may be conveniently divided into three categories.

1. With a slow and benign development. These eyes pass from the flat-eyed to the elongated type gradually without pain or symptoms. They progress slowly or almost imperceptibly up to a certain point and then remain stationary, giving no trouble in the future. These eyes are strong and well suited for urban occupations.

2. With a fitful and irregular rate of progress—greatly influenced by the favourable or unfavourable conditions under which they are placed. The rate and amounts often differ in the two eyes so that one becomes more short sighted than the other. After a time progress tends to be arrested, especially if the eyes are not overworked. Once settled the tendency to make a new start is not marked, unless some especially trying occupation (like engraving) is taken up. Although some wasting of the choroid coat of the eyeball is seen, the mischief is unimportant and the vision remains good albeit limited in range.

3. The tendency to progress very marked and easily accelerated by injudicious use of the eyes, constitutional weakness, etc., but not the same tendency for progress to be stayed by rest and remedial measures. Once started some extreme and rare cases seem unable to withstand even the ordinary work of daily life—reading letters, looking at magazines, illustrations in the papers and such occupations as can scarcely be avoided in the present day. Cases of this kind suffer extremely from school life. The short sight increases from term to term. The slightest over-pressure, as in preparation for examination or even the close perusal of an exceptionally interesting book, is followed by a disproportionate amount of injury. Although all short sight tends definitely to stop between 20 and 25 years of age, some of these progressive cases are found getting worse even in middle life.

These categories are not separated by abrupt lines but insensibly merge one into the other. The mildest cases may be regarded with indifference as little more than a peculiarity of development, whilst the most severe must be viewed with alarm as a mischievous and destructive process often ending in serious deterioration of the sight or even blindness at least in one eye.

It is popularly said "a short-sighted eye is a strong eye." This is a fallacy derived from an imperfect generalization. It has arisen from the fact that short-sighted persons have been observed to read small print without glasses in middle life and even to extreme old age. Eyes belonging to the first category, and a proportion of those belonging to the second, may be considered as eyes having the same strength (*i.e.* resistance) as those of normal development.

But a very large proportion of short-sighted eyes are weak eyes, of poor resistance and continually giving trouble. For example, to take one type of mischief, as the weakness progresses more and more difficulty is experienced in fixing a given letter with both eyes, and in the final stage one eye gives up the task, wanders outwards and a squint is established. At first (and in slight cases) this is not visible, but after a time it amounts to a deformity, altogether altering the facial expression. Short-sighted eyes are also extremely liable to a detachment of the inner layer and consequent blindness.

Therefore short sight must be regarded in childhood with suspicion, as though beginning in a trivial complaint it may end in the most serious catastrophes in middle life.

What is the duty of the teacher in the matter of prevention and management of short sight?

In the first place it is becoming more and more probable that congenital short sight is either non-existent or very rare. Apart from certain cases of disease and faulty development, the vast preponderance of all short sight is acquired, and is a purely artificial condition, induced by the misuse of the eyes during the period of growth. The particular evil is the employment of the eyes at fine work at a short distance, and as the majority of children are employed in school in reading, writing, and sewing, these occupations may be considered the main causes.

It is now universally admitted that short sight is (1) rare before the beginning of school-life (*i.e.* between the first and the sixth year); (2) that it is greater in amount and degree in town schools than in rural schools; (3) that it increases in amount and degree in the higher classes; (4) that it increases according to the number of hours a day employed in literary work; (5) that under the same conditions it is worse in badly lighted than in well-lighted schools.

Briefly, short sight may be said to be the result of faulty methods of education[1]. If this be admitted it is evident that a reform is needed in our system of dealing with the young (if not in other matters at least as regards their vision) and that the co-operation of the State, of medical men, parents, and teachers is earnestly to be desired. The evil conditions calling for watchfulness and care are somewhat as follows.

I. *Faulty conditions inherent in the pupils themselves.*

Short sight may be observed developing in school-children with the following factors existing as defects and so far independent of the conditions imposed from without.

(α) *Predisposition* (*from whatever causes*) *to special eye weakness.*

(β) *General weakness unfitting children to withstand the strain of school-life.* For instance, children who have indefinite brain or nervous troubles are observed to be subject to internal eye disease leading to short sight.

(γ) *The incidents of convalescence from disease.* The debility induced by measles, scarlatina, typhoid and other febrile

[1] This statement does not exclude the fact that many employments have very disastrous effects. Engravers, architectural and other scale-draughtsmen, compositors, clerks, etc. suffer severely.

disorders is frequently a starting point. The discontinuance of reading and writing during convalescence, not only in school but for amusement, is to be strongly urged. Books moreover assist in spreading infection, especially after scarlet fever.

II. *Faulty conditions imposed by teachers.*

(*a*) *Long hours* are harmful in a positive and negative way. They give rise to *too prolonged* congestion of the blood-vessels, strain on the accommodation and convergence, all of which are injurious in proportion to the time they are maintained, and they do not allow sufficient intervals for rest and recovery, so that both local and general powers of resistance are lowered. Reading is physical exertion differing in no respect from other physical exertions except in the delicacy of the structures involved.

Teachers may therefore err in making the tasks too long, in putting tasks of a literary nature in too close a sequence, and in not taking the eyes from near-work and expressly setting them to look at distance between whiles.

(*b*) In addition to literary tasks already excessive we find (surviving from an ignorant and coercive past) the custom of "*impositions.*" It is enough here to insist on the fact, that if ordinary schoolwork is already overburdening the eye, any addition out of hours should be forbidden.

Punishment inflicted out of school hours should not involve use of the eyes for near-work. Moreover detention in schoolroom prevents the windows being thrown open widely as they should be and the room thoroughly flushed with air as soon as it is vacated.

(*c*) *Excessive amount of writing exercises.* The amount of penwork done, especially by girls in schools, is amazing. Not only do they write out the greater part of their lessons, but they keep journals or registers of the work done. There is a superstition that writing strengthens the memory. A little patient observation would shew it does nothing of the sort. Its true business is as an aid to the classification, arrangement, and coherence of thought and for that need only be sparingly employed. The necessary details for the right conduct of writing are given under a separate heading, pp. 150, *et seq.*

(*d*) *Undue home lessons.* To take the evening when the brain is more or less fatigued with the exertions of the day, when the oncoming of restorative sleep dulls the perception, as the time to make the chief call on the acquisitive faculties is obviously to put them to work at a disadvantage. Morning is the time to learn, it is the period of wakefulness. Then perception is most alert, memory may be trusted, and tasks can be accomplished with the least possible expenditure of energy and time. More obviously is this the case with the eye. It, of all the organs, has the most marked premonition of sleep. When this stage is reached it stands to reason that this is the wrong time to revive the flagging energies of this organ, to excite its circulation and reiterate the changes of its nervous system when repair is already needed. Moreover, in vain do we consider carefully the lighting of schoolrooms, the arrangement of desks, the printing of books, if the responsible work of the eye is carried on under the unfavourable and ill-supervised conditions of home life. In the homes of the poor even fairly suitable arrangements are often wholly impossible. However difficult the reduction of homework may be from the point of view of school organisation, the oculist has no hesitation in affirming that home lessons are amongst the most perilous causes of defective vision in the young.

Faulty conditions imposed by the printer.

In judging the suitability of a book for school use the first point to be noted is the *paper.* It must be opaque, and not too thin or it will allow the print on the other side to shew through. There should not be any sign either from inkstain or pressure to shew that there is printing on the other side of the page. Note especially the effect of illustrations in this direction. Newspapers even if printed from good type are often quite indistinct, and trying to the eyes on account of this defect. Books are occasionally bound and pressed before the ink is dried and a faint impression of the opposite sheets causes a haze.

White paper affords the best contrast with black type, but pure white, owing to irradiation, rather diminishes the thickness of the strokes. But no positive tint has been found beneficial, though many have been tried. Old-fashioned *unbleached paper* of a faint tawny grey is most generally acceptable. The *smooth glazed* surface, now greatly in fashion, is highly objectionable. It gives rise to dazzling, and in certain positions the reflexions, especially from artificial lights, render the print almost invisible. It has crept into use from giving a fictitious appearance of finish to illustrations and type. It must be rigorously excluded.

The types in common use are the following:

Name	Height of letters	Specimens
Brilliant	0·75 mm.	a e i o u 5 3
Pearl	1·0	a e i o u 5 3
Minion	1·25	a e i o u 5 3
Bourgeois	1·5	a e i o u 5 3
Small Pica	1·75	a e i o u 5 3
Pica	2·0	a e i o u 5 3
English	2·5	a e i o u 5 3

It is obvious from what has been said that any of these types are visible provided only they are held sufficiently near the eye. Therefore the mere visibility of a type is not the criterion of its suitability.

The prime necessity in a type for children's use is that it can be read at some distance from the eyes, and that distance for learners ought to be considerably greater than would be convenient for a practised reader. Putting aside beginners (who ought to be taught from wall placards) the lower classes ought to be provided with type of a size that can be read fluently at a minimum distance of 24 inches. For instance, in learning a task of poetry or a conjugation, the child ought to be able to lean back in his seat and read from the page propped up on the far side of the desk. Holding the book in the hand is a custom having nothing to recommend it but convenience, and though not likely to be discontinued by adults, should be discountenanced in children.

In measuring the size of types the breadth is more important than the height, which in itself contributes little to legibility, though letters in use are usually about one-third higher than broad. As a standard the short tailless letters that occupy a space nearly square are to be taken. These, as they are usually drawn, should measure 2 mm. in height and at least 1·50 in breadth. Experiments shew that letters of this size are read fluently by adults at 24 inches. They correspond to Pica. This may be selected for the upper classes. For the lower classes and for learners it is advisable to have a larger type.

2. *Thickness of the stroke.* Much pretty looking type is unduly thin in the stroke. Printing began as an imitation of writing where the up-strokes are necessarily thin and the down-strokes thick, but in a mechanical fount there is of course no meaning or advantage in having one part of the stroke thicker than another. But forms are imitated long after the reasons for their adoption have ceased to exist and consequently a vast amount of printing illustrates the pride taken by the workman in his capacity to turn out hair lines rather than his understanding of the qualities that contribute to legibility. Reading is accomplished in the main by observing the differences in the shapes of the upper portions of the letters. Therefore the best type is that which marks

out those differences most clearly. The arches of the m, n, the openings in v, u, w, x, the horizontal line in the e distinguishing it from c should be perceived at a glance. Observe that an unduly thick stroke infringes on the open space and therefore may contribute to illegibility.

Italics are difficult and should only be employed for occasional emphasis.

4. The distance between the letters. It is obvious that the spacing between two letters has the same requirements as the open spaces in the letters themselves. Thus if we recognise the m by the two arches connecting its uprights, we ought to be able with the same facility to recognise that two adjacent letters are not connected by any tie.

m, nn, nu, nv, w, in, or words like *immense*, *murmur*, *minimum*, *mere men*, depend greatly for their easy recognition on the spacing of the letters. The spaces between two letters should not be less than half the width of the letter.

Printers are fond of encroaching on this valuable space by ornamental finials. Thus they prefer uwvy to uwvy because it gives the aspect of a nice even top. But the reader does not want a nice even line, he requires an edge with salient differences.

The intervals between words should be emphatically marked. For practised readers too great a separation of words is not advisable as it retards. A space of not less than double the width of the letters may be taken as a good working distance though more may be advantageously allowed for learners.

1. Some men amuse more than others.
2. Some men amuse more than others.
3. Some men amuse more than others.

It is obvious that arrangement No. 2 is the easiest to read for adults, but nevertheless an arrangement similar to No. 3 is best adapted for learners.

The distance between the lines. Leading. Reading is much facilitated by an ample space between the lines. Poetry and three-volume novels may be taken as typically well arranged books, though the motive is rather to spread a little matter over a wide space than to ease the work of the eye.

It has been asserted that separation of the lines is not of importance, but experiments have convinced the writer that ample leading is one of the most efficient means of reducing the labour of reading. A comparison of specimens indicates that the difference in the appearance of solid and leaded lines is greater than could possibly be surmised.

Solid.

Under the reign of the last Stuarts, there was an anxious wish on the part of Government to counteract, by every means in their power, the strict or puritanical spirit which had been the chief characteristic of the republican government, and to revive

Thin leaded.

Under the reign of the last Stuarts, there was an anxious wish on the part of Government to counteract, by every means in their power, the strict or puritanical spirit which had been the chief characteristic of the republican government, and to revive

Double leaded.

Under the reign of the last Stuarts, there was an anxious wish on the part of Government to counteract, by every means in their power, the strict or puritanical spirit which had been the chief characteristic of the republican government, and to revive

Solid.

Under the reign of the last Stuarts, there was an anxious wish on the part of Government to counteract, by every means in their power, the strict or puritanical

Thin leaded.

Under the reign of the last Stuarts, there was an anxious wish on the part of Government to counteract, by every means in their power, the strict or puritanical

Double leaded.

Under the reign of the last Stuarts, there was an anxious wish on the part of Government to counteract, by every means in their power, the strict or puritanical

Solid.

Under the reign of the last Stuarts, there was an anxious wish on the part of Government to counteract, by every means in their power, the

Thin leaded.

Under the reign of the last Stuarts, there was an anxious wish on the part of Government to counteract, by every means in their power, the

Double leaded.

Under the reign of the last Stuarts, there was an anxious wish on the part of Government to counteract, by every means in their power, the

The length of the lines. The longer the lines the greater to and fro movements must be made by the eyes, and consequently the greater fatigue in reading a given number of words. The less the distance which the eyes have to travel the better. The length of a line as determined by printers in quarto and large octavo books is too long, but the customs of compositors need not be inexorable. As determined by our literature the length of our line is mainly influenced by our ten-syllable blank verse and fortunately may be well printed in lines of a comfortable dimension. In Dyce's Shakespeare, in 100 consecutive lines only 17 exceed 3 inches, some are less. The prose passages in the same play are $3\frac{5}{8}$ths inches. In a library edition of a standard history the lines are $3\frac{6}{8}$ths. The column of a first class daily newspaper is $2\frac{5}{8}$ths. In books specially prepared for children, a well-printed work on outdoor life had lines of 5 inches, a large print book of general information $4\frac{7}{8}$ths. A popular French grammar $3\frac{6}{8}$ths, a German grammar $3\frac{1}{4}$th, a reader $3\frac{5}{8}$ths, a geography $3\frac{1}{8}$th. So that on the whole the poet and the general editor may be said to do better for us than the special providers.

A general maximum of 3 inches may fairly be adopted as a standard, and books with lines much exceeding that length should not be used for continuous reading.

Arrangement of matter. Printers, aiming at a mechanical uniformity, like to see the upper edge of their lines as even as possible, and all the lines of the same length. The eye prefers exactly the opposite conditions. It prefers a well-varied upper edge and lines of differing length.

The modern advertiser, who understands human nature and who wants the qualities of his goods appreciated at a glance, runs directly counter to printers' prejudices, and "displays" his matter by all sorts of ingenious variations of type-setting. No uniformity for him; nor should there be for the school-printer.

The paragraphs should be as short as possible[1]. When lines end in the middle of a word, the whole word should be carried to the next line and not be hyphened. Nor should the spacing of letters be needlessly varied. Thus German printers, using roman type, have an annoying trick of separating the letters of words for the sake of emphasis or filling the full space of the line.

Here is an example of the printers' love of neatness leading to a bad arrangement:

> For mankind an absolute monarch, with the most perfect military machine in Europe at his command, Frederick is constantly spoken of as a man typical of his century. In truth he was throughout his life in ostentatious opposition to his century on its most remarkable side.

[1] The arrangement of verses in the Bible is excellent. If the Bibles (or separate books thereof) supplied to school children were printed in good sized type (and not as they often are in exceptionally small type and on thin paper) they might be considered as good models for school printing.

A child's eye would have to wander from "per" to "fect" and back to "per" again before the whole word could be grasped, and so on.

Except at the beginnings of paragraphs the left hand should be vertical, with as free a use of capitals as possible, but the right hand may be advantageously varied.

Dialogue is the example of easy reading. Vocabularies and glossaries should never have the first letters small. A ruled line assists the eye in running down a list of words. It is generally used only to divide columns but it may be advantageously used as a guide to the eye in children's glossaries. Underlining horizontally for the sake of emphasis is on the other hand distracting to the eye.

Remarks on special subjects.

Music. Girls frequently volunteer the statement that music is more trying to the eye than reading. The lines are too long and the conditions of reading very complicated. The eye has to travel horizontally along the lines of the stave, but at the same time be continually moving up and down vertically to follow the position of the notes in the scale and their relation in the treble and the bass.

Moreover a quantity of music is now printed cheaply by lithography and other rough and ready methods.

Some is very small.

Only well printed full-sized music should be used in teaching.

Special large sheets have been prepared for beginners and should be used.

They are known as the giant notation.

Greek. Boys complain of Greek. The type is really easier to read than Roman of the same dimensions, the forms of the letters being well varied and the upper openings well defined. It is the unfamiliarity that renders it difficult and not its essential qualities.

German, on the other hand, has a radically vicious type with very ill-placed hair lines at the top of the letters. Germans themselves, bred to it from their childhood, suffer considerably from its imperfections and our children have to contend with the additional difficulties of unfamiliarity. It is likely to die out before long in its own country and may therefore be only sparingly employed in our schools.

Maps may be instanced as having type much too small. Modern processes permit the production of most beautifully executed little maps at a very small cost, but though creditable to the workman they are exceedingly bad for the eyes. The lettering is moreover confused by names of districts and provinces sprawling irregularly among the names of towns, by the meandering of rivers and the shading that symbolizes mountains. Moreover the contrast is diminished by the colouring of divisions. Children having to find out the position of a town set to work by searching for the name by means of their forefinger, and in the effort to find one name they may have to read a hundred. The use of the index and the latitude and longitude was certainly exceptional in schools visited. Teachers seem indifferent to, or unconvinced of, the value of large wall maps and the practice of the pupils themselves drawing maps either from pattern or from memory on the blackboard. In schools where the custom is seriously adopted the advantages are generally marked, and the abolition of small maps may be confidently expected to follow the spread of this particular method.

Summary.

Short sight is a malformation of the eye, varying from a slight elongation, scarcely distinguishable from an excess of development, to a marked bulging of the back of the eyeball accompanied by inflammatory and destructive changes.

Vision may be exceptionally good for fine work close at hand, but below the standard for distance unless aided by spectacles. Severe cases are accompanied by deterioration of both near and distant vision.

Short sight in low degrees is well adapted for urban occupations, but in varying degrees is inadequate for outdoor life, *e.g.* soldiering, sailoring, emigration, etc. Short sight is not strong sight, and in severe cases the sight is often in great peril during middle age and advanced life.

A large amount of short sight is progressive not only as regards deterioration of vision but as regards changes in the structures of the eye.

Short sight is due to the employment of the eye in near-work, reading, writing, sewing, etc. The amount of damage inflicted on the eye is influenced by the immaturity of the eye, its especial proclivity and unfavourable conditions under which it is exercised.

The entire prevention of short sight cannot reasonably be expected, but much may be done to reduce the amount and degree.

The hours employed in literary work should be reduced and literary tasks alternated with bodily exertion or employments not needing the eyes. Written impositions should be abolished, home lessons if not forbidden most carefully supervised.

Increase in the use of wall diagrams, in the use of the blackboard both for teaching and learning, and in oral instruction.

Books must be carefully chosen and great attention paid to the quality of the paper and the printing, the legibility of the type and the arrangement of matter.

Reading must never be practised except in a good light.

Finally, short sight implies injury to an important organ, deterioration of a faculty and possible loss of an invaluable sense. Education implies the cultivation of every faculty and the improvement of every sense to the highest perfection possible in the individual endowment.

CHAPTER XI.

SCHOOL FURNITURE AND WRITING.

THE question of seats and desks has attracted great attention, but in the voluminous literature which has grown up around the subject there has been too great an insistance on the necessity for perfect furniture and too little on the proper management of growing children—thereby diverting the teacher's observation from the essential points. Many possessors of patent desks have indeed been lulled into a false security and led to suppose they could not go wrong so long as their mechanical contrivances were right, and have in consequence persevered in long hours and much writing which they would have discarded if they were thoroughly convinced of the injury likely to be inflicted. A good desk is undeniably better than a bad desk, but it cannot in the nature of things be free from all bad qualities, it preserves some whilst mitigating others, and it may be so injudiciously used that it may actually be inferior to common household furniture employed in a rational and careful manner. The charge preferred against seats and desks is of promoting short sight and distortion of the spine. The charge is to this extent true that the occupation specially carried on at the desk is writing, and this, confessedly a bad employment for adults, is one of the worst to which a child can be put. Carried out under the most favourable conditions it means a strain on the eyes and the bones of the trunk, which those organs are by no means adapted to resist.

THE SITTING POSTURE. Both in standing and sitting the body is supported by the skeleton. But the skeleton will not stand alone, it bends at the joints unless balanced by the opposing tension of muscles which draw upon the bones in various directions and keep them fixed in the necessary positions, much as the ropes in a ship brace the yard-arms at the necessary obliquity to catch the wind.

Standing and sitting are therefore not positions of rest but of modified activity, the immediate exertion is not so great as in movement, but is more continuous. Thus in rowing the body is moved to and fro. In the forward movement the muscles in front of the trunk etc. are contracted, those of the back correspondingly lengthened, but at the pull the back-muscles are contracted and the front lengthened. This alternation of lengthening and contraction is *exercise*. But in sitting the muscles assume a certain degree of contraction and keep it. Thus in stooping slightly forward as in writing the body is held up by the requisite contraction of the back-muscles continuously exerted; there is no alternation of contracting and lengthening as in active movement. This maintenance of one position by the prolonged and unrelaxed exertion of muscles is not exercise but *strain*. Exercise is healthful, strain harmful. In the act of sitting, the body is supported on the haunch-bones which form an arch from side to side, so that there is very little tendency to fall either to the right or left, but from before backwards these bones have only a narrow curved surface which affords little more base than a soda-water bottle, so that the equilibrium resembles that of a rocking-chair on a pair of very short rockers. A little assistance is given behind in maintaining the balance of the body by the hidden remnants of the tail which terminates the backbone. But if the muscular support is withdrawn the body either falls forward or backward according to its inclination. As a rule a writer sits fairly upright for a time, until the supporting muscles of the back become fatigued and he then leans forward and supports his chest on the edge of the desk or on his elbows. How then is the body kept upright in sitting? By the action of the muscles using the thighs as a base.

THE SEAT. The first requirement of a good seat is adequate support for the thighs. The depth of the seat should be just a little shorter than the underside of the thigh, measured from the buttocks to the bend of the knee. It must not be longer, otherwise the haunch-bones cannot rest against the chair-back.

In order to render the base more firm the feet should rest on the ground or on a footstool. The height of a seat should not exceed the length of the leg measured from the bend of the knee to the heel. The foot should rest easily on the floor. The base is further strengthened by supporting the back of the haunch-bone and hindering it falling backwards. A cross-bar support should fit the upper part of the haunch-bone just below "the small of the back." This support loses some of its value if too high, as it then impinges on the flexible part of the backbone, where it is not wanted. A low-backed chair of this kind fitted to the size of the child reduces the evils of the sitting posture in writing to a minimum. If the chair is needed for resting—*i.e.* leaning back—the back must reach as high as the shoulder-blades and slope backwards from above the cross-bar. The wooden chairs made for kitchens are often scientific in construction and thoroughly restful. Of course they are too large for children. The music-stool is the worst seat yet devised.

In cases of spinal deformity the chair-back must be specially made to fit under the direction of the surgeon.

THE DESK. If the desk is too much separated from the seat the writer must lean forward, if it is too low he must stoop, if too high he must raise his elbow and shoulder to reach up.

The edge of the desk should therefore come well over the seat.

Its height from the seat should be the interval from the seat to the elbow, the arms hanging by the side, the forearms flexed at right angles. The writer should be able to sweep both forearms easily over the desk while he is sitting bolt upright and both elbows level with his sides. If these conditions are fulfilled it is easier to sit upright than crooked. With a thorough understanding of the guiding principles the village carpenter will make seats and desks of a suitable character, the simpler the better.

The one essential requirement is to have the furniture suited to the size of the pupil. The pupils must be classified according to the length of their bones and not according to mental ability.

For home teaching the ordinary tables and desks can be used if the chair is made with adequate length of leg and a proper foot-rest so that above conditions are fulfilled. In schools it is advisable to have furniture of varying dimensions. Mr Priestley-Smith considers four sizes are sufficient. The following figures are taken from his specification and will serve as a guide for those who have to furnish. Mr Priestley-Smith has designed a desk and seat fulfilling all ordinary requirements. There are many others in the market.

	ft. in. ft. in.	ft. in. ft. in.	ft. in. ft. in.	ft. in. ft. in.
Height of Scholar	3 6 to 4	4 to 4 6	4 6 to 5	5 to 5 6
Height of seat from floor	13	14½	16	18
Breadth of seat	10	11	12	13
Height of desk and back from seat	8	8¾	9½	10½

In the patterns supplied by school-furnishers desks and seats are so constructed that they can be readily adjusted as required. But with a due attention to the growth of a child much harm is not likely to occur if the dimensions of writer and desk fairly approximate. Injury is not inflicted by the *temporary* use of a bad desk, but the reiterated assumption of a bad attitude and day by day engaging in an occupation which always puts the strain in the same parts may ultimately so twist and distort the body that the deformity becomes visible to the most uninstructed eye. There is a slight difference in the proportions of girls and boys. Girls are relatively longer in the body and shorter in the limbs, and therefore require the desk rather higher from the seat; $\frac{3}{4}$ of an inch is the usual allowance. The question of the change of attitude must be considered. When the seat and desk are in the proper position for writing the pupil cannot of course stand. He must push the seat back or the edge of the desk forward. The former is the more convenient arrangement. Some patterns of desk are provided with flaps which turn up when the pupils require to stand—under certain circumstances as when the row of seats is against a wall this answers, but as a rule the readily moveable seat will be preferred. To rise, to set back the chair, to stand at attention entirely free from all furniture, with no possibility of leaning on anything is a good beginning of the necessary relief from sitting. In fact all school furniture should be as light and portable as possible, so that it can be moved in order to allow the floors beneath to be thoroughly and frequently scrubbed and when practicable to be moved entirely out of the room.

Desks are better made to serve as desks only and not as lockers and bookcases which collect dirt and are difficult to clean. They should be kept thoroughly polished all over with beeswax and turpentine. Well polished wood shews up dust and harbours but few germs. The work of polishing is excellent exercise for the pupils and helps to make them handy. Teachers may well imitate those naval captains who point to the state of their decks and their brass as indices of the efficiency of their crew. There is an educational as well as a hygienic advantage in teaching children to take a pride in the smartness and cleanliness of their school-rooms and in allowing them to contribute actively in the work. All lockers, cupboards, and shelves should be periodically emptied and thoroughly cleaned, books dusted and put out in the open air.

CURVATURE OF THE SPINE. If you pass your hand down the back of a child you will note a convexity between the shoulders and a concavity at the loins. These are the natural curvatures of the spine and are very graceful and pretty to behold. But if you view the line of the spine from the nape of the neck to its lowermost point you will note it is exactly perpendicular and has no deviation to the right or the left. If at any part it has a bend, that must be regarded as a deformity.

A certain proportion of school children, especially girls, suffer from this complaint, and special authorities on the subject attach great importance to the evil effects of writing. How does this occur? We have already learned that the spine supports the weight of the body. In adults the bones are hard and capable of so doing. But in children the bones are comparatively soft and pliable. The same amount of force that will snap the armbone of an adult will only partially break it in a child so that it is bent but not broken through. A fracture of this kind is aptly named "green-stick," and if the child is allowed to grow up without surgical aid the bone will be bent, though strong. The Chinese lady's foot is another example of the flexibility of young bones.

The spine consists of a number of disks piled one on the other, they are soft and therefore compressible, they are growing and therefore tend to expand in the direction of the least resistance. If the weight is unequally distributed or there is a persistent pull of the muscles in one direction (which amounts to the same thing), the verticality will be lost and a curve is begun. The whole mechanism of the body is so complicated that one part cannot be altered without affecting other parts and compensatory curves and deformities immediately follow on the first defect. So it happens that the parents of these children first notice an ugly projection of the right shoulder-blade and it is not till they are taken to the surgeon that the real nature of the deformity is suspected.

If one of these children is examined nude, the curve in the spine may or may not be visible to the unpractised eye, but almost always there will be noticed a dropping of the right shoulder, a projection of the lower tip of the shoulder-blade, and a raising of the right hip. Obviously in a child such a tilt must imply further deviation from the perpendicular in the course of growth. Slight cases carefully treated recover so far that the deformity is scarcely visible, but cases that are allowed to progress often grow up with a crooked back that implies not only a loss of appearance (which in the case of girls may count for something) but an insufficient development of chest. Remember the desk and seat are only contributories to some causes already in existence. The sitting posture is bad and tired muscles are bad, but awkward sitting would not be indulged in nor would the muscles too readily fatigue if there were not behind all a general debility of system. The children who suffer in this way have generally feeble, ill-nourished muscles—they have been brought up with too little physical culture or the muscles may not be in proper exercise at the time. To put a muscle on the strain after it has been at rest for some time and after it has been well vivified by exercise is to act on two different things. There should be always exercise before a writing lesson to stimulate the resistance of the trunk-muscles and after to restore their tone, and as writing is a lop-sided occupation movements of both sides are to be commended. In fine weather almost any active game with a good deal of running and catching (like prisoner's base) will do. In wet weather a few minutes' dumb-bells before sitting down, and a tug of war (best two out of three) in the corridor after the lesson may be recommended. Remark that exercise of the muscles not only benefits by equalizing their action, but by causing an increased flow of blood improves the nutrition and strength of the bones in their vicinity. A blacksmith's apprentice grows up not only with stronger muscles than an office-boy, but with stronger bones. Moreover muscles which are allowed to go by default—to remain for long periods inactive—lose the habit of acting in collaboration and do not easily perform those symmetrical and harmonious movements which constitute grace and which when employed for a useful purpose constitute skill. A sedentary child is likely to grow up ungainly and to be unapt at all pursuits demanding dexterity.

COPY-BOOKS, ETC. Early writing lessons are often given on slates. They are not to be commended as the writing is often not easily visible and the child crooks its head to get a favourable angle of view. Besides, the fashionable mode of cleansing and erasing by means of saliva (too common to be ignored and too convenient to be put down by edict) must have some (even if inconsiderable) dangers attaching to it. The present writer has no hesitation in saying that the early lessons should be given on the blackboard. This method throws no strain on the eyes, allows the children to move about, to write large, which is easier for their untrained muscles, and permits of the copy being at a distance. The best copy-books are made of paper sufficiently smooth to permit of easy movement of the pen but not glazed or shining so as to throw a glare. They should be ruled with lines easily and distinctly seen, sufficiently wide apart to allow the tails of the long letters to be clear of the tails of the lines above and below. Double lines should be avoided, the effort to keep within their boundaries calls for considerable attention from the eye.

The worst copy-books are those which have the top line occupied with a faint printing of the words to be traced. All varieties of tracing should be rigorously banished. The idea that by tracing, the hand can be trained to the performance of the movements required in either drawing or writing is vicious in the extreme. The maximum of work is thrown on the eye without affording any visual training—indeed the power of appreciating form is weakened. Under no circumstances should it be allowed—neither in copy-books nor in the form of transparent slates. The same may be said of squared sheets and other similar devices popular in many kindergartens.

Copies printed (or written by hand) at the head of the page are less objectionable. But the best plan is to have the copy separately printed on a card and supported on the book-rest, or still better on the blackboard or wall-placard. This leads us to the root of the matter.

METHOD OF TEACHING. The reason why writing is so difficult for children (and even disastrous for some) is that they are brought to the task with insufficient preparation. The recognition of the immaturity of the brain and the eye in the child and the consequent and inevitable want of co-ordination of its muscular movements will at once cause teachers to reject the conventional routine teaching of writing. The waste of energy is apparent once the idea is grasped. The whole question cannot be discussed here but the following simple rules may be relied on to save time and energy.

1. No child should be set to write till it is familiar with the written characters—in other words the education of the eye is the first step and he must know when he puts his hand to the paper what he is going to do. This must be accomplished by the teacher writing first single letters and then words on the blackboard till the pupils are familiar and fluent. Specimens of writing on cards and books should be also used.

2. Children should be practised making single letters on the blackboard, first from copies and afterwards from memory. For example, the letter *a* being selected it should be drawn half-a-dozen times, then the whole rubbed out and the pupil, to the best of his ability (no matter how badly), draw half-a-dozen *a*'s while the recollection is fresh. No child should be permitted to go to the copy-book till he can write all his letters easily on the board.

It must be remembered that young children perform large movements with their hands better than small and the board makes a less call on their nervous energy than the book.

POSITION OF THE COPY-BOOK. THE SCRIPT. The question of slanting or upright writing. The old plan of putting the page to the right hand and sloping the pen with the handle pointing to the ear has happily died out. It is obvious the more the page is put to the right the more tendency there is for the body to twist and the more awkwardly the eyes must follow the point of the pen. To attain straight sitting therefore the mid-position of the book as in reading has been recommended. The further the book is to the right the greater tendency there is to slant the writing, but in the mid-position the writing becomes upright. But the mid-position has certain inconveniences and if rigorously enforced is found awkward by many writers and tends to give a backward slope to the writing—a most objectionable trait—so that a compromise is found advantageous. Remember the object of the position of the book is not a particular kind of writing (that may be left for adults to choose for themselves) but the welfare of the child—so long as the child is straight it does not matter whether the book or the writing is crooked. After many experiments it has been found that the easiest position is a little to the right so that the middle of the page about corresponds to the side of the body and sloped upwards about 20 degrees. The down-strokes are now made nearly vertical (in relation to the edge of the desk), but when the book is restored to the level position the writing slants to the right. More children seem to write easily in this position and maintain it longer, but the mid-position and the truly vertical writing seems to come easily and naturally to others. Something may be left to individual peculiarities.

Sewing and other occupations. The foregoing remarks are applicable to sewing, and sundry kindergarten occupations such as pricking patterns, threading beads, making paper mats of coloured strips, &c. In themselves comparatively harmless they are undertaken before the coordination of the muscles has been sufficiently advanced by practice on free and large movements. Empirical reformers have been misled in supposing that the mere change of an occupation from a task to an amusement is sufficient to make it suitable for childhood. Learning to sew in the ordinary manner by rushing at it with untrained faculties is a long and wearisome business, but when undertaken by those who have learned to use their hands it is quickly acquired—so with other fine movements. Nature should be observed and children allowed to perfect the muscular movements in their own way. The idea that the human body and the human mind will not develope without continual jogging from the schoolmaster is a modern and pestilent heresy. First notice what kind of actions a child uses of his own accord and suit the occupation you give him accordingly. Thus you will aid in the conversion of spontaneous action into voluntary movement, which is the end and aim of education. You will find fine movements like those of sewing (and writing) come on later and you lose nothing by following Nature rather than trying to anticipate her. Tasks taken up in their right order are quickly mastered. This to some extent anticipates what has to be said on over-pressure, but it has a practical bearing on successful teaching of routine subjects.

As a preliminary to sewing, NETTING is a very good training. It can be begun large and made smaller in the mesh as handiness improves and there is something to shew at the end. Though apparently some way off sewing (and probably not at first acceptable to the conventional teacher) it will be found excellent in habituating the fingers in dealing with string, twine, wool, thread, and fine silk in succession. While aiding manual dexterity, it need throw little or no work on the eye.

Professional sewing is done with a thread the same colour as the stuff. Even adults complain of this obedience to fashion. Scientific sewing would employ black on white or white on black, and children should be supplied, not with threads which match and are therefore difficult to see but with a good contrast.

LIGHTING IN RELATION TO THE DESKS.

Everything looked at by children should be well illuminated. Blackboards, wall-slates, diagrams, placards, etc., should never be used except when in full light, and this rule must be even more rigidly obeyed in regard to all desk-work—books, slates, copy-books, atlases, etc.—and such occupations as sewing, music and drawing. With a badly arranged light—either insufficient in amount or dazzling from bad direction—children hold their heads close to their books and injure their eyes or twist into awkward attitudes and disturb the growth of their bones. The principle is to throw a full light on to the object viewed and to preserve the eyes from a direct glare. We have then to consider first the *quantity* of light, and secondly *its direction.*

To measure the quantity of light practically, an adult teacher having standard vision should be employed. He should be able to read fluently 20 type at 20 feet (or 6 metres) in any part of the room, and diamond (or brilliant) at 12 inches minimum distance, the book lying on the desk as it would be used by the pupil. With less light the tendency is to hold the page nearer to the eyes, or still worse to poke the head down to the book and so induce strain of the eyes; besides interfering with respiration. As the conditions of light vary considerably at different seasons and times of day the estimate should be made whenever twilight is approaching. A room that is sufficiently well lighted for reading at noon may be dangerously dark at 3 p.m. In our great northern cities the afternoon light is very bad for at least four months in the year.

WINDOWS. In rooms built for the purpose the windows should have the greatest lateral dimensions consistent with the stability of the building. As the top part of the window is the most valuable it should reach to the roof-plate, and there should be no loss of space from stone tracery (as in pseudo-gothic erections) or stained glass, blinds, or other obstructions. On the other hand the sill should not be too low, 4 ft. is an appropriate height. If the window has been made to reach to 3 feet from the floor (as it may be advantageously in regard to ventilation) it should have the lower panes frosted or deadened by blinds. The blinds should be made to pull up from below as in artists' studios.

THE WALLS AND CIELING. As a great proportion of light is reflected from the cieling it should be white. The *colour* of the *walls* has immense influence. The amount of light reflected depends not so much on the actual colour as on what artists term its "value," *i.e.* its dilution with white. Some tint is advisable to take off the bare bleak look of whitewash, and taste may be allowed to play a part in the choice: pale yellows, blues, greens, or french grey can be obtained from common painters; but some little artistic skill may be required in diluting red or terra-cotta tints to the required brilliancy. The space occupied by blackboards cuts off a good deal of light.

They may be covered by white blinds when not in use, or have the backs painted the wall-colour so that they can be reversed. A very simple arrangement of hinges enables this to be done. A dado of darker tint than the walls or of light polished wood adds to the appearance of comfort without harm.

SURROUNDING BUILDINGS exercise a most pernicious effect. Few board-schools in great cities stand in the space they require either for health or lighting. The width of the street (alas that schools should be surrounded by streets!) and the relative height of the buildings has to be considered. The accepted rule that the street should be twice as wide as its houses are high is to be regarded as the strict minimum. School-boards (for many reasons) should be on the alert to secure open spaces for future use in the outskirts, before unrestricted building makes the price prohibitive, and so acquire the right to regulate the erection of contiguous houses advantageously. Outbuildings, brick walls, etc. may be improved by white-washing. The schoolmaster's rough and ready rule in reference to obstructing buildings is never to place a child for reading or writing where he cannot see a strip of sky. The height of the top of the window must regulate the distance of the desk. In a smoky town experiments shew that there is a point from every window (determined by many conditions) beyond which effective lighting most rapidly diminishes. That point does not greatly exceed the height. For instance, a window 10 feet high gave an effective light to 12 feet along a desk, but beyond that the diminution was remarkable although the room appeared to be well lighted throughout. As a rule desks placed beyond $1\frac{1}{4}$th height of window are to be regarded with suspicion as only being useful under favourable conditions (which are never those to be considered) and the teacher should only allow them to be occupied under reserve. Children should be shifted about and not always occupy the same situation. Those who are seated far from the window one day should be nearest the next. These remarks apply more particularly to rooms which have not been especially or skilfully constructed with regard to light, but the cautions given should not be neglected even if circumstances seem favourable.

Direction. In writing the main light should come from the *left* so that the shadow of the hand and pen should be thrown away from the script. But the light ought to be so diffused that the depth of shadow is insignificant.

The light should never come from the front, nor from below as when the sills are too low, as then dazzling is experienced.

Auxiliary lighting. Although the main light must come from the left it is not always possible nor desirable that it should come *only* from that direction. In our dark climate all opportunities of admitting light should be seized, and as the width of school-rooms is determined by other considerations than their suitability for writing, auxiliary windows may advantageously be provided. A kind of clerestory running along the right-hand side or back, with sill at 8 feet from the floor, allows ample space for blackboards beneath and does not contest with the main light from the left.

Tutors and governesses in *private houses* are often disadvantageously placed. Rooms in sunken basements are frequently selected for lessons, but should be declined in favour of a room on an upper floor—the higher the better in town. The desks should be wheeled near to the windows and the precautions above mentioned carefully observed. It is in the preparatory stages of education that much harm is begun, and home arrangements are too often in direct antagonism to the care taken in a well installed school.

Artificial lighting must sometimes be employed though it cannot be commended except by saying that it is sometimes superior to our smoke-obstructed sunlight.

Its drawbacks are feebleness, flicker and glare.

It is generally inefficient. Whatever illuminant is employed there should be plenty of it and a general source of light sufficient to light up the whole room cheerfully and to cause a diffusion capable of counteracting any pronounced shadows which may be cast from desk or side lights.

For this purpose—and indeed for all others—electricity is most convenient as it can be fixed in any position without regard to danger from fire. The general light should proceed from groups of 16-candle lamps fixed immediately below the cieling. In this position with the glass frosted the whole reflecting power of the cieling is utilized without causing any dazzling.

In the case of gas, Wenham burners (or other enclosed lights) can be placed high, or when not easily procurable, as in country places, an excellent light may be arranged by using a ring of horizontal fish-tail burners (as over a billiard table) suspended at about two-thirds the height of the room and having beneath it a concave tin (or silvered) reflector which throws the light well on to the cieling while shading it from the eyes. The village gas-fitter can easily make this and it is very cheap.

The disadvantages of petroleum are so great that it is to be only used when unavoidable. As the rooms in gasless places are generally small a few hanging lamps may serve for general lighting. The lower half of the globes should be frosted.

Whatever source is adopted the books in use are to be immediately illuminated by lights about 15 inches high, carefully shaded by large shades so as to completely screen the readers' eyes from the glare.

Flickering is very annoying to the eyes. Gas is the worst offender. Unguarded flames flicker from draughts, and jumping takes place when there is insufficient pressure or water in the pipes. It should be sedulously remedied. There are many forms of good Argand burners, and the incandescent mantle, which render gas steady; petroleum and electricity burn evenly.

As light to be agreeable ought to be diffused, the *glare* from a bright source such as a naked flame or glowing filament should be carefully shaded from the eyes. Enquiries are often made concerning the irritating qualities of various illuminants and the brighter often supposed to be particularly injurious. This is only the case when the light is placed so as to fall directly on the eyes. When properly shaded the brighter it is the better. Workmen are fond of hanging electric lamps within a few feet of the desk and in front of the writer. During the past few years the origin of much irritation and discomfort has been traced to this arrangement and remedied by the use of shades. No naked light should be permitted in a school-room, either diffusion is to be contrived by ground-glass globes. or concentration on the books by means of shades.

Summary.

Desks should be made to fit the children and not children the desks.

The most harmful occupation pursued at desks is writing, and the especial evils curved spine and undeveloped chests.

More turns upon the way a desk is used than on its structural perfection; short lessons at bad desks are likely to be less injurious than long confinement at the most perfect.

The sitting posture is in itself bad and should be directly counteracted by active exercise.

The use of blackboards, &c. for drawing and writing by beginners, in place of copy-books is earnestly advised.

All forms of tracing, drawing by means of squares or dots should be prohibited. Many Kindergarten tasks are very injurious.

For writing the light should be bright and proceed mainly from the left side and from a level above the desk, but a diffused light is better than one proceeding from a concentrated source.

Auxiliary light therefore may be provided, but it should not be from the front and the window-sills should be considerably higher than those on the left.

A poor light, or one proceeding from the front or below the level of the desk, causes children to assume awkward attitudes and to hold their books too close to the eyes.

Artificial lighting only to be employed when unavoidable. Generally insufficient in quantity. Should be steady, diffused and strictly shaded from the eyes.

CHAPTER XII.

THE AIR PASSAGES.

NOSE, THROAT, AND EARS.

If we look into the open mouth we see that the back part over the root of the tongue is spanned by a fleshy arch having at the highest point of its curve a little pendant about half an inch long, the uvula. All the space in front of the arch is the mouth, all behind it the throat. The archway which is capable of modification in size and shape by muscular action is an opening used for the passage of air and of food. By means of specially constructed mirrors we can examine the cavity above and below. Downwards, behind the root of the tongue, is the windpipe employed in the vital process of admitting air to the lungs. At its upper end is a sounding apparatus, the larynx, which when set in motion produces the voice. Further back is the gullet leading to the stomach, and used for swallowing food. Exploring upwards, we find in front two great orifices, the nostrils, by which we ought to breathe, and behind, on each side, the small internal openings of the ears, the Eustachian tubes. Altogether six tubes, of which one, the gullet, is concerned in the occasional act of swallowing, while the other five are concerned in the passage of air. So that we must consider the throat as a meeting place for the tubes concerned with the management of the air necessary for the health and vitality of the body.

These structures are all continuous, are all liable to be affected for good or ill by the same influences, and a diseased condition arising in one is liable to occur from the same circumstances in another or to spread by continuity.

All are lined by mucous membrane, a softer and more delicate covering than the skin. It is more freely supplied with blood-vessels, more easily damaged by small particles. It is habitually moistened with a thin layer of clear fluid. If irritated, or the blood-vessels become relaxed, this fluid is apt to become excessive, thickened and sticky. It then forms one of the most favourable of soils for the cultivation of any disease-germs that may happen to fall on it. When thoroughly healthy, with only the normal moisture on its surface, free from abrasions, germs have no resting place and cannot congregate and therefore perish from inanition like any other living organisms. The chief aim therefore in preserving the health of the breathing, vocal, and hearing tracts is to keep the mucous membrane in a state of good tone and not unduly moist.

The Nose. The nostrils are seen as two small openings, one on each side of a partition at the lower part of the fleshy projection of the nose. The sides of the openings are not rigidly held apart but tend to approximate rather in the form of chinks than tubes, a remnant of a state of existence when the nostrils could be closed at will to keep out water. Each leads into a large chamber, extending from the roof of the mouth to the base of the brain-pan on a level with the notch between the forehead and the nose. The chamber is divided into secondary passages by thin plates of bone which add enormously to the amount of wall space, as the surfaces of hot-water pipes are sometimes increased by projecting metal plates technically known as "radiators," and the narrow nostrils opening into a large chamber may be compared to Tobin's tube opening into a big entrance hall so as to ventilate without draught. So that when the air is inspired it does not rush through the nostrils as a draught and pass directly into the windpipe as a cold current, but it mingles with the air already warmed by the surface of the nasal cavity and passes into the lungs at something approaching the temperature of the body. Hence in part the importance of breathing through the nostrils and not through the open mouth.

Young children are especially liable to what is miscalled "cold in the head." The symptoms are familiar. The nostrils are clogged with a thick, yellow, sticky discharge, which cannot be, or is not, blown into the handkerchief, but presents itself as a disagreeable stream dribbling down the upper lip. Among the unwashed a good deal of picking of the nose goes on, and the irritating discharge is carried by the nails and sets up pimples, causes sores and scabs on the skin of the face, among the hair, and may even give rise to inflammation and ulcer of the eyes, not only of the child affected but of his associates.

Care should be taken that children do not "catch" cold, and that colds are cured as speedily as possible, as all "colds," and indeed any form of discharge, is likely to be infectious or contagious.

The great preservation against "cold" is the habitual free exposure of the mucous membrane to clean fresh air. Pure air is not easily found. The air on the ocean and on the higher mountains is absolutely clean, in the country fields and hillsides it may be considered practically pure, but in the narrow streets of towns, dwelling-houses, theatres, churches, and crowded schoolrooms it is unclean, being loaded with dust, dirt, decaying organic matter, and living organisms, all in varying degrees irritating to the mucous membrane. The air of a town playground is not what it should be, but it is better than the air of the occupied schoolroom, and in order to prevent cold-catching children should be sent as frequently as possible out of doors, not only for the purification of their own air-passages but for the general purification of the air they are to be exposed to during work.

Sudden or violent changes of temperature are dangerous. It is bad to go from a hot room into cold air, it is nearly as bad to do the reverse. Out-of-doors exercise by maintaining the vigour of the surface circulation enables resistance to be made to the paralysing effect of cold on the filaments of the nerves, but a person who has been seated reading or writing in a hot room has his circulation reduced to its lowest ebb and his resistance minimized; if he goes straight from his desk to the cold air he is easily chilled before he has time to start a vigorous heart's action. Therefore it is well when the outside temperature is low or there is a keen wind blowing to put the children through a few minutes' specially vigorous and rapid exercise before turning them out.

On the other hand, when the terminal nerves are enfeebled by cold and they have lost their control of the fine blood-vessels, a sudden rise of temperature causes a rapid relaxation and outpouring of an excess of surface fluid. The inbreathing of germs or irritants always present in the air of crowded rooms completes the business and a cold is established. It is therefore right to open the windows and thoroughly ventilate the room while the children are out so as to blow away the germs and impurities of occupation, and to have the means of raising the temperature to the required degree at will, but not to have too great a contrast when they enter. As the circulation quietens down the temperature should rise. There should be no pedantry in the matter and no blind following of the thermometer nor routine adherence to fixed seasons. Judgment founded on experience and observation must be exercised. As a general rule a room should feel fresh on entering it, there should be no sniff of previous occupation, there should be a pleasant sensation of shelter and comfort but not of heat, there should be no feeling of chilliness or coldness of the hands or feet after sitting. The greatest difficulties arise from East wind or fog, the two atmospheric conditions most fatal to young children. The former lowers vitality to an extent incommensurate with the mere lowness of the temperature, and the latter renders ventilation by the open window impossible. With a well-arranged playing shed a good deal of useful exercise can be managed away from the wind. Active combative games where there is no standing about may be allowed, but expedients should be devised to prevent dawdling or standing still. Fog is the one condition when young children should be kept indoors.

Draughts are fatal—no child should be allowed to sit in a draught, and the currents of air from open windows or ventilators (which have a trick of working the wrong way) should be jealously watched.

As "cold in the head" is the result of a general chill and not merely of the nose, parents should be instructed to clothe their children safely and rationally. The question of rational clothing may be dismissed in a sentence. It should be loose and it should be woollen. Arrangements should be made in all schools for a change into dry shoes and stockings in wet weather.

A sharp look-out should be kept for growths impeding breathing by the nostrils. Two kinds are frequent, (1) Enlarged tonsils, familiarly known and visible through the opened mouth; (2) Small fleshy growths, occurring behind the veil of the palate, invisible except by the aid of special apparatus, and known as "adenoids." Both kinds frequently exist together and may be recognised by the following symptoms, which are generally obvious to any teacher who has established a good ideal of sound health.

Breathing through the nostrils is impaired and the nose acquires a pinched look, the mouth is habitually kept open, giving an expression of stupidity, the voice is thick or hoarse, the nasal resonance is impaired, so that m's and n's are badly pronounced and replaced by b's and d's, there is a good deal of dribbling from the nose, and hawking of phlegm and general symptoms of persistent "cold in the head." Headache and malaise are common. Breathing is an exertion and the lungs are imperfectly filled so that affected children are shortwinded and do not like running games.

Among the grave consequences of the defects here alluded to are (*a*) An imperfectly expanded and therefore ill-developed chest; (*b*) insufficient aëration of the blood, with its further result—ill-nutrition of the brain, and impaired digestion; (*c*) deafness.

These cases require surgical treatment. But the teacher has peculiar opportunities of detecting the symptoms, in thick utterance, persistent nose-discharges, and so on, and it is his duty to notify parents of the source of the mischief. A considerable percentage of town children suffer in this way.

Common sore-throats are popularly ascribed to cold, but though chill as aforesaid undoubtedly acts as the predisposing cause, the real and effective cause is the inhalation of irritants or impurities. The liability to sore-throats therefore may be temporarily increased by a chill or it may exist as a permanent condition owing to a natural delicacy of the mucous membrane, or a constitutional defect such as rheumatism. In many cases it is not possible to trace the noxious influence giving rise to the attack, but recurrent sore-throats in children should at once arouse suspicion of drains and the condition of the home should be investigated. The victims of enlarged tonsils are more susceptible than others, a great variety of germs finding in them a congenial habitat.

Even tubercle, the active factor of consumption, may through the tonsils find its first establishment in the body and spread to other parts. The swollen neck glands so commonly seen are frequently tuberculous in character and have been absorbed from the throat.

Acute inflammatory attacks, quinsy, the onset of scarlatina or measles, diphtheria, need not be here considered, as children suffering from these complaints are not likely to be sent to school. But the rule should be to deny admission to any child suffering from any form of sore-throat, as there is no predicting whether or not it may become infectious. On this head a medical opinion must be sought.

The Care of the Ears.

The ear in relation to the physiology of hearing is a very complicated organ, but in regard to hygiene it is simplicity itself. Unlike the eye it is not directly affected by school-life, but its hygiene is nearly identical with that of the throat and nose, in which originate most of the diseases affecting its function. In order that the waves of sound may reach the nerve-structures that constitute the essential organ of hearing a tube passes obliquely downwards from the side of the head to the throat. This air-tube is not a mere hollow pipe but differs in structure in three portions of its course. At first it can be seen, leading from the lobe of the ear, as an open tube called the meatus or outer ear. About its middle it expands into a small irregular chamber called the drum. Between the drum and the throat extends a narrow passage called the Eustachian tube. This, unlike the outer meatus, is not an open tube, but the sides are in apposition except during the act of swallowing when they open and permit the air in the throat and the drum to communicate. The meatus is lined with skin and is consequently liable to the ordinary diseases attacking the skin, such as boils and eczema. The drum and Eustachian tube are lined with mucous membrane and are liable to the affections proper to that tract.

Between the meatus and drum is stretched the drum-membrane, a thin transparent structure capable of being set into vibration by the impact of sound-waves, as the parchment of a soldier's drum responds to the tap of the stick. The vibrations are conveyed to the sound-perceiving apparatus by three small bones acting as levers, and resembling the levers between the keys and strings of a pianoforte.

The foregoing sketch enables us to understand that deafness may be caused by anything that impairs the free vibration of the drum-head, thickening of the membrane itself, stiffness in the joints of the bones, fluid in the drum or stoppage of the Eustachian tube.

There are no precise tests of hearing adapted for popular use. The tick of a watch and the human voice, though both vary enormously, are the only two tests generally available to teachers.

To use the watch as a standard. The same watch must be used in all trials. Ascertain the distance at which the tick of your watch can be heard by taking a number of persons of presumed good hearing. The furthest distance the tick can be heard definitely is the standard for that watch. The watch must be held suspended by its handle or chain on a level with the ear and the person under examination must not look at it. The test should be begun by holding the watch beyond its known distance and gradually approaching the ear till the tick is definitely heard. The distance for an ordinary hunter will probably be found to be about four feet. Any marked failure should be notified to parents.

The carrying power of the teacher's voice should be ascertained for teaching purposes as well as for ascertaining the deafness of children. The pupil should be stationed at a definite distance, say 20 feet, with his back towards the speaker so that the movements of the lips are not seen. Then phrases should be uttered in the ordinary speaking voice, and if not heard the speaker should advance step by step till unfamiliar and out of the way words are distinctly heard. The average distance being ascertained any marked failure is easily noted.

If the voice does not carry to the distance at which the most distant members of the class are usually seated the vocal instruction may be regarded as ineffective. If particular members of the class fail to hear phrases audible to the majority, they may be assumed to be more or less deaf and should be referred for expert opinion.

No noise made in a school injuriously affects the ear. Oral instruction may be continued indefinitely without inflicting the slightest injury on the hearing. The diseases requiring care on the part of the teacher can be anticipated as they arise in the nose and throat and be recognized before they reach the ear. Two conditions are however to be noted.

Ear-ache attacks young children with great frequency and severity during their second dentition. It will arise from draughts on the side of the head or more frequently from a general chill, cold feet or too abrupt change of temperature. The pain is often severe and distressing, but if the patient is kept quiet and in an even temperature it often passes quickly away, leaving no ill effects.

Discharges from the ear are frequent consequences of infectious disorders, scarlatina, measles, whooping-cough. Sometimes they are thin and glairy, more often they are ordinary yellow "matter," sometimes streaked with blood and sometimes smelling offensively. Whatever the degree of severity, they are disgusting in appearance and give rise to a certain amount of deafness. A superstition exists that they should not be stopped. No more mischievous doctrine has ever been accepted. The purulent disease is at first confined to the mucous membrane —where it is comparatively harmless—but it spreads to the innumerable cavities that communicate with the ear, causes inflammation and the death of the thin bony plates that separate the ear from the brain. Finally, the membranes of the brain are attacked, giving rise to purulent inflammation and abscess of the brain—from which ensues death.

Every untreated discharge from the ear is a potential cause *of death from brain disease.* It ought therefore under no circumstance to be overlooked by the teacher.

The drum membrane is likely to be ruptured by concussion. One common cause is the rush of water into the meatus in plunging. As a rule water does not enter the ear forcibly as the air acts as a cushion as it does in a diving-bell, and thoroughly healthy ears stand a good deal. But when there has been frequent inflammation or ear-ache there is danger, plunging should be indulged in with moderation and wool worn in the ears while bathing. The other cause is boxing the ears, a time-honoured punishment that no self-respecting teacher would now inflict in the present state of our knowledge of injuries reported.

The Care of the Voice.

The larynx (or Adam's apple) is a triangular chamber of hard gristle with the apex forward and the base behind. Its shape can be felt from the outside. It forms the frame by which the breathing aperture is kept open and supports the vocal chords by which the voice is produced. The vocal chords are not chords, but folds of membrane attached by broad bases to the inside of the larynx, but having sharp edges projecting into the air passage. When at rest the opening is triangular with the apex forward. In this state the air passes to and fro without sound. By the exertion of muscles the chords can be tightened and the chink between them narrowed. Then if the air is expired with more or less force its passage causes a vibration which gives rise to the voice. The sound varies in loudness according to the force of the expiration and the note varies from low to high (in the same individual) according as the chords are loosely or tightly drawn. The mechanism so far is comparable to an Æolian harp. When the sounds are modified by movements of the tongue, teeth, and lips articulate speech is accomplished.

The only points needing attention from teachers are, that the higher the note the greater the muscular exertion, and that the quality of the voice—that is to say its clearness, huskiness etc.—is affected by the healthy or unhealthy condition of the whole mucous tract lining the nose, throat etc. and not only by the state of the larynx.

The voice is not directly harmed by school work. Indeed as quiet is a necessary condition for literary study the voice in school suffers rather from want of development than over exercise.

But, even for the sake of health, children should be encouraged to "speak up" and to articulate clearly. Every muscle in the body is intended to be exercised and the perfect command of every faculty should be the aim of education. By the habitual exercise of the muscles of speech from youth upwards the full strength and mobility of the throat can be attained and public and sustained speaking rendered easy and harmless. Clergyman's sore-throat is frequently due (at all events in part) to the attempt made to speak very carefully in the pulpit by persons who have indulged in a lifelong slovenly articulation, so that an entirely new set and combination of muscles are called upon in church from those used in ordinary life. Hence the symptoms of strain which might be avoided by judicious training from the beginning.

Children therefore should be encouraged to articulate clearly in class. Shyness and timidity must be overcome. Mumbling, low speech, with teeth closed and half-opened lips, means imperfect inspiration and a perpetuation of that bad aëration of the lungs that is one of the banes of school-life.

As a means to a clear and easy articulation the mode of inspiration must be watched. Singers and speakers who breathe by using their abdominal muscles do better than those who merely raise the chest walls. In just the same way the teacher's voice is more effective and has far better staying power if it is used in accord with the plain laws of breathing and articulation. In dealing with children, care should be taken that nothing exists that interferes with the movement of the abdomen. Tight lacing (not unknown even among young girls), tight belts or trousers-bands, overloading of the stomach with food (no good singer will sing directly after a full meal), flatulence, are all impediments to proper voice production. The teacher should especially notice the movements of the collar-bones during recitation or singing, and if there is over-action he may safely infer something injurious in the conditions of the dress round the waist. Bearing in mind that the production of high notes throws the most work on the vocal chords, the teacher of singing will be careful to keep a child well within its upper register. Tunes and exercises that can be taken easily are wholly beneficial. Regular practice in school and all that may encourage it outside are to be strongly advocated.

A very remarkable change takes place in the vocal organs as puberty is reached. The larynx rapidly enlarges and the voice correspondingly increases in volume and power. During the time occupied in this change systematic exercise of the voice should be interrupted. This does not imply that all singing should be forbidden, as easy tunes, such as hymns in church, and occasional songs of a small compass, are harmless. The changes occur in girls from twelve to thirteen and in boys on an average some two or three years later. The change is more troublesome in boys than girls, and of course the permanent alteration considerably greater.

SUMMARY.

1. The nose, throat and ear are portions of one tract and diseases occurring in one part are likely to occur from the same causes in another or from continuity.

2. The health of the tract is promoted by habitual free exposure to pure air; susceptibility to disease is fostered by indoor life and coddling.

3. "Cold in the head" is due to the inhalation of irritants or poisonous germs over a mucous membrane weakened by a chill or other debilitating causes. The bad air of an ill-ventilated room is often the immediate cause of cold.

4. Remains of a cold at the back of the nostrils is frequently the starting point of disease of the ears and other parts of the throat.

5. Enlarged tonsils and adenoids, by impairing breathing, disastrously hinder the development of the chest besides interfering with the hearing and the voice. Enlarged tonsils may form starting points for the absorption of infections and even of tuberculosis.

6. The ear does not suffer from over-pressure in school-life. Its hygiene is the hygiene of the throat.

7. A discharge from the ear should be sedulously treated. It is often a cause of death.

8. The larynx is not sufficiently exercised in schools. The voice should be developed by clear utterance in class, elocution and singing. Shouting at games is the fulfilment of Nature's instinct and should not be stopped.

CHAPTER XIII.

EXERCISE.

1. *General considerations.* The chief use of exercise is to vivify and purify the blood. The function of the blood, roughly stated, is the conveyance of two things to the tissues, oxygen and food. Oxygen is the prime vital necessity. A man can live some days without food, but deprived of oxygen dies in a few minutes.

Life is a process of combustion maintained by the oxygen of the air exactly in the same manner as a fire burns in a grate. If the air is blown through the fire by the bellows the fire burns briskly, the carbon of the coal combines with the oxygen to form carbonic acid which escapes by the chimney. Smoke is unconsumed carbon; with a bad draught the more smoke and the more ashes and cinders to clog the grate; with no draught the fire goes out, though the grate may be full of fuel. By an economical arrangement, common in Nature, the lungs are both the bellows for the supply of oxygen and the chimney for the removal of carbonic acid. Inspiration is the act of supplying oxygen, expiration of removing carbonic acid (and other products). Air which has been once breathed is stated to have lost 5 per cent. oxygen and gained 5 per cent. carbonic acid. The amount of carbonic acid exhaled by an adult in 24 hours represents about 8 ounces solid charcoal.

The lungs consist of two bags, with their inner surfaces enormously extended by subdivision of the bronchial tubes. On these surfaces is spread a network of tubes called, from their hairlike fineness, capillaries, which convey the blood. The walls of these tubes are excessively thin so that gases pass easily through them. The blood is pumped into the lungs about 70 times a minute. Air to meet it is inhaled about 20 times a minute. The blood as it enters the lungs is loaded with carbonic acid and crimson in colour; when it leaves the lungs, after exposure to the air to return to the heart, it is relieved of carbonic acid, supplied with oxygen and scarlet in colour.

Carbonized blood is a poison to the brain and nervous system. French suicides effect their object by breathing the carbonic acid supplied by burning charcoal. Partially carbonized and therefore partially poisonous blood is provided by detention in school-rooms and other places of assembly. No system of ventilation yet discovered will render the air indoors as vitalizing as the open.

The diseases of sedentary life (well recognized in middle age) are the result of suboxidation. School-life in so far as it relates to study is sedentary and tends to suboxidation, in so far as it relates to games tends towards perfect oxidation and health.

Other impurities are due to food and products of the wearing out of the bodily structures.

Food when digested is conveyed by a slender duct and dribbled into the great vein and thence distributed by the heart to the remotest parts of the body. If diet were exactly proportioned to the body-waste it would be all absorbed, but no perfect food exists and therefore a surplus remains in the circulation. In people who eat too much or with bad judgement, the surplus constitutes a source of disease.

The various structures—muscles, brain, liver and other organs continually absorb the food necessary for their life and work and cast out into the blood their waste products. In good health with a vigorous circulation and respiration a thorough combustion is maintained and the waste products are readily eliminated, but with sluggish combustion all kinds of intermediate products are formed, many of which are poisonous and with great difficulty removed.

The first and obvious effect of exercise is to quicken and deepen respiration—in other words to supply more oxygen. Taking the inhalation while lying down as 1, walking at three miles an hour rather more than trebles it, riding and swimming more than quadruples it. The advantage of gentle exercise is therefore apparent.

The second effect is quickening and equalizing the circulation. When a man sits at an intellectual task—as writing—there is an increased flow of blood by attraction in the brain, where for the time it is wanted, and there is an accumulation by gravitation to the lower part of the abdomen, where it is not wanted, and where it does harm. But when the heart's action is improved by exercise, local congestions disappear and the blood is equably distributed.

Third, it promotes the strength and growth of muscles, and it is well known that the whole body may be rendered bigger and stronger, or that certain groups of muscles may be especially trained. The apostles of culture affect to depreciate muscular strength, but when it is remarked that the HEART is nothing more nor less than a muscle—albeit it is the most important in the body—and that the stomach is a muscular organ, we are compelled to admit that the muscular development is of the utmost importance. It may be a matter of indifference whether we start a boy in life with a strong or weak biceps, but it must be a matter of earnest endeavour to start him with a sound heart.

Muscles are arranged in three groups: (1) those wholly under control of the will, like the muscles of the limbs; (2) those partially under control, like those of respiration.

Ordinary breathing is an involuntary act, but we can breathe deeper or quicker as we wish; (3) those entirely beyond control, as the heart and in the intestines.

The skin is commonly regarded as a covering added to the body for the sake of beauty and protection (for which we have substituted clothes) but it is in reality an organ of respiration of great importance. Like the lungs (though to a less extent) it absorbs oxygen and exhales carbonic acid, but its chief property is the removal of water holding salts in solution. Under ordinary circumstances no liquid appears on the skin but the water exudes in a state of minute subdivision termed *invisible perspiration*. Under the effects of heat, exercise, or emotion, the whole surface may be bathed in sweat. Two or three pounds weight may be lost by manual labour on a hot day, and considerably more has been observed as the effect of a single Turkish bath. In the interior of the body the kidneys perform a nearly similar function of removing vitiated water. The organs are to some extent compensatory. When the skin is active the kidneys are relieved, but if perspiration is hindered they are forced into extra work, which in the case of a chill may be so excessive as to cause disease. The beneficial effects of a moderate daily sensible perspiration is doubted by none. The danger of chill from excessive perspiration arises from the rapid cooling of the surface by the conduction and evaporation of the moisture, the conditions are exactly the same as in stepping out of a bath and allowing ourselves to dry without using a towel, contact of saturated cotton clothes instead of appropriate porous and absorbent woollen material, and exhaustion of the nervous system from over-exertion or want of food. It is not perspiring which causes the chill, but the avoidable circumstances which accompany it.

SCHOOL-EXERCISES are to be divided into two classes, *Disciplinary* and *Recreative*. The first fit the body for useful work and sports by training the muscular system (including of course the nerves) in a regular manner capable of graduation to the strength or requirements of the individual. They ought to be as carefully studied and administered as any literary rudiments. Walking, running, rowing, swimming and climbing (or gymnastics) should be habitually practised under superintendence so as to avoid slovenly work and get the best that can be got out of the material. It should not be left to chance whether a boy walks or lounges. He should be taught to walk straight, and made to walk regularly. It should not be left to chance whether a boy flounders or swims. He should be taught to swim and practise regularly till he can swim with style and strength.

Recreative exercises or games are quite indispensable on account of the mental enjoyment and excitement they afford. The exercise is more haphazard and cannot be graduated and arranged so as to train for endurance or for the exercise of a particular set of muscles. If a boy is sent for a four-mile walk we know how many steps he will take and the time he will occupy, if he goes to the wicket he may stay there for an hour and get plenty of exercise, or he may go out first ball and loaf the whole afternoon.

Walking.

Walking necessarily forms a great part of everybody's exercise. Without doubt children might be kept in good health by games alone, but concentration on their trivial details would tend seriously to narrow the mental outlook and to this walking, with its change of scene and varied incident, is the natural corrective. Moreover wet and stormy days unfit for games can be profitably employed in brisk walks. In fine weather a country ramble affords great pleasure to children. They take a keen delight in hunting for small animals, birds' nesting, butterfly collecting, mushroom gathering, and so forth. Thus many a man has laid the foundation of observation and classification. Fatigue may be avoided by a few simple precautions. Children must not be hurried nor put to keep step with longer-legged comrades, they must be allowed plenty of rests and frequent snacks. The high-road should be avoided and a route over fields or common with a varied surface should be chosen. It is not the distance traversed, but the time occupied in open air exercise that does good.

When no sports are afoot a short brisk walk should form part of school-life. Great liberty of action should be allowed. The "Crocodile" of ladies' schools is depressing to the spirits and inefficient as exercise.

The ill effects of walking are but few. In both sexes the rapid growth of the long bones at puberty changes the centre of gravity and the leverage of muscles and is apt to bring out latent defects. Girls are especially liable to a "turning in" of the ankle, which if not corrected may persist, others knock the feet or ankles together as they step.

Flat-foot is due to weakness of the muscles and ligaments for which heredity may be to some extent responsible. But children who are kept at the desk, when Nature requires them to be running about, increase in weight without acquiring a corresponding increase in the strength of the legs, and thus the arch of the foot becomes unable to bear its burden. The untoward effect is much hastened by continuous walking on *pavement*, which has a most disastrous effect on all feet—young or old. These distressing and disabling affections are seldom seen among the dwellers in hilly country and it may therefore be taken as a good working rule that the strength of the lower limbs should be cultivated by free exercise over soft uneven ground, before the weight of the body begins to tell.

Badly made shoes. The shoemaker has so thoroughly adopted the advice to stick to his last, that he has almost forgotten the shape of the foot. Specific instructions on shoe-making are beyond our scope. But it may be pointed out that the shape of the foot in action differs considerably from that at rest, so that a shoe that fits in the shop may be injurious in a long walk. The inner side is nearly straight and the great toe does not turn out at an angle, therefore the inner side of shoes should be straight also, and not curved like the shoulder of a coffin.

If the transverse arch of the foot is compressed the joint between the third and fourth toe is loosened, and a painful neuralgia (mistaken for rheumatism) is established. A thick and rigid sole with tight laced ankles (plough-boy fashion) prevents bending of the foot and leads to a slouch of the whole body. However thick the sole the waist should be supple and the upper leather should permit free ankle play.

A good shoe fits the hinder part of the foot snugly, and allows free play to the fore part, it holds the foot by fitting and not by compression. Sandals are now made for children, and are good.

Running.

Running, the foundation of most active games, is (rightly) carefully cultivated at our great public schools and (wrongly) neglected at those of an inferior grade. I fail to see any reason for the difference, as vigorous health is as necessary to the poor man's son as to the rich. No other exercise has so good an effect on the respiration and circulation. By no other (in the time) can the impure air of the schoolroom be so completely pumped out of the lungs and replaced by the pure outdoor air. The only supervision necessary is to see that children are not forced to run beyond their strength either in pace or distance. Systematic practice in running makes games pleasurable and profitable. Disinclination for games often springs from feeling "not fit," easily getting out of breath, "stitch in the side" and other grievances of the child who has been coddled or allowed to loaf. The calls made by games are intermittent, but very sudden and exacting and require good previous preparation if they are to be met with any degree of enjoyment.

Runners should be carefully observed to discover awkward movements, and pains should be taken to ascertain their origin. Bodily deformities are sometimes responsible, at others shoes. Insistence on good style has a good influence in promoting symmetrical growth.

Young boys and girls run with equal ease, but from adolescence onwards in consequence of a difference in configuration a marked change in favour of the boys is seen, and the training of the two sexes rather differs. As a rule girls are altogether neglected. This is wrong, for although not so well adapted for long runs, they benefit fully as much as boys by being exercised up to a lower standard.

Three descriptions of runs may be commended, as generally useful: (1) Short run at a moderate pace—especially useful as a lung cleanser and dispeller of the fidgets in the breaks. Schoolmasters are by no means alive to the value of breaks—they give too few and do not utilize them. A man who from long literary training has become endued with an artificial patience (as we all are in our own particular form of drudgery) can scarcely realize the tedium and weariness suffered by the young and unaccustomed sitting over books, the awful languor of the brain with a circulation nearly down to sleeping point. A short run of a few hundred yards will often revive a class that seems hopelessly stupid and inattentive.

(2) The race run at full speed over a measured course with the precautions of either grouping the runners or a handicap.

(3) The long run into the country. This may be taken over a given distance chosen for its surface, and the pace a "go as you please." Town schools may advantageously take a little lift by train out of the smoke. Public school boys cover 8 to 12 miles as "a grind" with benefit. Only a small

percentage of town lads are fit for so long a course but steady practice does wonders even for the most unpromising. As a variation the paper-chase with the added interest of a little sport is very popular.

Running is more easily overdone than any exercise and requires watching. Common sense is alone needed to form a judgment. After a run within the strength the runner comes in fresh, with a heightened colour, breathing perhaps difficult, but recovering rapidly on rest, thirsty and hungry and ready for food directly cooling is finished. The exhausted runner is pale or grey, skin covered with a cold perspiration, attention perhaps wandering or actually stupid, no disposition to undress or change clothes, faint or dizzy, no disposition to take food but often sick or nauseated if the attempt is made to eat or drink. Appearance drowsy but sleep either impossible or accompanied by dreams and twitches.

ROWING is one of the healthiest sports for boys or girls and its acquirement is valuable as it can be continued (with judicious slowing down) till an advanced age. Nearly every muscle is called into play, but those of the back are especially strengthened. It is therefore beneficial to girls who are liable to suffer from weakness of these muscles in consequence of the combined effects of the sitting-posture and the unnatural habit of wearing stays.

No more force need be expended in rowing than in walking a given distance, but more stress is thrown on heart and lungs. The drawbacks to the wide adoption of rowing are want of suitable water and the expense of hiring or purchasing boats, but as the exercise does a great part of the work of the gymnasium in a healthier way it should not be lightly set aside.

Over-exertion usually occurs in racing or when an untrained boy is sent to row with others in good practice, and is forced to continue pulling when he requires an easy.

Rupture occurs—it is greatly promoted by tight belt round the abdomen—Trousers should be made sailor-fashion tight round the hips. Girls should be forbidden to row in stays.

Precautions. Do not row after a full meal, till in good training pull a slow stroke and take plenty of easies, do not choose too light a boat, a moderately heavy craft gets more way on. Keep the mouth open during the pull, take breath during the return.

The *special danger* of rowing is drowning. Therefore, learn to swim and save life. Do not stand up in the boat, never change places without rowing to shore, if an oar is dropped overboard row close to it, one only of the crew is to be deputed to put his hand out to seize it and that without leaning over—better make half-a-dozen attempts than upset. If thrown out of a boat keep calm, unless near shore swim towards the boat, seize it if possible near the stern so as not to disturb its trim, do not on any account attempt to mount into the boat but let the rowers make for the shore. A drill for practice in shallow water of the management of an upset boat and above-named accidents has been found very interesting to boys and is of course sufficiently useful to be worthy of close attention for teachers.

Swimming.

An art so valuable that its neglect amounts almost to a crime. Every child, male or female, should be taught to swim, as occasions may arise when the power of swimming or of merely remaining calm in the water may mean the difference between life and death.

Its neglect is partly due to the assumption that a large quantity of water is necessary for teaching. On the contrary a large bath is a positive drawback, as young children are frightened at the immensity, noise and strangeness of our public baths. An adult can, at a pinch, be taught in a bath 12 ft. × 6 ft. with the water breast-high, and children in one of proportionally smaller dimensions. The maintenance of such a bath is probably not beyond the means of most schools within reach of an urban water supply.

The entrance to the learners' bath should be a gentle slope with a good hand-rail. Every precaution should be taken against alarm and fright combated by demonstrating the safety of every step taken. Support and aid should be freely given and only gradually withdrawn, no tricks should be allowed, disturbing and alarming noises forbidden, and the water warmed (70 to 75 F.).

The great value of swimming lies not alone in its exercising all the limbs, but in its training the respiratory muscles, as a right economy in the taking and husbanding the breath is part of the art. The body lies nearly horizontally in the water, with the weight removed from the spinal column, and the equal movements of the trunk-muscles have a great effect in counteracting the evils of the writing-posture. Mothers who desire symmetrical figures for their daughters should arrange for them to swim frequently. Few exercises have a more marked influence in straightening the back.

Harm is chiefly due to staying too long in the water. Boys are especially prone to dawdle half in and half out of the water till they shiver, and their extremities are "dead." In very hot weather two or three bathes may be taken in the day with advantage, and as a rule two short dips are healthier than one long immersion. Muscular exhaustion may result from a miscalculation of distance in swimming out from shore or from being caught in a current, or buffeted by rough waves. Hence boys should not be allowed to swim out in deep water (rivers or the sea) without an accompanying boat to pick them up when fatigued.

DIVING into shallow water from a height is dangerous to the unpractised. Fractures of the skull, dislocations and other serious and even fatal accidents have been known to occur. Too much care cannot be expended in teaching diving thoroughly. It affords the keenest enjoyment to the young, and is not more dangerous than any ordinary form of gymnastic exercise.

Ears which have suffered from disease are liable to be injured by the rush of water, causing giddiness, inflammation, or deafness. In healthy ears the air-pressure generally keeps out the water after the manner of a diving-bell. Those suffering from delicate ears should wear pledgets of wool when diving. Cases of drowning supposed to be due to cramp are now generally considered to be often due to ear-mischief causing giddiness.

PRECAUTIONS. Bathing should not be allowed sooner than about two hours after a full meal. The results of neglect are vomiting, headache, flatulence and indigestion. Nor when overheated or exhausted from violent exertion; but it is better to be a little too hot than a little too cold, so that it is important to forbid dawdling about on the bank after undressing. The strong may bathe before breakfast but for delicate children noon or afternoon is better.

Rheumatic children and those having fits should have medical sanction before bathing. Each case must be judged on its merits.

Exercises in SAVING LIFE afford a good deal of fun, and have a practical value. Systematic instruction should be given when swimming is mastered. The first step is to practise in clothes, the second to learn how to approach the victim without incurring peril. Boys told off to represent the drowning man usually enter into the spirit of the thing, and embarrass their saviours in a sufficiently realistic manner.

The Royal Humane Society offers a prize to schools for proficiency in life-saving practised under conditions.

Cycling.

Cycling has had a remarkable effect on the health of adults, and might be expected to take a prominent place in school exercises. But it may be dismissed from consideration except as a means of locomotion. It enables town children to get out easily into the country—no small matter—and numbers now ride to and from school, with the distinct advantage of keeping their feet off the pavement. The young learn easily and ride with surprisingly little exertion, so that a machine may be regarded as a great source of pleasure not likely to do much harm unless adopted as a substitute for more varied exercises. Accidents of course will occur, as they must with any thing on wheels, but they are generally due to traffic, or to riding down hill without a proper brake.

Games.

Games are regarded by children as pleasures, but by the wise teacher as the attraction whereby the regular open-air exercise essential for growth and health may be secured. Therefore they are to be regarded seriously.

School games are for the most part varied exercises in walking and running, with the added use of the arms in throwing and hitting the ball. The trunk-muscles are continually called upon to perform rapid and varied movements in maintaining the balance of the body. Regular play at cricket, football, hockey, with the practice necessary to acquire proficiency may be counted on to exercise every muscle in the body in a pleasurable manner without fatigue. The various gymnastic "systems" which are the delight of certain arm-chair pedants, may be dismissed as fitted for valetudinarians rather than children. Occasionally for the sickly and deformed "movement cures" have undoubtedly great value, but the healthy need none of them. Our national character has not been formed by waving our limbs about and pulling at ropes in dreary obedience to the directions of a manual, but in contests, struggles, and emulation on the field, the river and the moor.

Games and sports are the amusements of the Englishman and they are answerable for his mental qualities and his muscles. Hence the unwritten law of our public schools that makes games compulsory is a good law.

Unfortunately the law of the land has made detention in a schoolroom compulsory, but has not touched on the subject of healthful exercise.

CRICKET is the king of summer games. It is permanently interesting, keeps the players out in the open for hours on the turf, and provides the most varied movement, besides (in common with other games) providing lessons in temper, self-restraint, and educating the hand and eye to act in concert.

Girls become keen cricketers, and though they seldom excel (indeed falling off as they approach womanhood) they nevertheless derive enjoyment and health. In the better class girls' schools it is encouraged, but like other things connected with physical health, a good deal neglected in others.

FOOTBALL is a good muscle-forming combative game which does more to promote strength than any other. Objections have been urged on the score of danger, but among boys it is really remarkably free from accidents. Its popular reputation is largely due to the comic papers and not to observation of facts. Boys require to be classified so that the youngsters are not overweighted. With that precaution it should be played throughout the school. It is wholly unfitted for girls.

HOCKEY, an admirable fast game, necessitating much turning about and change of attitude beneficial to the trunk-muscles. It requires less strength than football, but keeps the breathing in full work. It has the advantage of being playable all through the winter, and on all sorts of ground, turf, the sands, or ice. It is the source of many small accidents and many bruises, unless sticks and sides are carefully watched. No game seems to have so marked and immediate effect on the health of girls. They play with keenness and ability, and many continue to play after they leave school.

The foregoing exercises suffice to maintain a good standard of health but do not fully develop the arms and chest.

The GYMNASIUM though apparently artificial, really satisfies an instinctive need of climbing felt by the young. Children left to themselves invariably climb. Boys perch themselves in the branches of trees to read, and play on the tops of walls, roofs, and other positions that offer nothing but terrors to adults. Ladders, ropes and bars, are no substitute for outdoor exercise, but have an important influence on development. Injudiciously pressed they have a tendency to overdevelop the upper parts. The pupils of professional strong men are almost always top-heavy.

The ordinary gymnastic exercises are well adapted for their purpose, and only need caution in keeping well within the strength of beginners and the untrained. It is not by attempting feats beyond the powers that the body is strengthened, but *by the reiterated performance of* easy tasks. The fancy tricks of the gymnasium are unsuited to girls, but a selection is easily made. A word in favour of the trapeze may be said. It is greatly neglected, but girls find it exhilarating, and it has a most excellent effect in training shapely arms and shoulders. Female gymnasts who excel in this exercise are said to have exceptionally good health, and not to suffer in any special way.

No one would neglect dumb-bells, bar-bells, and Indian clubs—used when possible to musical accompaniment.

For girls fencing should form a part of winter exercise—there is no substitute for it, and it is rightly becoming popular.

For boys single-stick and boxing are more congenial, and should be practised.

The wise teacher will encourage a variety in games, by example, rather than by compulsion. Children are imitative and follow the fashion, which changes frequently, with advantage, as all games have their weak and strong points and are often mutually corrective. The chief care should be to see that play is vigorously practised, that the bookworm is brought into the open air, the loafer stirred into activity, and that no excuse in the way of work or indoor entertainment should be allowed to interfere.

CHAPTER XIV.

OVER-PRESSURE AND THE GENERAL MANAGEMENT OF HEALTH AND DEVELOPMENT IN RELATION TO EDUCATION.

Over-pressure is a term that has been adopted of late years to describe condition of failing health seen in school-children. It is especially applied to cases of nervous breakdown supposed to result from excessive intellectual work, but this application though containing a part of the truth contains only a part. Its acceptance, which may be said to be general, indicates a curious wrong view of the purposes and functions of the teacher. Pressure, provided it be not too heavy, seems to be admitted as an allowable condition in education and only dangerous and condemnable when "over" or beyond what is bearable by the pupil.

But for a right understanding of the question all ideas of pressure must be put aside. Education means expansion and not pressure, it means leading or drawing out and not pushing in. A child is not to be forced but to be led, not to be hurried but judiciously restrained, not to be taken out of the hands of Nature but to be protected from the artificial evils of modern life, not to be moulded or squeezed into the particular shape that happens to be fashionable at the hour, but to have the faculties of body and mind that happen to be his personal endowment encouraged and developed to the utmost fulness of their capacity.

A rational system of education would provide for the improvement and not permit even the temporary impairment of the child. Slowly it may be, but surely, bodily strength and mental ability should increase. The muscles, the nerves, the internal organs, the senses should all improve. At the end of a term all the children should be better—in every respect—than they were at the beginning. The holidays may be needed for the teachers, they may be desirable for the maintenance of home life and family ties, but they should be entirely superfluous in the matter of health. Nature has no terms or holidays—she builds up by the perpetual increment of infinite small additions. She repairs waste as she goes along. The rush of a modern school and the loafing of the long holidays have not the sanction of any natural law. It is assumed that you may "take it out" of a child to any extent provided there are long holidays. The holidays are definitely supposed to be periods of rest and recovery and children are supposed to return to school improved in health. This is all topsy-turvey. Children should be better at the end of the term than they were at the beginning and short of accidents like an epidemic this should be the test every teacher ought to apply to his management. In some schools this result is very definitely, easily and permanently attained.

A school ought to be a healthier place than a home. Because the teacher ought to be an expert in the administration of the laws of health, but parents are necessarily only amateurs and for the most part possessed of the merest smattering of hygienic knowledge. They constantly err from ignorance, from indulgence and mistaken kindness, from indolence and from over-occupation in outside affairs of life. The children of the well-to-do eat and drink unwholesome food, sit up late, go to theatres, parties, and are often wearied with sight-seeing before their teens, and if they live in towns they stick indoors and refuse to go out without an object, and are very much dependent for their health on the annual visit to the seaside. It is not difficult for a school to do better. Among the poorer people a most marked illustration of the benefit to be derived from school may be seen in many of our infant schools. Here the children are taken from the crowded houses, from the unwholesomeness of washing day and other domestic difficulties, and put into well lighted airy rooms with cheerful companionship, singing, marching, bustling about in games directed by sympathetic and intelligent teachers. Without question the children are great gainers, and the writer has no hesitation in saying that they would do better without holidays.

The question of over-pressure is not merely one of school nor of the mind alone, nor is the schoolmaster wholly responsible for many breakdowns. The deficiencies of home life, inherited weakness of constitution, the subtle, almost imperceptible effects of infantile ailments, injudicious feeding, such as late dinners, wine, etc., cramming by conscientious governesses and music teachers, or on the other hand a slackness and want of preparation (both of body and mind) that make all application or effort a toil, assist in producing the lamentable result. No single or simple cause is efficient. A general wide survey of all conditions must be made. The first duty of a teacher is to make himself a proficient observer of the health of children and to learn how to vary his routine so that the favourable influences are continually (not intermittently) brought to bear and the unfavourable are banished. No great amount of knowledge is required. The trainers of racehorses and dogs may be trusted to bring their animals to the post in the pink of condition on the strength of close personal observation, mother wit, incessant care, and a determination to win.

THE STANDARD OF HEALTH. The first thing to do is to establish a standard of health. This is generally pitched too low. Town dwellers especially have become accustomed to a condition of lowered vitality, and the family-doctor with an eye vitiated by the constant contemplation of sick people and convalescents is often too easily satisfied with a condition of health that is only relatively good. Personal observation should be made of really vigorous specimens of the human race, both in school and in adult life, to establish a standard of comparison, and when children fall short enquiry should be made into the causes and no pains spared to effect an improvement. Observation to a person of literary training is at first irksome but perseverance will make it easy, and the superior attractiveness of a first-hand knowledge of the real thing compared with the shadowy information derived from print, will tell in the end and make the task delightful.

One difficulty experienced by the untrained observer is in seeing things as they are and not as he would wish them to be—to divest the mind of preconceived ideas. One source of the great modern advances in medical knowledge has been the observation of the natural history of disease, in other words, noticing what happens when a disease runs its course without interference from the doctor. At one time the treatment of diseases was exceedingly vigorous, and patients were blistered, bled and cupped on the slightest pretext. But the observation of cases left without remedies has shewn how far Nature may be trusted, and afforded a standard whereby the efficacy of treatment may be estimated.

By simply looking at facts as they were a revolution was effected.

The teacher must begin by clearing his mind of prejudices in favour of his own calling. He must observe the child freed as much as possible from interference. He must note the instincts, the modes of activity, signs of fatigue, ways of taking rest. He must note the bent of the mind and the various ways in which interest is aroused and exhibited and how boredom is reached. He will then find that children naturally do certain things which conduce to health and others which contribute to disease. He will have no difficulty in offering a guidance that will be wholly beneficial. He will learn that signs of fatigue, listlessness, mental ineptitude are his best guides, that his buildings or his method of teaching, or his subjects, or his time-table are wrong, and he will reform accordingly. He must cultivate the habit of observing children incessantly as a sailor watches the weather. But he should not attract attention. Children should not be fussed about their health, or be bothered by too many measurings, weighings, or scientific investigations. Above all they should not be questioned without cause. The outward and visible signs of health should be first noted.

THE COMPLEXION. The aspect of a healthy child should not be difficult to learn.

The cheeks are plump, the skin smooth and free from blotches or pimples, the tint more or less inclining to red, but varying from a delicate pink to a ruddy brown according to type.

English children are not naturally pallid unless born in the tropics, but those of a foreign ancestry often present a yellowish tinge which is compatible with health.

The lips are never pale.

THE SIGNIFICANCE OF PALLOR. The reddish tint of the skin and the pronounced crimson of the lips, etc. are due to the colouring of the blood shewing more or less clearly through the tissues. The colour is not held in simple solution but is due to an infinite number of small disks not unlike coins in shape. These red corpuscles (as they are called to distinguish them from another kind called the white or colourless) are very small, being only $\frac{1}{3200}$th of an inch in diameter, not more than a fourth of that in thickness. Their chief use is to convey oxygen to the tissues, and they are therefore directly concerned in the maintenance of life. Their number is subject to great variation. A full number implies bodily vigour, but a diminution means corresponding weakness, and if reduced beyond a certain number breakdown and death follows.

The importance of the complexion as a gauge of vigour is obvious. When the number of corpuscles is so reduced that a marked pallor results the person so afflicted is said to be anæmic.

A vast proportion of town dwellers are slightly anæmic and though they pass for healthy are really carrying on life in a state of lowered vitality that only senses blunted by custom would allow us to tolerate. But though the necessities of earning a livelihood may render a change of conditions impossible to adults, no difficulties should be allowed to stand in the way of the prevention and cure in the case of growing children.

Although it arises from many causes independent of school it is to an overwhelming extent artificial—the result of an indoor life and the deprivation of sunlight. Flowers can be made anæmic by being grown in the twilight. In the early stages the pallor of the complexion may not attract attention, but the child becomes languid, loses appetite for solid food—but may even eat pastry, messes, or odd articles such as slate pencils, bits of chalk or coal—shirks games, is inattentive, yawns, and is drowsy. At this period doing away with certain lessons and substituting gentle exercise in the open air will often be all that is needed, but a pronounced anæmic should not be allowed to come to school and should be placed under medical care.

GROWTH. Growth is the *raison d'être* of childhood. If man could be born full-sized like Minerva there would be no need of childhood, but he is of necessity born small and he has to be built up to his natural stature from the outside. An infant weighs from 6 to 12 lbs. at birth (some considerably less), but a healthy adult Englishman may be expected to weigh from 140 to 180 lbs. without any superfluous fat. It is by the absorption and assimilation of substances in the shape of food derived from the animal and vegetable kingdoms that the transformation of the tiny infant to the full-grown man is effected. If a child does not grow it is because it is not absorbing sufficient food. Either the food is insufficient in quantity or of indigestible quality or the organs are not doing their duty. "One man's meat is another man's poison" because one man has a powerful digestion and the other has not—and the problem of providing wholesome food is much simplified by providing an active penetrating gastric juice. Failure of growth means a digestion not doing its appointed work of supplying repair of present waste and putting by something for the future. Insufficient supply to any growing organ means a failure of that organ to reach its natural capacity in adult life. It may be the heart, or brain, or the limbs that suffer from the deprivation, but if the full vigour and strength is not reached during growth the deficiency can never be made up. We can train an organ comparatively late in life, but we cannot build up its force.

Taking the growth as an indication that the nourishment of the body is or is not proceeding properly, the teacher should devise means for keeping some record of measurement. But little time need be occupied and the teachers' work need not be much increased. Children are always interested in their own heights, and prefects may be trusted to be sufficiently accurate for school purposes. A rough measurement is always desirable for the allocation of writing-desks, for classification in runs and contests and is sufficient for practical purposes. In taking measurements the teacher must rely on his own observation of the children under his care and beware of being beguiled by tabulated averages which from the nature of things fit nobody accurately. It cannot be too clearly laid down, or too frequently repeated, that the business of the schoolmaster is with the individual and not with the mass, so that the minute measurements that might be serviceable to anthropometry are not immediately useful to the particular pupil whose well-being happens to be in question. The problem is not whether the average growth of the boys in Mr. Blank's school is above or below the published average, but whether the growth of Exe minor or Wye major is proceeding at their own normal rate as ascertained by previous measurements. The growth of children is of course liable to be affected by various causes independent of the temporary conditions of health. Short people grow less than tall and allowances must be made not only for national but for district differences of stature. A rate that would be satisfactory in a boy from a Welsh family would be unsatisfactory in one from a Yorkshire, or one from Surrey compared with one from Connaught. Generally speaking the opulent classes grow quicker than the labouring and manufacturing.

But the general characteristic of healthy growth is its conformity to a settled plan, the variations occurring at settled periods as trains may be run at different rates of speed over the same ground but always slowing at the same hill and quickening on the same down gradient. The rate at which each train mounts the gradient is in a definite ratio to its hourly mileage, a good pace for the thirty miles train might mean failure of steam for the express, but a retardation on the level would surely indicate something wrong with the engineering of both.

The published statistical tables are very confusing to readers who do not combine some medical with arithmetical knowledge.

Typically healthy growth during school-life should be uniform with two exceptional periods, one between 11—13 of slight retardation, the other of great acceleration between 15—17 in boys About a year younger for girls.

Boys who may be expected to attain a height of 5 ft. 6 in.

—5 ft. 8 in. grow about 2 inches per annum; the nearer they keep to this standard the more stalwart they are likely to be. Much less than this if regular indicates a dwarfed stature, if irregular defective nutrition or illness. If above 3 inches per annum besides indicating a corresponding tall stature involves a great strain on the stamina.

In the curious period of retardation not more than half the usual annual rate is likely to be reached.

In the great start of puberty the ordinary rate may be doubled. In both sexes, but more especially in girls, this period is one of great stress and of inestimable importance in the development of the constitution. Muscular and brain-work should be lessened, no feat requiring long-sustained exertion either of body or mind should be allowed. A jealous watch should be kept for the earliest symptoms of failure and immediate and decided measures taken to give relief. It is at this dangerous period that the "seeds of consumption are sown," or that an adequate nervous system has its development arrested so that it grows up with a fraction of its intended power and exhibits weakness in the shape of hysteria, neuralgia, irritable temper, and even insanity.

Teachers of singing are the only people who have preached a physiological rest—they are wiser than others, as the voice is something whose quality can be measured by the senses, whereas the nervous system is only understood by physicians after long study. But what is true of one organ is true of the whole body and every part of it. Heavy strains must be paid for dearly in after life.

CHEST-GIRTH. Increase in the circumference should also be steady, but no very precise rule can be given. Half an inch per annum may be taken for a fair average for two inches of growth. Rather less at the period of retardation, and about $1\frac{1}{2}$ inches during the remaining three or four years. The development of the chest does not follow the startling increase in the limbs that occurs in the one critical year, but failure to maintain its own rate of growth throughout should be viewed with suspicion. The development of the chest is much more an affair of management than the length of the legs, which is to a great extent settled by nature. Indoor sedentary life means shallow breathing and a poor chest. But no part of the body responds so rapidly and surely to systematic exercise. Mr Maclaren's reports of the Oxford Gymnasium are well known and most instructive, but equally convincing results can be obtained with children taken haphazard, reducing the amount of the conventional desk-work and substituting equable, graduated, and simple gymnastics suited to the age. A broad chest is one of the best guarantees for success in life, but an ill-developed, narrow, pigeon-breast is a handicap on hard work and often little better than a death-trap.

WEIGHT. The most dependable test of a child's increase in bulk is the weight. An adult should maintain a fairly even standard, putting on or dropping a few pounds according to circumstances without any marked variation in health; but a child should steadily increase year by year according to a definite standard. Failure to reach that standard must be regarded as an ill omen and actual *loss* of weight a sign of imminent danger.

Many tables have been published but they have only a limited value in practical work as they deal in averages and are therefore inapplicable to the individual. It cannot be too often repeated that the business of the teacher is with the individual and not with the mass. The question is not whether a child's rate of growth is above or below the average —as the phrase runs—but whether he is or is not maintaining his own proper standard and whether that standard is one that has been unfavourably influenced by outward circumstances.

The teacher who desires to keep himself informed of the progress of his pupils should therefore ascertain the rate of increase peculiar to each child and take that and not the table of averages for his guidance.

The weight ought to bear a constant relation to the height, the margin of variation being small.

At 5 years of age a child weighs about the same number of pounds as he is inches high—a healthy child may be expected to be about 40 inches high and if sturdy a few pounds more in weight, say 42 to 44. The sexes are on an equality.

The rate of increase should be about 2 lbs. to 1 inch of growth and there should be a tendency for the proportion of the weight rather to increase. Excess of weight over height is a favourable sign—a deficiency unfavourable. In lanky, weedy children the weight is frequently outstripped—in common phrase "they outgrow their strength." These children should be made to rest by lying down in the daytime, be carefully fed on plain nourishing food; exercised in the open air sufficiently to maintain a healthy appetite, but not so much as to cause fatigue. All mental application that is not interesting and amusing should be rigorously stopped. With adequate care a temporary disturbance of the proportion of height to weight need not lead to permanent harm, but without precautions, often of the most stringent kind, these weeds are liable to grow literally *up* and never to attain their proportionate health and strength, so that they are burdened with a skeleton too long for their muscles and nerves and are easy prey to all those diseases which invade the feeble.

The rate of increase for the two sexes is fairly uniform till the onset of puberty, when in both a sudden start occurs corresponding with the acceleration of growth. The change is more remarkable in girls than in boys, but it lasts a shorter time. The transformation of the girl into the woman is a more abrupt, more rapid and more exhausting process than the change of boy to man.

The exact date of course varies but when it occurs is so remarkable that it cannot escape observation. It is now that the due proportion between increase in height and weight is likely to be adversely affected. It is now that the calls made by nature on the system are often dangerously exhausting and leave no margin for mental or bodily exertion. Fatigue must be avoided as a danger. Cases in girls observed as over-pressure have resolved themselves into nothing more than efforts to continue a not excessive amount of study during this period of constitutional strain. If a girl seems to flag without obvious cause she should be weighed, and if the weight is deficient everything thrown aside till the balance is restored. The routine of schools is purely artificial and bears no rational relation to the laws of the body's development, and unfortunately preparation for examinations is so mistimed that occasionally an increase of work and responsibility occurs at the time when both should be lessened. Growth at this juncture is not merely increase in bulk, but the transformation of a being hitherto merely self-existent into one capable of giving life to others. The wise teacher will regard nature's work with reverence and recognize the propriety of sparing the nervous system until the time of stress has passed.

The following table of proportionate height and weight during school-life (Ashby and Wright), will be found useful.

Height inches	Weight lbs.	Height inches	Weight lbs.
40	44	51	67½
41	46	52	70
42	48	53	72½
43	50	54	75
44	52	55	77½
45	54	56	80
46	56	57	82½
47	58	58	85
48	60	59	87½
49	62½	60	90
50	65		

Measuring and weighing do not replace but give precision to personal observation. The teacher should cultivate the habit of watching the physical development of children at first hand. He should especially frequent the swimming-bath and make himself acquainted with the plump rotund appearance and firm feel of strong growing muscles compared with the unsatisfying outline and flabbiness of the ill-nourished, whether from insufficiency of food (as amongst the poor) or insufficiency of exercise as amongst the sedentary. The familiar act of "feeling the biceps" affords more information than the tape. The shape and mobility of the chest should be observed. Contrast the well-curved sides and the free lift on inspiration of the well-grown out-door child with the poor flat front and the sunken hollow under the collar-bones, the feeble respiratory movement of the sedentary town-dweller and remark the flattened sides and narrow frontage of the pigeon-breasted. The final outcome of these chests should be studied in the adult. Nothing is more convincing of the value of physical culture in youth than a comparison of the efficiency in life of men with broad chests with their feebler brethren. Note should also be taken of the growth of the bones—if the limbs are equal in length, if the child stands straight with a vertical spine, or whether one shoulder is higher than the other with a lateral crook in the back, of bow-legs, knock-knees, inturning of the ankles, flat-foot, overlapping of the toes. After a careful study of the nude, awkward movements will be easily detected in the clothed and referred to their right cause, and the teacher thereby enabled to recognize the beginnings of perverted developments in the play-ground.—No knowledge is better worth cultivating, as failure of growth may very frequently be remedied if taken in time but if neglected a defect that need only be temporary will become permanent. Besides the visible aspects of growth, we must remember the internal organs are at the same time developing well or ill in accordance with the general rate of progress made by the whole body.

The Nervous System. The nervous system is the seat of all bodily and mental force. From it are derived the power that causes the heart to beat and the influence that regulates the rapidity of its pulsations. The foot in walking or the hand in writing are as much moved by the brain as are the limbs of marionettes by the fingers of the hidden showman. Breathing, digestion and other inner functions all depend on the nervous system though all are not equally under the control of the will. In brief the whole machine may be said to be driven by the brain as the prime mover, but the brain being in itself a bodily structure is dependent for its nourishment and vitality on the very organs it governs. Thus a shock to the nervous system will give rise to indigestion, this leads to insufficient nourishment of the brain, which becomes further weakened from lack of food and more and more incapable of providing the necessary nerve-force to the stomach for the performance of its work, and so the reciprocal enfeeblement goes on, cause and effect changing places and culminating in a permanent injury to the efficiency of both organs.

Intellectual work, though apparently metaphysical, is also an outcome of brain activity. The movements of the muscles required in the arts of music, sculpture and painting, articulate speech, writing, all result from action of portions of the brain acting in combination, and the same is true of perception by the senses, of memory, imagination and abstract thought. The painter drawing the outline from a model, the mathematician making a calculation, the philosopher evolving a theory, all set a portion of the brain in action, all cause the destruction of a portion of the brain tissue which is thrown off as waste products. These must be removed and the waste repaired by fresh brain just as certainly as the ashes must be taken from a furnace and replaced by fuel if the engine is to go on.

During school-life the nervous system is called upon to provide for (1) the general muscular movements of bodily exercise. This removes more waste-products than it causes and promotes repair by improving appetite and digestion; (2) for the small muscular movements of writing, drawing, &c. and the purely intellectual work of learning. These cause waste-products, but do not assist in their removal and therefore tend to final enfeeblement; (3) for the exhausting strain of growth and consequent changes. These in nowise provide for repair, and sometimes occur with such violence that they may be likened to a run on the bank and only be met by calling on the reserve and strict economy in all other outgoings.

The peculiarity of the nervous system is that it is built up very slowly, but it is liable to very sudden destructive changes. A blow on the head may convert a potential genius into an idiot. "The brain, it should never be forgotten," says Sir J. Crichton Browne, "is made up of explosive material, the explosiveness of which may be heightened or reduced. In states of disease such as insanity or epilepsy the brain-substance, or certain tracts of it, are raised to a higher degree of explosiveness, as gunpowder is when mixed with nitro-glycerine. In states of idiocy or imbecility it is reduced to a lower degree of explosiveness, as gunpowder is when mixed with moistened clay so that it only burns slowly away or will not light at all." This illustration by one of our highest authorities conveys no more than the exact truth which should be pondered by every teacher. Sir J. Crichton Browne of course speaks from the actual evidence that has come under his notice, evidence as tangible to him, a skilled observer, as the debris of a building after a firework explosion would be to a surveyor. But he might have added that though the results of the explosion are manifest afterwards there is neither noise nor smoke at the time of its occurrence—nor is there always sufficient warning to enable us to avoid the catastrophe. It may be compared to short-circuiting, which occurs without warning and lasts scarcely a second, and yet may throw an expensive galvanic battery entirely out of gear and perhaps destroy it.

Thus the teacher will perceive he is in charge of a machine of which he does not and cannot understand the construction —one not fully formed, but liable automatically to inflict injury on itself, and one which he may as readily influence for evil as for good.

Warnings of the explosions. Precocity is the delight of parents and ill-informed teachers. Two kinds may be distinguished. (1) Natural, in the case of genius, as in Goethe, Mozart, Pascal, and Christopher Wren. It indicates a brain of unusual character and often corresponds to an exceptional physique, capacity for endurance and longevity. (2) Merely exceptionally rapid growth (activity as contradistinguished from stability), great impressionability, receptivity and excitability. These children see their way to good places in class and can accomplish their wishes, they are often highly emotional and sensitive to praise or blame, easily egged on by emulation. They can be run with a minimum of trouble for examinations and scholarships. The brilliancy they exhibit is not strength but excitability.

It is a matter of common observation that the after-careers of show children do not correspond with their start, but the suspicions of the literary teacher are scarcely yet aroused to the danger and inefficacy of pushing them.

But however contrary it may be to justifiable aspirations and wishes the conscientious teacher should regard a precocious mental activity unaccompanied by exceptional physical strength (broad chest, big limbs, equable growth and calm disposition) with grave suspicion and generally an indication for putting on the drag and not for the use of the whip. Common sense would dictate that if a child present more than ordinary cleverness, either from genuine natural gifts of a stable order or from exceptional impressionability, there is the less need for pressure, and if the artificial baits of grants, scholarships and the examination-advertisement could be withdrawn from our system no doubt common sense would prevail and a reasonable course be pursued. But temptation is placed in the way of teachers to do wrong under the similitude of duty.

Visible warnings. Epilepsy in its more pronounced form is a familiar disease, but it also occurs in a masked form without the ordinary convulsions, and accounts for strange short lapses of memory, unwarrantable and unaccountable exhibitions of passion and periodical fits of dulness. A bad form occurs only at night during sleep and can only be inferred from the wetting of the bed and lethargy on the following day or days.

St Vitus' dance is well known to follow on fright and emotion in certain constitutional states.

Physicians consider these diseases, though not directly caused by school, as liable to considerable aggravation by bad educational methods. In a minor degree jerkings, twitching and even fidgets may be signs that the nerves are becoming unstable and require bracing up.

School-headaches. The teacher should be on the alert to discover headaches in the oncoming stage when they are rather a symptom than a disease and therefore curable. If not checked they may persist, like all disorders of the nervous system, long after the original cause has ceased to exist. Healthy children never suffer from them and they therefore betoken either something wrong with the constitution or some defect in hygiene. When existent no trouble should be spared to discover the cause and apply the remedy. In enquiring about headaches and other pains direct questioning should be avoided, partly because children should not be encouraged to consider their own health too curiously, and partly because the way of the malingerer should not be made easy.

The headaches commonly found in schools are the following:

(1) Those due to temporary causes, such as injudicious feasting at the tuck-shop, late parties with suppers of sweet things and wine (!), smoking, the early stages of cold in the head, the premonitory stages of epidemic diseases.

(2) Those occurring in weakly children unfitted to withstand the strain of school-life. There are generally other signs of debility, anæmia, poor appetite, languor, fidgets, nervousness. But often no obvious sign of ill-health is present and the children appear robust so long as they are favourably placed. But the confinement and headwork of a school falling upon a nervous system which is immature begin to tell upon them. After a period in which headaches occurring after difficult tasks, a little over-excitement, &c., give warning of danger, some definite symptoms make their appearance and a breakdown occurs. Children of this kind withdrawn from school and sent to a farm where the greater part of the day can be passed in the open air are often revolutionised. With regard to the question whether positive disease can be provoked by trying to push through with a brain unfitted for its work, the answer seems affirmative. Sir J. Crichton Browne entertains no doubt on the point. Bearing in mind the extreme liability of the child's brain to become the seat of inflammation on small provocation the necessity for extreme caution in regard to headachy children is apparent.

(3) Those occurring in children with obstructed nostrils and frequent cold in the head. The dulness and heaviness of a cold in the head are well known and are due to the swelling of the mucous membrane. Neglected children are sometimes seen, some disgusting discharge always falling from their nostrils, their breathing obstructed by adenoids and tonsils. They are exceedingly liable to headaches which disappear after proper treatment of the nose and throat.

(4) Those dependent on eye-strain. The overwhelming majority of school headaches are due to this as a first cause. The greater proportion are relieved by the mere use of proper

spectacles, and give little or no trouble, but there is a small residuum in which the nervous system has become artificially over-sensitive and the habit of pain remains after the most careful adjustment of glasses. The kindest and the shortest plan with these cases is to send them into the country for a term or two. As a rule headaches depending on the eye are quickly as well as effectively cured by spectacles alone.

CHAPTER XV.

OVER-PRESSURE AS AFFECTING THE INTELLECT.

WHEN we approach the hygiene of those elements of the nervous system which take part in what are termed mental processes the difficulties of observation increase. The origins of good and ill are less tangible. There are no means of weighing or measuring—there are no standards for comparison; whether strength is being gained or lost, whether growth is equable or disturbed, can only be estimated by personal observation and inference. The welfare of the larger muscles and that part of the brain which governs them can be directly tested by noting if the increase of strength is in satisfactory accordance with age and growth, by the record of weight lifted, or the work on the parallel-bars, the pace in the running-field or in swimming, and so forth. All these facts can be measured by scale or tape or stop-watch with the greatest accuracy and entered in a ledger. But the perfection of "mental processes" cannot be gauged. The working of the higher intellect is an inscrutable mystery and cannot be measured except in a rough and very inaccurate manner. It might be supposed that a child's capacity to learn lessons would afford a safe guide to the condition of its brain. But no: as well attempt to measure the healthiness of its digestion by its capacity to swallow food. It is well known that children will eat too much, or choose unwholesome food, and starve in the midst of plenty from the discrepancy between their appetite and assimilation.

Certain disorders of the stomach are accompanied by "feelings of sinking" and an increased desire for food so great as to look like greediness, and the food swallowed only aggravates the evil. In the same manner excitement or irritation of the brain may give rise to a temporary increase in the capacity to learn, and a spurious cleverness which it is impossible to distinguish from the genuine and healthy action of the intellectual centres.

Actual destructive diseases of the brain, both in child and adult life, are often preceded by a period of exceptional activity and brilliancy to be followed by a lamentable fall. Hence the necessity for caution in dealing with show children.

Part of the business of the educator is to stimulate and exercise (with the requisite gentleness be it understood) the centres of the brain in proportion as their activity becomes manifest. In order to do this no recondite knowledge is required. A profound conviction of the delicacy and complexity of the organs in question and close observation of the doings and sayings of individual children must form the basis of safe teaching. The teacher does not make or call into existence any part or function of the brain as ambitious mothers are prone to believe. He plays the part of the driver, who has not bred his horses but who by the right use of reins and whip regulates the paces and economizes the energies of his cattle, so that not only does a good whip get more out of his team than a bungler, but they are in better condition and they live longer.

There is all the difference between good and bad teaching that there is between good and bad driving. In studying children from infancy (and no teacher should omit infancy) especial note should be taken of what they do spontaneously, what use they make of opportunities, and what they do by dint of imitation. A conscientious observation of these indications used in devising the scheme of education best adapted to individual children would be the death-blow to more than half the artificial teaching at present in vogue.

For instance, children present certain common characteristics, the difference being in the rate of development and not in the order. A baby in the early stages puts anything it takes hold of into its mouth, later on it will look at the object before tasting, later still the tasting is omitted. There is never any variation in the order in which these processes occur, so of others. Nature observed without prepossession, will be found to be occupied with the development of the senses and the regulation of muscular movement long before any purely intellectual qualities are shewn, and this order is not dependent on teaching but on the growth of certain sections of the brain. Now during this nascent period the senses can be most easily trained in combination with muscular movement, but only with difficulty in combination with the reasoning powers.

A most obvious combination of a sense with muscular movements is speech. A word is heard by the ear and imitated by the movements of the mouth—a great number of sounds heard and imitated constitutes a vocabulary.

Children of normal intelligence acquire extensive vocabularies with amazing facility if entirely taught by the ear, but they learn very slowly and retain very badly if taught by means of books. This is the stage at which languages can be profitably taught (orally), singing, music and dancing—for the sense of hearing is in its most receptive condition and the muscles most obedient to instruction. To listen to music and to dance is natural to healthy children, and though the discipline necessary for learning the steps may at times be irksome the dancing lesson itself (if not foolishly prolonged) is pleasant because it is (in part at least) a fulfilment of a natural instinct. In like manner children can be taught to draw not only triangles, polygons, and geometrical forms but complicated patterns and the shapes of natural objects and animals—in other words, to draw anything they see—long before they can be taught by their own reasoning or the reasoning of others that the angles at the base of an isosceles triangle are equal. But public opinion demands that the angles should be understood, and the delusion exists that the *sooner* they are begun the *better* they will be mastered. So far from this being the case years are frittered away in confusion and irritation without any good result because the necessary sections of the brain are not yet sufficiently matured to assume effective action.

It is beyond the province of this essay to do more than hint at the natural bases of education, but the foregoing essential point requires to be grasped in order to understand why the ordinary studies are so ineffective with some children, so irritating to others, and so benumbing and stupifying to an unfortunate few.

A comprehension that the brain is a complicated sectional organ occupied like the rest of the body with the exhausting process of its own growth—*in its own manner and its own time*—lies at the bottom of the hygiene of the nervous system. The common-sense rule is to follow the dictates of nature and watch the development of every faculty before attempting its cultivation. Unfortunately every function is capable of stimulation *before* its time. The danger of certain vices is universally admitted to depend on this fact. It is undoubtedly true of the mind. Clever, excitable children can be stirred up to a fictitious display of mental ability that is deceptive even to cautious and experienced observers. Only the miserable failure in after-life betrays the mischief done. But in certain cases the ill effects are visible at the time.

Beginning with very slight indications, fidgets, twitchings, excessive sensibility to moderate reproof, unreasonable outbursts of temper, irregular brain-action, fits of sharpness being succeeded by fits of stupidity, or quickness in learning by inexplicable slowness over similar tasks, "over-pressure" may shew itself by well-marked signs.

Excessive difficulty in getting to sleep and talking in the sleep—disturbed dreams, somnambulism and night terrors are due, of course, to many causes of irritation (*e.g.* indigestion or worms) besides mental irritation, but are frequently due to over-excitement of the brain from lessons.

A mother volunteered the statement (without understanding its import) that her boy "walked in his sleep" always on the night of his most difficult lesson.

Hysteria is generally associated with the idea of attacks of uncontrollable laughter, tears, kicking, &c. and rather a subject for joking, but the real affection is a most lamentable defect in nervous nutrition, and shews itself in many strange fashions, especially by a mimicry of genuine diseases. The victim presents all the appearances of being a malingerer without really malingering. Excruciating pains are felt in the joints, loss of power in the legs, partial blindness in one or both eyes, &c. The moral nature appears to suffer, and incredible deceptions are practised by girls who have formerly been open and truthful. Boys are not exempt, but the symptoms are generally less marked. No doubt exists in the mind of well-informed physicians that though the affection is spoken of contemptuously and its symptoms are frequently ludicrous, it is a definite and serious malady, capable of wrecking the happiness of lives. The influence of school may cut both ways—so far as irritation from injudicious or excessive literary tasks goes it may tell badly, but so far as order, method, and discipline are concerned it may work for good.

From the foregoing it will be perceived that the special danger to the nervous system from schooling is exhaustion by premature stimulation, and that the chief error to be avoided is that of supposing that all brains are equally developed, or even adapted for a system of education which is purely artificial and conventional. Thereby occurs a waste of energy which in some cases may cause friction and worry, and suffice to injure a nervous system, with the balance dipping towards the wrong side from causes unconnected with school. The mistake generally made is to endeavour to make the child fit in to the school routine rather than to modify the routine to meet the peculiar needs or weakness of the child.

Children vary astonishingly in nervous energy—even more remarkably than they do in physique—and the same child varies from time to time according to the calls made upon its constitution. Thus the period of the second dentition affects some children, especially those brought up without sufficient open-air exercise. A child is naturally less impressionable than it is in infancy, when "cutting the teeth" may amount to a source of danger, but anyone who has suffered from the worry of a tender tooth or an aching jaw may realize that the process of replacing one set of teeth by another may be a serious drain on the nervous energy of a poorly constituted child. The accomplishment of puberty is sometimes accompanied by very curious mental disturbances, untowardness, morbid introspectiveness, religiosity, and other signs of debility to those who know how to read them. Unfortunately at this time of stress important examinations often have to be faced, and a temporary condition is aggravated and prolonged by the necessary hard work and inevitable anxiety. All who have had charge of the young are aware of the difficulty of managing this troublesome period.

The fag-end of winter—miscalled the spring—finds some children in an exhausted condition, requiring considerable relaxation of work and increase of rest. Convalescence from febrile diseases—measles, scarlatina, mumps, typhoid, &c. is another period to which sufficient importance is not attached. The fact that a great acceleration of growth frequently takes place during the attack indicates that vital processes have been hastened and a compensatory slack time is required. The ill effects of immoderate reading in the early period of recovery must not be forgotten. A comparison of the ratio of weight to growth assists in forming an opinion.

Even the time of day has to be considered. A child that is fresh and capable in the morning may be enfeebled by the afternoon and incapable of any safe work in the evening. The custom of postponing preparation till the evening is opposed to physiology and common sense. Its prevalence is evidence of the neglect of hygiene by educators. There is some reason for supposing that it is rather of modern growth, and due possibly to great improvements in artificial lighting that followed the invention of gas. Leigh Hunt in his account of Christ's Hospital school (*circa* 1800) gives the hours of leaving off work at 4 p.m. in winter and 5 p.m. in summer. If this is true of other schools we may in this matter with advantage recur to the wisdom of our ancestors.

L'ENVOI.

Over-pressure is not a positive condition, but a failure to reach the potentiality of the bodily and mental strength in any given child, and due not to one cause but to the action of a number of small influences acting in combination in a direction that makes for ill, and a concurrent omission of those influences which should in the course of nature be allowed to make for perfect development. The wise teacher will bear in mind that he may aggravate or counteract the evil influences of ancestry, unhygienic home surroundings, or a bad dietary. He will mistrust the artificial routine of educational systems and apportion his tasks to the development of his pupil. He will study the causes that tend to the promotion and growth of the young animal—viewed frankly as a young animal; and he will not be drawn from his course by the temptation of successes at examinations or the cheap applause of ignorant and exigeant parents. He will find he needs little beyond a steady first-hand observation of children for the means of acquiring the necessary facts, and little beyond common sense and a moderate degree of invention in devising methods for the attainment of his object. But he must above all things begin with an open mind and resolutely put aside all pedagogic prejudices, and remember that Nature never omits to call for the payment of a debt, only unfortunately she is not always certain to call upon the true borrower. The sins of the fathers are visited on the children, and so also unfortunately are those of the schoolmaster.

CHAPTER XVI.

THE BODY CONSIDERED AS A MECHANISM.

In Nature one of those rare places at which there seems, owing perhaps to the imperfection of our knowledge, a distinct gap in the long chain of creation lies between living things and things inanimate. Physiology may be described as the study of the working of living things. In this animate field of Nature the physiologist is a student somewhat as the engineer is a student of inanimate machines. The living machine, like those of the engineer, produces work—moving itself and things—and produces heat—hence our body's warmth—and produces electric stresses, and so on. The living machine wears too as it works, but, more complex than the machines of the engineer, it restores its parts as they wear and much of its labour goes in renewing its own living fabric from suitable dead material which we call food.

The engineer studies his machines that he may drive them to the best advantage, that he may if they break down repair them, that he may make new ones better than the old. The physiologist in reverent study of the living machine knows—no one so well—he cannot construct another, still less achieve improvements on the old. Yet among his practical aims one is the acquisition of knowledge how best to keep the body from damage as it works, active and healthy. For the teacher who has charge of so large a fraction of the daily life of growing children such knowledge is especially important. The principles underlying the healthy working of the body are the basis of Hygiene. School Hygiene consists in large part of the commonsense application of these principles to the particular needs of the schoolroom and the play-ground.

Chemistry and the Bodily Machinery.

Last century the chemist carried out a vast analysis, impossible at any previous stage of human history. He tested the chemical nature of the materials of practically all the million-sided universe perceptible to man. He learned that despite all its diversity it is yet chemically composed from relatively few, about eighty, essential substances therefore called "elements." As the many thousands of words in a great language are compounded from the relatively few letters of the alphabet so though in vastly greater variety the countless assemblage of different chemical substances are but diverse combinations of a few score of recurring chemical elements.

The chemist's analysis included living matter, the human body and that of animals and plants. It might have been thought that matter exhibiting life would reveal chemical elements peculiar to itself and different from those of the inanimate world. It is not so. Some few of the chemical elements most widely spread in air and sea and rock make up the tale of those which everywhere compose the machinery of life in all its forms. The secret of the chemical difference between life and death lies therefore less in the nature of its elemental ingredients than in the manner of the compounding of them. Many illustrations could be taken. Carbon compounds preponderate not only in plants and animals but in many rocks and soils. Those of the latter dissolve and from their solutions can be obtained as crystals. Now though the body consists of water to the extent of more than half its weight, its carbon-compounds are for the most part not dissolved therein but exist in a kind of particulate suspension. Unlike those of the rock they will not crystallise out; and they contain not definite but variable proportions of water. They do not carry electrical charges in the same way, they do not exert the same pressures or exhibit the same tensions. They offer much greater difficulty to present methods of chemical research. The number of constituent atoms which their molecules contain is much greater; the energy locked up in them is greater and in great part easily liberated because they are combustible *i.e.* decomposible by oxidation; their movement in watery media is more easily restrained by membranes. They are in a state which is termed colloidal. Not that the living body is devoid of simpler chemical compounds such as are characteristic of the inanimate world. The living body contains mixed with its colloids dilute solutions of crystalloids. And this commingling renders their study still more intricate.

How largely the working of the body is a chemical problem is evident from the profound effect wrought on it by the minutest quantities of certain poisons which admitted to it work havoc with the delicate chemistry of life. A drop of cobra-venom or of diphtheria poison injected through a hollow fang or needle and the whole machinery perishes in a few hours or days. We can realise that the body, a chemical machine, sometimes poisons itself in its own working. In the chemical decomposition which is the constant accompaniment, indeed the basis, of so much of the living activity of the body, some of the products formed are harmful to vital machinery. If the activity of an organ be too intense or too prolonged these products tend to accumulate more quickly than they can be neutralised or removed, and thus tend to impair the activity. Fatigue seems to be such a case, a case of temporary poisoning of the body by the chemical débris resulting from the body's own superactivity.

Proteins.

The colloids which chemistry finds in the body are all of them carbon compounds. They belong to three great groups called respectively proteins, carbohydrates, and fats. The proteins bulk largest, are present in almost bewildering variety. They contain nitrogen. They constitute the kernel so to say of the chemical construction of all living matter. They are an indispensible food for all animals since they are necessary for the repair of protoplasmic waste, the animal being unable to build up its proteins except from protein material. Besides carbon and nitrogen they contain the elements hydrogen, oxygen and sulphur, and many of them phosphorus and iron as well. The albumens, such as those of egg-white and of blood are proteins. We eat meat chiefly for the sake of the proteins which mainly compose it. Although the protein class embraces a wide range of different degrees of chemical complexity, even the simplest of them are immensely complex. The chemist in his laboratory is however now able to construct certain of the very simplest of them from their elements. Among the atomic groups found in proteins are many which belong to the fatty acid series and are therefore akin to fats; some also contain atom groups akin to the carbohydrates. In their decomposition the proteins yield ultimately ammonia and carbon dioxide and water, and their natural decomposition in the body has as its characteristic end product urea, $CO(NH_2)2$, the main constituent of the urine and to be broadly regarded as a compound of ammonia and carbonic acid.

Of the protein decomposed by the body in its living practically all the N finally leaves the body as the N of the urea. The amount of N in 1 grm. urea is about ·47 grm. This is about the amount contained in 3 grms. protein. But 3 grms. protein contain 1·5 grm. C, and ·2 grm. H and ·03 grm. S; whereas the 1 grm. urea corresponding with 3 grms. protein contains only ·2 grm. C, ·06 grm. H, and no S. Therefore the 3 grms. of protein in their degradation in transit through the body to 1 grm. urea though they have lost none of their N have lost 85 °/₀ of their C, 70 °/₀ of their H, and all of their S. These missing quantities are accounted for in the other excreta of the body and there appear in fully oxidised form as CO_2, water and sulphates. The protein entering the body has therefore its C and S and most of its H treated as fuel and oxidised, thus yielding energy to the bodily machine, but its N the living oxygenation process does not oxidise. The rôle of the N may be figured as that of furnishing a chemical centre to which are attached side-groups of readily oxidisable C, H, S, and other atoms, and holding them attached in a suitable form for introduction into the living machinery as fuel for the energy-liberating combustions conducted by that machinery. If the surplus of C and H attached to the N of the protein does not appear in the excreta it is retained in the body as carbohydrate or fat; in this case its appearance in the excreta is merely deferred for the carbohydrate and fat will in due course be treated as fuel and ultimately oxidised to CO_2 and H_2O.

CARBOHYDRATES.

Carbohydrates are a great chemical group exemplified by the starches and sugars, and more abundant in plants than animals. The sugar glucose is of wide occurrence in the animal body; so also glycogen, a carbohydrate of larger molecule, obtaining its name from its readily breaking down into glucose. The carbohydrates are built of carbon, hydrogen and oxygen. The sugars are less complex than the starches, are crystalloid not colloid like the latter, and the chemist has succeeded in synthesising many of them from their elements, which means that he knows more perfectly their chemical structure. Much of the energy liberated and dispensed in the working of the body is traceable to the decomposition of the carbohydrates. For instance when a muscle contracts and does work it does so mainly at the expense of the chemical energy supplied by the combustion of carbohydrates in the muscle.

Fats.

The fats of the body are in large measure glycerides, that is, they are compounds of glycerine with fatty acids. These acids contain in their molecule relatively large numbers of carbon and hydrogen atoms, hence they are weak acids. To them the glycerine behaves as a base, so that the fats are neutral bodies. They are chiefly olein, stearin and palmitin usually commingled though in different proportions in different samples of animal fat. The fats contain the same chemical elements as the carbohydrates though quite differently combined. The proportion of oxygen is much less in the carbohydrates. Some of the fats are much more easily oxidisable than others, an important point for their utility as fuel to the body.

Besides these simpler fats there are in the body a number of more complex fat-like substances. Some of these contain phosphorus and some nitrogen as well. They are especially abundant in the nervous system, where they sheathe and insulate the nerve-fibres. But they are distributed in small quantities very widely through the body and even in these small quantities are highly important. The products of decomposition of fats and fat-like substances in the body are in some cases fraught with harmful results, but in health the fats are a concentrated source of energy of which the body avails itself with great advantage.

Water and Inorganic Salts.

These manifold and complicated substances, protein, carbohydrate and fatty, which are the ingredients as it were in the great chemical complex of living matter have water as the medium in which they are suspended or dissolved. Water forms more than half the weight of the human body. The living material must be regarded as fluid rather than solid. When muscle exerts its mechanical power, its contraction, the means it uses are essentially a movement of the water in it. The blood that carries nutrient material to and waste material from all parts of the body is water with those materials dissolved or suspended in it. When the nerves carry their electrical messages they do so according to the laws of fluid conductors, of salts, dissolved and dissociated in water, the water being the water in the nerve fibres. It is water which forms the field of interplay of all the chemical substances, complex and simple, large molecules and small, composing the living body. And in this interplay the large molecules of the colloids, stores rich in easily liberated energy, and the small mobile molecules of simple salts—sodium, potassium, calcium, chlorides, carbonates, phosphates, are mutually reacting so as to control the movements and states of each other in ways important to life, but as yet little understood.

The Body a Commonwealth of Cells.

The chemistry and physics of the body go forward in a watery field, but this field is for the most part minutely subdivided by membranes, importantly restraining and directing the reactions. A first point to bear in mind in this connection is that the body is built up of *cells*. Eighty years ago the microscope made its greatest discovery. The old Greek simile of our school classic likened to man's body the body politic, the State, a corporate whole composed of individual members. Biology gives this a literal truth. The microscope reveals that plants and animals are literally commonwealths of individually living units, each unit a mere speck. Collectively in each one of us they outnumber the whole earth's human population. Thus the corporeal house of life is built of living stones. In that house each stone is a self-centred microcosm, individually born, breathing for itself, feeding itself, consuming its own substance in its living, renewing its substance to meet that consumption, harmonising with its own inner life some special function for the benefit of the whole, and destined ultimately for an individual death. Day long, night long, in this commonwealth which constitutes each one of us there goes forward as in the body politic the subservience of many individual purposes to one, the sacrifice of individual lives for the advantage of the many, and the birth of new units which replace the dead. And in all this we ourselves do but resemble each plant and animal we see. And each of these living commonwealths began its individual existence as a single unit, whence arose the myriads which compose its adult being. Division of labour developed among the multiplying units and with it differentiation of structure, organisation going hand in hand with growth.

The cells produce also fibrous material and fluid which collect about them, so that the cells become imbedded in and separated by quantities of extra-cellular material of their own making. The living laboratory of the cell in these cases manufactures even the medium in which the cells themselves lie, and this surrounding material is in some instances a fibrous and lime-hardened framework as in bones, in others a supple and often elastic tissue as in ligaments and tendons, in others the very saps and juices of the body, for example the fluid of the blood and lymph. This material formed and shed by the cells makes up a large part of the body; it is not alive but it reflects very closely the condition of the living cells themselves and its chemistry is almost inseparable from that of the living cells. The difference between the child who, recovering from some disease is immune to that disease, and the child who not having suffered is not immune seems prominently expressed as a subtle chemical change in this extra-cellular "internal medium" of its body.

Subdivision of Labour and Differentiation of Structure.

The cells of the early embryo are to visible appearance all pretty much alike. But as growth goes on and in vast and vaster numbers they take up their stations in their destined places forming the manifold organs of the infant frame they individually assume characters which are widely different. Were the history of their descent not known they would not easily be recognised as descendants from a common stock. The cells of the skin surface become horny scales, the cells of the digestive glands become little sponge-like masses containing tiny grains of matter for secretion, other cells serving as store-houses for elaborated nutrient matter become tiny bag-like sacs for oil, for glycogen, etc.; the muscle cells become lengthy fibres with threadlike filaments running through them; the nerve-cells become fibres finer still and branching near their ends. Most of the cells when once they have assumed their places in the body remain there, anchored and stationary, but some, such as those of blood and lymph, are free, and move actively or are moved passively about within those fluids. In addition to the above-mentioned there are cells which form the so-called connective tissues of the body—tissues which perform for the most part mechanical functions, encapsulating organs, so as to hold together the soft semi-diffluent substance. The capsules of the liver and the spleen, the membranes covering the lungs, the heart, the brain, indeed the deeper layer of the skin encapsulating the whole body, are instances; also the strong fibrous bands binding the bones movably together at the joints, also the bones themselves, and the fibrous cords called tendons attaching the muscles to the bones are instances of connective tissue. The various connective tissues are formed by special cells which spin the fibres characteristic of them.

By physics and chemistry physiology is able to account if not in detail, yet at least in principle, for the various functions of the cells composing the body so far as concerns the running of their machinery. But in virtue of what principles it is that the progeny of the original fertilised cell arrange themselves into a complete organism and assume their various structural forms and special properties it cannot at present say. Heredity is, however, the term used to cover the principles here involved though its intimate nature is unknown. Careful observation of its results under various conditions is now being vigorously carried on, and its practical application is termed Eugenics.

The cellular structure of the body shows clearly that an animal individual, each of ourselves for example, is not a single life but a multiple life compounded of the lives of many myriads of individual cells. The cellular structure of the living body impresses on us that the chemistry of each organ, let alone that of the whole body must be a chemistry resultant from the myriad tiny foci, each an individual seat of oxidation, reduction, polymerisation, fermentation, hydrolysis and what not. For instance, as regards the heat of the body, physiology has to reckon with not one seat of heat production, but with countless numbers of microscopic furnaces with conditions and rates of action very different in some from that which they are in others.

The Unity of the Cell Commonwealth; Integration.

Thence arises one of the great problems special to physiology, namely animal integration, the manner of the successful welding of the innumerable cell-lives together so as to form the corporate and unified life of the whole individual animal. The integration is obviously not the result of any single agency at work within the body but of several. There is the mechanical combination of the unit cells of the individual in the single mass. This is effected largely by the fibrous connective tissue binding parts together, and by solid intercellular material, as in the bones forming the skeletal scaffolding which supports the body. In muscles this mechanical integration can arrive at providing a single cord tendon by which the stress of many thousands of contractile cells can be additively concentrated upon a single restricted place of application. Again, there is the integration effected by the circulation of the blood. Every one of the living cells throughout the body requires for its replenishment food and oxygen for which its only source is the world outside the body, though buried in the body's mass it has no access to that world. Hence the arrangement that food entering by a limited region of the body surface, the intestine, and oxygen entering through another limited surface, the lung, is delivered over into a running stream of water, the blood, which a central pump, the heart, drives through a system of distributing tubes to all parts of the body; in that way the food and oxygen is put within the reach of every cell in every part of the organism. And the same channel serves as a drain for the waste products of the cells, and these are carried to special outlets, the lungs and kidneys, for removal from the body as a whole. Another agency of integration consists in the discharge by some one organ of chemical material destined to influence the activity of other distant organs. Thus a small gland, the adrenal, discharges into the blood on occasion a substance, adrenalin, powerfully influencing the arteries and so the flow of blood as occasion may require. Such internal secretions are called hormones. Finally, there is the integrative action of the nervous system, which works through living lines of stationary cells along which it despatches waves of physico-chemical disturbance—nerve impulses—and these act as releasing forces in distant organs where they finally impinge, driving these to temporarily increased activity or restraining their activity as the case may be and according as occasion may require.

By these and other agencies of integration the living body is organised from a congeries of separate microscopic self-centred unit lives into a unified animal individual leading a corporate individual life; and this is nowhere better exemplified than in the body of man himself. Disease and death arise invariably not from the simultaneous malaction or cessation of all the constituent cells at once, but from the breakdown of some particular set among them, entailing in consequence the disorder and failure of all the rest of the linked machinery that makes up the living body's whole.

CHAPTER XVII.

THE BLOOD AND ITS CIRCULATION.

Its cellular structure shows that the body is an assemblage of multitudinous individual lives coexisting in union, a commonwealth of co-operative units. The circulation of the blood illustrates the unification of this commonwealth and the mutual interdependence of its unit lives so that together they constitute a living individual. To continue its life the body must take food since every cell in living must replenish its energy and material ultimately from the world around. In animals consisting of a single cell that cell lies in immediate touch on all sides with the environment and the nutrient resources there. But in multicellular organisms, such as ourselves, great numbers of the cells lie buried within the bulk of the organism cut off from direct contact with the raw food material offered by the outside world. A mechanism is required for supplying them with food. That mechanism is the circulation of the blood, and serves them all and brings food within the reach of each and every cell. The blood is a nutrient fluid brought by the circulation to every living cell.

Before multicellular organisms there were unicellular, and we may be sure the unicellular organism was aquatic. In ourselves to-day the cells of the body are still essentially aquatic, living in and bathed by aqueous media, the lymph and blood. From the lymph each cell draws its immediate sustenance. Into it each cell also discharges its waste matter. The lymph is relatively stagnant. The office of the blood as it streams along in its thousands of tiny channels is to keep the lymph charged with nutriment and to remove from it the waste products of the cells.

The blood as it flows is confined everywhere within membranous tubes, *blood-vessels*. Its course, as William Harvey discovered in 1619, is a closed circuit. This circuit has four successive parts through which the blood successively passes and repasses. These are as follows: (1) Countless minute tubelets (*capillaries*), so small that Harvey, the microscope not being as yet to hand, could not actually see them although he postulated their existence. Through their thin walls the requisite exchange of material takes place between the blood within and the lymph bathing the living cells outside. (2) The *arteries*, a branching tree of elastic relatively stout-walled tubes with its stem at the heart. The arteries lead the blood from the heart to the capillaries. (3) The veins carrying blood back from the capillaries to that end of the heart opposite to the end from which the arterial tree-stem passes. (4) The *heart*, a hollow rhythmically contracting muscle which receives blood from the veins and pumps it into the arteries.

It is in the capillaries that the blood fulfils its great purpose and all the rest of the circulatory apparatus is accessory to the capillaries, serving simply to keep up the capillary flow on which depends the life of the cells of the whole body. In ourselves and other warm-blooded animals the circuit traversed by the blood is a double one and the heart divided into two halves, one half serving one circuit, the other half the other circuit. One of these circuits takes the blood through the lungs, the other through all organs other than the lungs, and any drop of blood has to thread these two circuits in succession.

The Blood.

The blood itself is water containing dissolved and suspended in it representatives of those great classes of substances—proteins, carbohydrates and fats, so constantly associated with life. Of these the most abundant in blood as in living cells themselves are the proteins. The blood-proteins are not exactly the same as the cell-proteins. Just as each class of cell has proteins characteristic of it so also the blood has its own. The body's cells, although the blood-proteins are a source of nutriment to them, refashion their pabulum as they assimilate it. The carbohydrates of the blood are sparse: chiefly the simple sugar, glucose, but even of that only about 1 gramme in half a litre of blood. The importance of carbohydrates as a source of energy to muscles and other organs contrasts with the smallness of this quantity. But if constantly withdrawn from the capillaries in the muscles etc. and constantly entering the capillaries in the liver a brisk traffic in carbohydrate may go on though there be at no one time any large collection of it in the blood. Much money may pass through a banking account though the credit balance at any one time in the bank may not be great. The quantity of fat in the blood varies considerably from time to time. After a meal rich in fat the blood may be quite milky with fatty particles; these are soon removed from the blood in its circulation.

The office of the blood as a drain for waste products is clearly shown by the constant presence in it of urea, one of the best known of the excreta. The kidneys take it from the blood in passage through their capillaries and pour it out with other waste material in the urine. Another and more abundant waste matter in the blood is carbon dioxide, partly dissolved as such and partly combined with sodium as the bicarbonate and carbonate.

The blood contains further certain other inorganic salts, *e.g.* chlorides of sodium, potassium and calcium. These are not exactly nutriment or excreta. Part of their significance is that they help to regulate the exchange of water between the tissues and the blood and the due balance of alkalinity and acidity, and influence the condition of the proteins and of the cells suspended in the blood.

It must not be thought that in all capillaries the blood simply parts with its nutriment and receives merely waste products. Besides supplying nutriment to hungry cells outside, it has also to charge itself with nutriment or its store would be exhausted. In the capillaries of the intestine and the stomach the blood draws from the intestinal and gastric cells and lymph, proteins and sugar prepared by those organs from the food in the food-tube. It also obtains sugar and proteins or protein material from the liver. As for fats these are poured into it chiefly by a special lymph channel which itself comes from the intestine.

Much of the nutriment dispensed by the blood to the various cells of the body is not immediately used up by them although they take it. Each organ and each cell can store within itself a certain amount of nutriment. Some organs, *e.g.* the liver, serve as storehouses not only for themselves but for the whole body, storehouses whence through the blood-stream again this nutriment may be drafted to other organs as required. Nor has the blood-stream the power of forcing upon the tissues at any time more nutriment than they require. Each organ and each cell is the arbiter of its own intake of nutriment. Its life is in so far a law unto itself; it takes more or less according to its condition and activity at the time; but though it may take less than the blood offers it, it cannot take more than that; hence a sufficient supply by the blood is a necessity for the work of every cell.

The Resistance which the Circulation overcomes.

The streaming of blood through the capillaries is therefore a necessity for the life of every cell. How is this streaming of the blood produced and maintained? To move fluid through millions of minute tubelets is no light work. Even water in such flowing develops much frictional resistance. Fluid driven along a pipe may be pictured as moving in layers concentrically arranged round the axis of the tube, the outermost experiencing greatest retardation owing to its adherence to the tube wall (skin-friction). The next layer inwards is in its turn retarded by rubbing against the almost stationary one outside it (internal friction); and so on till in the centre of the bore of the tube we have the least retarded flow, the axial stream. This frictional resistance is greater in blood than in water, because the proteins and other substances make the blood more viscous. The narrower the bore of the tube the greater the frictional retardation of the stream because all the fluid then must pass close to the wall and even the axial stream is not far from it. With tubes of very narrow bore the resistance is very great indeed and the capillaries as their name says are no wider than hairs. They are very much narrower than the arteries and veins. Hence the frictional resistance of the circulating blood is concentrated chiefly in the capillaries and in the smallest arteries (arterioles) directly leading to them.

The frictional resistance in the capillaries would be even greater than it is, but for two circumstances. If we follow a particle of blood in its course through the circulation, from heart through artery, capillary and vein back to heart again, we find that the capillary portion is the shortest part of its circuit, rarely $\frac{1}{100}$ of the whole circuit, often not $\frac{1}{1000}$. This highly frictional region is therefore quite short. The other circumstance is that the blood-flow in the capillaries is very slow, much slower than in the arteries and veins. And the friction diminishes greatly with lowered velocity of flow. In fact the friction developed by the blood in the slow-flowing capillary stream amounts for these reasons to less than that in the less narrow but more rapid blood-streams of the arterioles just leading to the capillaries. And since the size of the arterioles is under the control of the nervous system, the nervous system has its hand upon the frictional resistance and can regulate it and in that way importantly influences the circulation both as a whole and in the separate organs.

THE PUMPING ACTION OF THE HEART.

Whence comes the force which, despite the frictional resistance, moves the blood onwards round the circulation? This propulsion is supplied by the heart, a globular hollow muscle whose chambers form part of the circuit through which the blood courses. This muscle rhythmically contracts and by its contraction, its *beat*, forces the blood out from it onward into the arteries, and these latter are tubes which repeatedly subdividing become finally minute and open into the capillaries. A figure of the heart as shown in some text-book of physiology should be referred to and copied by the student-reader. The heart is a single muscle but its cavity is divided into right and left halves by a muscular partition, so that the right and left chambers do not communicate in the heart. The right half is the pump for the lung's circulation, the left for the general circulation. Each lateral half is further subdivided into a main chamber or ventricle which drives blood into a great artery, and a lesser chamber, the auricle, which receives blood from the veins and drives it in its turn on into the ventricle.

The heart at each beat acts as a force-pump and both sides of it beat together and pause together. Its muscle like other muscles is built of living threads, *fibres*, which have the power of shortening, i.e. *contracting*. The muscle fibres of the heart are arranged in loops encircling its chambers; when they contract they tend to obliterate the chambers they encircle. The blood in these chambers is thus pressed upon and expelled through the openings from the chambers. The heart is in many animals simply tubular. The human heart though more complex is also essentially tubular, a paired tubule, its median partition bisecting the original single tube lengthwise. Muscular tubes are common in the body. Their muscle fibres looped ringwise round them constrict them by contraction. A muscular contraction starting at one end of the tube spreads in a wave-like way along it. This is well shown by the intestine whose contents are shifted onwards by that means. The beat of the heart is a specialised case of wave-like contraction sweeping along a tube. It starts where the veins open into the heart. It sweeps along the twin right and left tubes together and ends at the outlets of the heart into the arteries. Travelling thus it squeezes the blood from auricle into ventricle and then from the latter into the arterial stem-tube. It could not accomplish this but for membranous valves which guard the orifice from auricle to ventricle in such a way as to shut off the ventricle from the auricle during the contraction of the former; thus the blood cannot under pressure by the ventricle rush back into the auricle and veins.

The beating of the heart keeps the arteries filled with blood by repeatedly injecting blood into them at their heart end, though from their other end blood is always running out from them into the capillaries. So filled does the heart keep the arteries that distensible and elastic as they are they are always greatly stretched. They exert therefore an elastic force on the blood within them. This *arterial tension* is so great in the stem of the general arterial tree, the *aorta*, that it exerts on the blood a pressure of about $\frac{1}{5}$ of an atmosphere. That this arterial tension is all turned to account for moving the blood onward is due to a membranous valve which guards the opening of ventricle into aorta, and is so set that while it allows passage of blood from ventricle to aorta it prevents blood from passing back in the reverse direction. The whole arterial tension thus becomes a force directed to forward the blood onward into the capillaries. The elastic arterial system forms therefore a pressure reservoir with pressure sufficient to drive the blood, in spite of its frictional resistance, through the arteries, capillaries and veins round the complete circuit back to the venous end of the heart again. In this circuit the pressure on the blood lessens progressively as it is progressively used up all along the circuit until the blood finally collects under quite a low pressure in the heart's auricles.

It is clear therefore that the mechanical problem before the heart is to transfer blood from the low pressure reservoir of the great veins and auricles into the high pressure system of the tensely distended elastic arteries. It effects this transference by the contraction of the ventricles. The Sisyphus task of the ventricle may be likened to that of a man who has from a pool at his feet to lift pail after pail of water to keep full a rapidly draining reservoir above his head. The ventricle does this at each beat by raising the pressure in itself from that of the low pressure auricle up to that of the high pressure arterial system. It is thus alternately a low pressure chamber into which the blood from the veins can easily run, and then when its beat comes a high pressure chamber with a pressure even higher than that in the arteries so that its blood bursts open the valve at entrance to the arteries and rushes into them. And in this way it rhythmically redistends the arteries and so causes the *pulse*, that rhythmic distension of the arteries which immediately follows each heart beat and is so easily felt in the radial artery at the wrist. The ventricle's beat over, it relaxes and becomes again a low pressure reservoir into which the blood streams once more from the veins and auricle, to be injected into the arteries and redistend them when the beat recurs again.

The auricles beat too, and their beat occurs just before that of the ventricles. The auricle beat is the less important mechanically and merely helps to fill the ventricle from the veins. But it is in the auricle that the heart's beat commences and the beat of the auricle has the important function of setting the time to the beating of the ventricles themselves. The beat of the ventricle would occur less frequently were it not each time started by the auricle. Hence the auricle is called the pace-maker for the heart.

The right ventricle is less powerful than the left; it is proportioned to its work which is lighter than that of the left ventricle, for it has to pump blood through the lung vessels only, while the left has all the rest of the body's vessels to supply. But though the right ventricle beats less forcibly it keeps exact time with the left. Two faint sounds are emitted by each ventricle as it beats. They are of value to the physician who judges from their character whether the heart valves are working properly, for they are chiefly produced by the quick tightening of the heart valves when the ventricle changes from a low pressure chamber to a high pressure chamber and back again.

The frequency of the heart beat varies somewhat from one individual to another. It is usually about 75 per minute in adults, and about 80—90 per minute in a child of 12. It is quickened by exercise, excitement or fever, and lessened by repose and during sleep. It is very sensitive to muscular exertion, being distinctly slower when we sit than when we stand and when we lie down than when we sit. Lying down is a good way of easing the work of the heart. The slowing is obtained by lengthening the pause between the beats and does not lengthen the beat itself. The length of the pause between each beat is about twice as long as the beat itself so that the relation between work and repose in the heart constitutes an 8 hours day.

Each ventricle by its beat drives about 100 c.c. blood into the arteries. This volume is rather more than that of a medium hen's-egg. This means a vast volume of blood driven by the heart daily. To obtain the day's work of the heart this volume must be multiplied by the pressure at which it is driven into the arteries, and this pressure is equal to the pressure of a water column 2·5 metres high. The work done by the heart in the day is equal to that of lifting a weight of 4 lbs. from the bottom of the deepest mine to the top of the highest mountain in the world.

The Blood Pressure.

In brief the heart is a rhythmically contracting muscular bag which pumps the blood into a distensible elastic reservoir through the arteries. The pump keeps the elastic reservoir distended to such an extent that the stretched spring-like arterial wall pressing on the blood moves it on to those parts of the circuit where the pressure is less. Now the pressure is greatest in the great artery springing from the heart, and from there onwards through the circuit the blood moves always from points of higher pressure to points of lower pressure. The direction in which the blood traces its circuit from artery through capillary and vein and finally to auricle tells us there is a fall of blood pressure in that direction. The gradient is however not regular. The pressure falls in each part proportionately to the resistance passed. The friction in the larger arteries is small so there is little fall in pressure until the arterioles are reached. In the arterioles the friction varies much according as they are dilated or constricted by the nervous system, but it is always much greater than in the arteries. In the arterioles and capillaries the frictional resistance encountered by the blood is great, the gradient of pressure fall in them is steep, and when the blood has passed through them and entered the veins its pressure-head has been largely dissipated in overcoming the resistance so that the blood pressure in the veins is low. The veins are wide and little friction occurs in them and the small pressure in them yet suffices to move the blood through them to the heart. Finally when the auricles of the heart are reached by the returning blood all that pressure under which it was sent forth on its round by the great arteries distended by the ventricle has become spent and the blood collects in the relaxed heart partly by the suction action of the heart's relaxation after each beat and partly by the suction action of the chest expanding at each indrawing of breath.

The veins owing to the low pressure of the blood in them are easily closed by pressure from without, for instance by muscles, in the body's movements. This compression displaces the blood in the vein and would drive it backwards as well as forwards were it not for the vein-valves. These are little membranes stretched partly across the inside of the vein. They allow the blood to flow past them in the heartward direction, but are caught up and close the tube if a current sets in in the opposite direction. They therefore make every external pressure on the veins of aid to the forward movement of the blood. Thus in the case of the leg-veins. The column of blood from these veins up to the heart of course exerts its pressure on the vein-wall, and before the blood can move upward along them toward the heart the circulatory force on that blood must at least exceed that pressure. If for a time one stands without moving the legs the veins at the ankle swell, and the circulation in the feet is impeded. If one then takes a few vigorous steps the swelling subsides; the skin as it is drawn on and shifted in the movements of the limbs alternately compresses and frees the veins, and each compression, owing to the valves, pumps blood toward the heart. Long standing is a frequent cause of that permanent distension and thickening of the veins which is called "varicose veins."

The work of the Arteries.

The blood enters from the heart into the arteries in gushes; but it leaves them in a perfectly steady stream through the capillaries. The elasticity of the artery-walls transmutes the jerky force into a steady one just as the elasticity of the traces attaching a team of horses to a heavy cannon converts the irregular pull into a continous steady drag. Hence, in spite of the heart's action being intermittent it maintains throughout the capillaries a perfectly smooth steady stream of blood in virtue of the mediation of the elastic arteries. We see therefore how great and important is the work done by the arteries. With age and ill health they become less elastic and tend to break. The saying that a man is as old as his arteries has much practical truth, and insurance offices take that view. It is in the great arteries near the heart that the blood-flow is most jerky, most pulsatile. The pulse is a transient extra-distension of the arteries when at each beat of the ventricle a fresh dose of blood is injected for a fifth of a second. The falling blood pressure in the artery is thus counteracted by brief rhythmically recurrent rises; with each rise the blood-flow is quickened. In the capillaries there is no such rhythmic disturbance.

When an *artery* is cut there is rapid flow in jerks from the end nearer the heart, but the other end may bleed almost as much owing to communications with other arteries. When a vein is cut there is a slower and steady flow, greater from the end further from the heart, but the other end usually bleeds freely too, owing to junctions with other veins.

The Speed of the blood-flow.

The blood does not flow with the same speed in different parts of the circuit it traverses. A river flows slowly where its channel is wide, quickly where that is narrow. The same amount of water must evidently flow through each section of this channel in the same time or the water would collect unequally at some one part. The same quantity to get through the narrow section must flow more quickly. The arteries fork and branch in such a way that the section of the sum of the branches is greater than that of the parent stem. The section of the whole arterial channel increases as it branches more and more in the direction away from the heart, and finally when the capillaries are reached the sectional area of all these tiny tubelets taken together sums up to a total larger still. The total channel for the blood is therefore widest in the capillaries, and for that reason the speed of blood-flow in the capillaries is slowest of all, one thousand times slower than in the aorta. In the veins the flow becomes quicker and quicker as they converge and coalesce on approaching to the heart, for the total width of the venous channel lessens as it approaches the heart.

Haemorrhage and Clotting.

The blood-vessels may break and then the blood escapes from them, under the skin if there is no wound as in a bruise, or externally as in the case of a cut. When an artery is severed the blood flows from it very much more quickly than it flows along the artery before it was opened; but from an opened vein the blood flows little faster than its normal rate in the intact vessel. The cessation of the bleeding that ensues so quickly with small cuts where no large artery is opened is brought about largely by the clotting of the blood. One of the proteins of the blood becomes jellified when it is shed and does so also at the mouths of the cut or ruptured blood-vessels so that these openings become sealed. The irritation which is caused by the bite of most blood-sucking animals, gnats, mosquitoes, fleas, leeches, etc. is due to the injection by the animal of substances which promote the bleeding by retarding the clotting of the blood. The clotting is a chemical process in which a ferment plays a part.

CHAPTER XVIII.

RESPIRATION.

The rôle of Oxygen.

One substance there is contained in the blood whose rôle both there and in the body generally is an outstanding one. This substance is oxygen. The blood as we all know is red. Its redness is due not to colouring matter dissolved in it but to millions of minute "corpuscles" suspended in it, the *red corpuscles.* Each of these may be regarded as a single cell though in higher animals such as ourselves so specialised and shorn of general cell-properties as to be merely a vehicle for carrying the great respiratory pigment, *haemoglobin*, which tints it red. When these corpuscles are separated from the fluid (plasma) of the blood this latter is straw-coloured and clear instead of red and opaque.

The red pigment is a peculiar protein containing iron. Besides a definite amount of oxygen, which it like all other proteins holds in full chemical combination in its molecule, it has the property of combining with further quantities of oxygen greater or less according to the concentration of any free oxygen offered to it. This extra oxygen it attaches to its molecule "loosely"; that is, it gives it up again quite easily without further radical disarrangement of its molecule. Its colour changes according as it is charged with the extra oxygen or not. In the latter state it is purple red, in the former it is scarlet red and is called oxyhaemoglobin.

Practically every living animal cell requires oxygen. Only by means of oxygen does the cell unlock the energy potential in the proteins, carbohydrates, and fats which compose it and have formed its food. The process by which it liberates the energy manifested in its vital actions is, broadly speaking, an oxidation of carbon and hydrogen to carbon dioxide (CO_2) and water (H_2O). The cell cannot work without oxygen. And the great source to which it goes for oxygen is the free oxygen of the air or, in the case of water-breathing animals, that dissolved by the water from the air. But in multicellular animals, ourselves for instance, the vast majority of the cells of the body, buried as they are within the body's bulk, have no access to the oxygen of the air. This difficulty for them is met by the blood-stream and its haemoglobin.

The Lungs and their Influence on the Blood.

The lungs, stripped of complexities, may be thought of as twin thin-walled bags placed in the chest and containing air in communication through the wind-pipe, throat and nose, with the free air outside. In their thin wall run vast numbers of capillary vessels through which blood is driven by the right ventricle (see above) into veins conveying it to the left heart. In this transit the blood is exposed to the air at the bottom of the lungs only an excessively thin and permeable membrane intervening. The oxygen of that air penetrates into the plasma and into the hæmoglobin-containing corpuscles of the blood which load themselves with it as fast as they arrive, and the blood passes on changed from a purple colour to a scarlet. Thus charged with oxygen the blood leaves the lung and reaches the left ventricle, which pumps it into the aorta (see above) and through that and its branches it is distributed with its loosely attached oxygen to all the organs of the body. In the capillaries of the organs it is subjected to a change the reverse of that which happens in the lungs. The avidity of the organs for oxygen is great, and they act as chemical reducers taking oxygen from compounds where it is not held too tightly. They take it therefore from the plasma and the hæmoglobin of the blood. The amount that is in the plasma they would soon exhaust were it not that the extra oxygen-store of the hæmoglobin replenishes the oxygen of the plasma as rapidly as that latter is removed. The capillary path is everywhere quite short (see above), and in streaming through it the time spent by the blood is not sufficient to allow of a complete stripping of all the loosely-held oxygen, yet enough oxygen is removed from the blood for this latter to lose the scarlet colour it acquired in the lungs, and darkened and purpled it reaches the veins. From the veins it travels to the right heart and so again to the lungs and there it reloads itself with oxygen once more.

The Excretion of Carbon Dioxide.

The oxygen torn from the blood by the organs goes to decompose the complex carbon compounds of the cells. The molecules of these crumble *gradatim* and break down in manifold ways. Finally the oxygen taken reappears combined with carbon as carbonic acid and with hydrogen as water. The subsequent history of the latter is difficult to trace, there being in the body so much water from various other sources. But about four-fifths of all the free oxygen taken appears finally in the form of carbon dioxide and the subsequent history of this is that it is excreted into the air in gaseous form by the same organ which is used for securing the intake of oxygen from the air, namely the lungs themselves.

The tissues and organs produce carbon dioxide in proportion to their activity, and shed it into their tissue-juice and the lymph. From the lymph around the systemic capillaries it diffuses into the blood, and is there for the most part simply dissolved. Its transit from tissue to blood is in obedience to the law of pressures by which gases flow from places of higher to places of lower solution pressure. Its lower pressure in the blood, enabling it to flow into the blood from the lymph, is due to a good deal of it being packed away in loose chemical combination with the blood-proteins and in part as sodium bicarbonate. By way of the right heart the CO_2 reaches the lung-capillaries. There much of it escapes by diffusion into the air of the lungs, and the blood thus relieved of it goes to the left heart for distribution to the body generally. Thus the amount of carbon dioxide in the blood is prevented from rising so high as to choke its escape from the tissues into the blood, and a transference of this waste matter from all the organs to the air in the lungs is constantly maintained, and the body is freed from its deleterious and most copious acid product.

Rate of Respiratory Activity and Rate of Living.

The amount of oxygen taken by the organs from the blood varies much according to the nature of the organs. Slow living tissues such as bones and ligaments take little. Quick living active cells such as those of the glands and muscles take much, and also give much CO_2 to the blood. And the amounts vary also much from time to time according as the organ in question happens to be active or at rest. Muscle when it contracts, that is when it is active, takes tenfold the oxygen it takes when at rest. And each organ is its own arbiter for the amount of oxygen which it shall abstract from the blood: it will not take more merely because the blood offers it more.

The need of all the organs for free oxygen is acute. Although they often contain stores of nutriment they seem unable to store up any considerable store of available oxygen. If the intake of oxygen by the lungs be checked even for a few minutes many of the organs, notably the brain, cease work and unless relief comes speedily death results.

The Ventilation of the Lungs by the Movements of the Chest.

From the air at the bottom of the lungs oxygen is being constantly abstracted, and to it carbon dioxide is as constantly being added; and both these actions are due to the gaseous exchanges between the lung air and the blood in the lung capillaries. The lung air would soon fail as a supply of oxygen to and as a trap for removing carbon dioxide from the blood were it not renewed by inhalation of fresh air after exhalation of some of that which it has rendered stale. This requisite ventilation of the lungs is effected by the rhythmic breathing movements of the chest. The barometric pressure of the atmosphere is of course exerted on the inside of the lung, the lung air being in free communication through the windpipe with the general air outside. The barometric pressure keeps the thin lung wall closely applied against the inner face of the chest wall and of the diaphragm the dome-shaped muscle which forms the floor of the chest. This muscle when it "contracts," that is each time that it becomes active, flattens so that the chest floor descends; at the same time chest-muscles contract by which the ribs are raised. The chest-walls and floor in consequence move somewhat away the one from the other, thus enlarging the chest-chamber. The wall of the lung-bag follows the movement of the chest-wall, since to that wall the atmosphere keeps it closely applied. The lung is thus expanded as the chest itself is expanded, with the result that fresh air flows in through nose and throat and mixes with and renovates the air already in the lung. This is the inspiratory action of the chest. In the adult the quantity of air drawn in by each inspiration is about 500 c.c. (a little more than a pint); but of this only some two-thirds actually enter the lung proper the rest merely entering the nose and throat and windpipe.

Immediately after the inspiratory movement there follows a contrary movement, expiration. On the lapsing of the contraction of the diaphragm and chest-muscles which carry out inspiration, the chest-walls and floor move inward to their old position again and the chest-chamber and the lung-bag become less capacious again, expelling as much air as had entered during inspiration. The air expelled, especially that expelled in the latter part of expiration, is air which has been immediately used in gaseous exchanges with the blood.

The frequency of the respiratory movement is greater in the child than in the adult; in the latter it is about 16 per minute, in a child of 14 about 20 per minute. A short pause free from all movement follows each expiration, and then inspiration recommences and draws a dose of fresh air into the lungs again. The expiratory movement as a rule involves very little muscular effort; it is chiefly an elastic recoil of the stretched chest-wall. Where however breathing is very active, as after running or in asthma, etc., not only is each inspiratory movement reinforced by other muscles coming into play to assist the ordinary muscles of inspiration; but the expiratory movement also is helped by the action of muscles, antagonistic to those of inspiration, which execute it with considerable force; and these latter are the muscles which are employed in coughing, and a cough is an enforced expiratory act.

CHAPTER XIX.

FOOD AND DIGESTION.

PRACTICAL questions in regard to food are what essentials constitute a diet suited to maintain health, and how ought we to adapt the dietary to various circumstances of age, of relative repose and activity, of climate, sickness, and so on. Also what should our dietary avoid.

THE USES OF FOOD.

The purposes of food we may consider to be fourfold:

i. To supply energy to the body. The body is a chemical machine. It does all it does at the expense of energy contained in chemical form within it, and that energy it sets free, as required, by chemical decomposition of a kind tantamount to combustion, *i.e.* burning with oxygen. The body's store of potential energy thus drawn upon from day to day must be from day to day renewed if the body's living is to continue. The basis of this renewal is the taking of food. The food must be fit to furnish the kind of material of which the body consists and which it can utilise. We have already seen something of the chemical nature of that material (v.s. pp. 226—229).

ii. To repair the wear and tear and damage daily accruing to the active organs and tissues.

iii. To enable during the period of growth that growth to go forward. How necessary this is in children is shown by the statistics which illustrate the undergrown condition of underfed children. Not merely deficient quantity but improper quality of food impairs and perverts growth; thus the too common disease rickets in which the growth of the bones suffers is clearly traceable to undue proportions of starchy to animal food in the diet.

iv. To supply certain stimuli which enable the organs better to carry out their functions. These appear to be substances which though present in very minute quantities in the ordinary diets established by common general usage are yet necessary, not on account of the mere quantity of energy available in them, but because of some chemical influence which they exert at certain steps in the life-processes.

Necessary Constituents of a Diet.

In every dietary suited to maintain health the following constituents are found.

1. *Proteins.* A brief statement has been given already on some of the outstanding features of these substances. As there said, proteins bulk largely in the composition of every living cell. They are puzzling complexes of weak acids which containing the atomic group NH_2 are called amino-acids. The body cannot live unless supplied with proteins. They exist in almost endless variety, and no one protein is absolutely like any other. Some contain atom groups particularly necessary for particular organs. Some of the food proteins bring into the body small quantities of phosphorus, of lime and iron very necessary to the working and construction of the vital machinery.

Lean meat, fish, eggs, are instances of articles of diet in which proteins are plentiful. The cheaper cuts of meat which may be stewed are just as nourishing and digestible and more economical than chops and steaks and other expensive cuts used for frying and roasting. Milk contains the protein caseinogen and cheese its derivative casein; bread contains in relatively less amount the protein gluten; there is more protein in whole-meal bread than in that made from white flour. Meat, gristle, and bone contain, as the cook knows, gelatin, but gelatin is a protein whose nutritive value is less than that of many other proteins. It does not contain a certain atom-group called the tryptophane radicle which is of special value. Zein, the protein of maize, is also without tryptophane, and if tryptophane is added to a zein diet young animals fed on the mixture thrive better than those whose sole nitrogenous food is zein. Peas and beans contain a good deal of protein; but as a rule the vegetable proteins are less nutritious than proteins furnished by animal food, and not wholly because they are less digestible.

2. *Carbohydrates.* Some points about carbohydrates were given above (p. 228). Their chief sources for human food are cereals and fruits. Common examples of them in our diet are the starch and dextrin of bread, biscuits and other flour-foods. Also sugar in its various forms. Carbohydrates seem not absolutely essential to life as protein is, but they form a wholesome and economical supply of energy of which the body avails itself eagerly and well. In many oriental countries they bulk more largely in the diet of the general population than they do with us. Coolies and rickshaw men do their large daily amount of muscular work chiefly on rice, an almost entirely starch food.

3. *Fats.* Of these a brief mention as to the forms in which they exist in the body was made in the opening chapter, and as in our body so also in food we have to distinguish the (1) fats proper and (2) certain fat-like bodies. The former contribute to diet chiefly in milk, butter, cheese, dripping, the fat of meat, and as olive oil. The latter, of which an example is lecithin, a compound of a fatty acid with phosphoric acid and a body cholin, occur in smaller quantities but in wider distribution, and very few animal foods are really

devoid of them. They are notably present in egg-yolk. The fats proper can perhaps be dispensed with in a diet, but the fat-like compounds cannot. It is certainly not well to exclude fats from a dietary.

4. *Salts.* These, such as sodium chloride, and salts of magnesium, calcium (lime, CaO) and potassium are for the most part contributed to the diet already admixed in meat, bread, milk, butter, etc. Sodium chloride (common salt) is frequently added during the preparatory processes, cooking, etc.

5. *Vegetable acids.* Certain fruit and vegetable juices contain useful acids, such as tartaric, citric, malic, etc., which are useful if not essential to a wholesome diet. To their absence is ascribable the "scurvy" prone to attack those who are compelled to subsist for longish periods on tinned food without fresh vegetables. The addition of lime juice in such enforced diets mitigates the evil and indicates its mode of causation.

One practical inference to be drawn from even so brief a summary as this is that one maxim for a wholesome dieting is to cultivate variety and mix things. Our palate, not an unreliable guide in such a question, counsels us likewise. Mix things and do not try to live on "bovril" alone, or "chocolate," or vegetable proteins only! Vegetarianism may be supportable by people with very strong digestions and very equable temperaments, but it is mischievous folly to preach that all should adopt it. Nor can we expect to keep well on an unbroken round of tinned meats and bread and butter, or for that matter cake. Fresh meat and fresh vegetables are necessary at not too long intervals. Nor because the carbohydrates are cheap should they be thought inferior; the addition of a fairly liberal supply of carbohydrates assists as well as economises the body's employment of the proteins and fats. "Proteins and fats burn better at the hearth of the carbohydrates." Proteins and fat to the exclusion of carbohydrates leads to malnutrition acetone in the breath, headache and malaise.

Each is good in its place and in its turn, and science counsels variety as prudent because it offers to the need of the body a larger assortment of different atom groups to take from, and some of these though in small quantity may nevertheless be very essential to the construction and working of the vital machinery.

(i) Energy Value of a Diet.

It was said above that a main object of food is to supply the energy which the bodily machine employs. Here we may ask the question, how much energy is thus needed? What quantity of energy does the body dispense daily at its usual rate of healthy living? The answer to this has been carefully ascertained. The forms in which the energy expended ultimately leaves the body are practically only two, namely heat and mechanical work, and since the mechanical equivalent of heat is known the answer can be expressed simply in the heat units, called calories. A calorie is the quantity of heat required to raise 1 grm. of water 1° C. The number of calories dispensed by an active adult in the 24 hrs. is about 3000. Hence an active man will hardly get on well and maintain his weight with a smaller supply than 3000 calories in his diet. Of course if he does extreme amount of mechanical (muscular) work he will expend and require somewhat more. But most, *e.g.* 90 °/$_{\circ}$ of his energy expenditure is due not to any mechanical work he does but to keeping up his body's temperature. From a child's body the escape of heat is relatively greater than from an adult's, hence a child dissipates relatively more energy than an adult, and his diet has to supply relatively more energy than an adult's, that is, it has to be relatively more liberal, especially if he is not well clothed in a cool climate.

(ii) Protein Allowance.

Another purpose of food is to supply material for repairing damage and wear and tear of the living machinery. In the body regarded as a machine there are distinguishable two sets of parts; one set embraces the actual living framework, the protoplasm, of all the cells, to the other belong (1) such cell-contents as are merely stored in the cells and are not part of this living protoplasm itself, (2) that large and relatively inert material in the body which is not contained actually within the cells at all but lies between them, and around them, as is so largely the case in bone, and tendon, and also in the blood. It is thus evident that in the body regarded as a fuel-fed machine we have to recognise that some of its own substance is fuel for parts which form the working machinery. And the body, unlike machines of human device, as it works not only refuels itself but also repairs the wear and tear of its own working parts and this it does likewise from the food it takes. The protoplasmic wear and tear is in the main a protein affair and only protein can repair it. Its amount is represented by about 4 grms. of the total average 17 grms. nitrogen we excrete daily. Proteins contain about 16 °/₀ nitrogen; so that some 25 grms. protein food per diem should theoretically be sufficient to meet this wear and tear. But the total average output, as said, is 17 grms., and though therefore three-fourths of this are from protein which has been used merely as fuel and could in so far be replaced by other fuel such as carbohydrate or fat, the consensus of practical and scientific opinion the world over seems to be that such replacement is not wise. Instead of reducing the protein intake to a sufficiency for just covering actual wear and tear of the working machinery, it seems wise to keep it several times as large as that.

(iii) Food and Growth.

Growth means that the actual working parts of the bodily machinery are increasing in number, size, and power. These parts are in the main built up chemically of proteins, and the body can apparently make protein only from protein. It is obvious that in the food allowance of a child the protein portion should be liberal. The quackery columns of the daily press advertise special brain-foods, muscle-foods, and so on. The advertisers seem unaware how complex and radical digestion really is. Science cannot point to any one compound however expensive which will, for instance, specially promote the growth of the brain. For that purpose the millionaire cannot for his child buy any food better than good meat, and bread, and butter; or provide any better stimulus than regular physical and mental exercise. The inequality of opportunity between class and class in this respect is not so wide. Some very good brains have been made largely out of porridge.

Quantity of Food.

Remembering these points we can roughly summarise in epitome a simple diet and somewhat forecast its values and what its quantities may be.

$1\frac{1}{4}$ lb. beef-steak (lean)	= about 120 grms. protein
	= 492 calories,
$1\frac{1}{2}$ lb. bread	= about 375 grms. carbohydrate
	= 1537 calories,
4 oz. butter and other fats	= about 100 grms. fat
	= 930 calories.

Total, 2959 calories.

Cooking.

Man is sometimes described as the "cooking animal." We may ask, What advantages does cooking bring? And in reply we can say: (1) It renders many foods more palatable and appetizing, and that means that through our senses and our nervous system it promotes the digestive powers in readiness for making their best use of the food; (2) In many cases it renders the food more digestible. Thus, in meat the gelatin-yielding tissue which enwraps the more valuable part, the muscle-fibres, is softened and jellified and the muscle-protein more readily reached by the digestive juices of the stomach and intestine. Again, nothing is more indigestible than uncooked starch. It may be suspended in but not dissolved by cold water; but by heating the water the suspended starch is in part made to dissolve. Starch occurs naturally in the form of tiny grains each covered by a coat which is practically indigestible. Boiling bursts the grain-cover. Hence potatoes and rice get soft as they are cooked, and cornflour and arrowroot on boiling expand into a soft pulp. (3) The heat employed in cooking tends to destroy germs only too likely to fall upon or even to penetrate raw foods. Some of these germs are harmless enough of themselves, but growing on the food as on a soil can decompose it and may develop in it harmful and even very poisonous substances, *toxins*, and these toxins no cooking will render innocuous. Cases of pork-pie poisoning and of poisoning by putrescent meat of all kinds are usually cases of toxin-poisoning. Further, germs of actual pathogenic species, that is disease-producing kinds, are apt to infect food. The bacilli which produce typhoid fever, tuberculosis, etc. if allowed to contaminate food may grow on it and be disseminated with it. Milk and butter are only too commonly the conveyers of tuberculous diseases. A thorough boiling kills almost every kind of germ. To boil the cow's milk supplied to children shortly before they drink it goes far to ensure that it can convey no disease to them. It has sometimes been feared that boiling may render such milk less nutritious for them; recent physiological experiments show however that this apprehension is in reality unfounded.

Beverages.

Although food can be taken in liquid form and very valuable food such as milk is often so taken, especially by children, most beverages have as their main physiological use the supplying of water to the body. The importance of water to the body is obvious from the simple facts that the body consists more than half by weight of water, that water is the field in which for the most part its chemical operations are conducted, that even the act of muscular contraction is in the main an act of transference of water from one part of the muscle-fibre to another, that a great part of the regulation of the temperature of the body is effected by means of the evaporation of water, that water is the medium of solution and suspension of the contents of the blood and lymph, and also the medium by which effete products are removed in soluble form by the kidneys as urine. And we may truly say that water is of itself the most important of all beverages. It is liable to contamination and good drinking water free from impurities, especially of bacterial kind, is not always easy to obtain. Where there is the slightest reason to suspect the purity of water supplied for drinking it is safest to boil it thoroughly before using it for that purpose. The germs of typhoid fever are not rarely conveyed by water and to boil water kills all germs in it, ridding it of such dangers more certainly than does filtering.

It is very customary to add to the water we take for drinking substances giving a pleasant flavour and acting as so-called stimulants. Hence it comes about that we often drink tea and coffee in preference to simple water. But it is to be remembered that apart from the small quantities of sugar and milk that may be added to these beverages the principles in tea and coffee of themselves add little or nothing of any nutritive value and are not food. Similarly with the alcohol that is the outstanding constituent in the long and varied list of wines and beers and spirit. It is not too much to say that the alcohol is always more or less harmful to the body, and the more so the longer its use is continued and the larger the quantity of it which is taken. Any even temporary services which it may seem to render are probably illusory. The harm which it does amounts often to complete ruin.

Digestion.

The food we take has not in a strict sense really entered the body when it has been merely swallowed and lies within the stomach and intestine. The process of its physiological entrance into the body is what is termed absorption, namely, the passage of its constituents through the wall of the stomach and intestine into the blood-vessels and the circulation. Before absorption it is subjected to digestion. Digestion is a series of chemical operations undergone by the food within the food-tube, altering it and rendering it absorbable. The living cells lining the stomach and intestine and the glands such as the pancreas and liver, which open into those viscera, and also the salivary glands whose ducts open into the mouth, pour out (secrete) digestive juices and these render the food-stuffs more soluble or more finely particulate. Most of these juices are faintly alkaline, though that of the stomach is acid. The potent constituents of these juices are ferments. The exact chemical nature of ferments is not known but they are able to split up the complex proteins and carbohydrates and fats into somewhat simpler constituent atom-groups without greatly dissipating the energy contained in the original substances. They fragment them into pieces which although more soluble than the original food-stuffs are still rich in available energy. The proteins are broken down into peptones, amino-acids and other useful atom-groups. One object of breaking them down is to allow a rearrangement of them in the proteins of the animal that feeds on them, because the proteins of one animal are often anathema to the flesh of another. The starches and dextrins and complex sugars split into simpler sugars, especially into glucose, are then absorbed chiefly in the small intestine and passed on into the blood. The fats are split into glycerine and fatty acids, and the latter converted into soluble soaps;

these in their turn are absorbed, and recombined into fats again and passed into the blood, not directly however but through the medium of the lymph.

The preliminary preparation of food by digestion before it is actually absorbed is very important, and some foods are more easily digestible than others. Among the former may be reckoned lightly cooked eggs, chicken, mutton and beef; milk puddings, rusks, toast, butter and fish oils. Among the less digestible are pork, fried meats, rich pastry and cake, and vegetables.

It is worth remembering that the whole of the food-tube is enwrapped in a sheet of muscle, and that the contractions and relaxations of this muscle cause irregularly rhythmic narrowings and dilatations of the tube, shifting and mixing the digesting contents very helpfully for the promotion of digestion. These actions of the muscle though during health they go on practically without our being conscious of them, are nevertheless influenced by the nervous system. It is further worth remembering that emotional stress interferes with them; the healthy movements of the digesting stomach cease under the influence of anger; an appropriate mental attitude of *bonhomie* is therefore conducive to not merely the enjoyment but also to the successful digestion of one's dinner.

Not to be forgotten is that this mechanical handling of the food by the stomach and intestine is unconscious and beyond our immediate control, but the important mincing and grinding of the food by mastication is completely within our control. In the mouth the food should be converted into a soft well-moistened pulp before being swallowed and passed on to the stomach. The tender skin lining the mouth has been modified by Nature at certain points where it covers the free edge of the jaws. At these points, ten in number in each jaw in the young child, and sixteen in number in the adolescent, specialised bits of skin are developed into what are termed *teeth*. In these the surface layer of the skin consists of lime-hardened cells shaped and set together somewhat like the basalt columns of a miniature Giant's Causeway, and forming the brilliant white *enamel*, the hardest tissue in the body, covering the whole crown of the tooth. Under this and making the framework of the tooth is a modification of the deeper layer of the skin, which though very different from the enamel is like it lime-hardened. This is the dentine; it surrounds and almost completely encases a soft central cone of living cells, the tooth-pulp. The tooth-pulp bears much the same relation to the dentine as does the marrow of a bone to the hard casing of dense bone which surrounds it. The tooth-pulp is richly supplied with minute blood vessels and nerves which are branches from those of the jaw itself. These enter the tooth-pulp through a special tiny channel which runs up the fang of the tooth. The layer of pulp which immediately lines the dentine consists of cells which thrust microscopic threadlets into the dentine and endow it with exquisite sensitiveness. These are the cells which in the early growth of the tooth have formed the dentine and they retain lifelong these sensitive connections with it, their threadlets occupying the so-called dentinal tubules. Just as in that part of the tooth which projects above the gum the dentine is overlaid with enamel, so in the part below the gum it is overlaid with a thin crust of bone, the *cementum*. The cementum is separated by only a thin membrane of fibrous tissue from the bone of the jaw itself where the bone is hollowed out into a socket for the tooth.

The life-history of a tooth shows that it begins as a little group of cells (tooth-bud) imbedded not far below the surface of the gum. The earliest tooth-buds are those for the central incisors and are formed long before the teeth are cut. The tooth-bud slowly grows and shapes itself into a tooth; as it does so it rises gradually toward the surface of the gum, and in due course its crown emerges in the place proper for it. This is a slow process even where quickest, as in the case of the central incisor teeth; in the case of the 3rd molar, the wisdom tooth, the germ has lain in the jaw 16 or 17 years before completion and the emergence of its crown. We can understand that the due growth and the emergence of the tooth at its proper place and in good position are liable to considerable risk of upset by ill-health, accident, and other causes through all this long period of post-natal development. A child of eight has no fewer than fifty teeth, mature and immature, within its jaws. The actual emergence of the crown of the tooth above the surface of the gum is called the eruption or cutting of the tooth. It is of itself a comparatively unimportant step in the career of the tooth, and its influence as a cause of childish ailments is unduly exaggerated by maternal solicitude. The average dates of eruption of the temporary or milk-teeth are in *months* as follows:

molars		canine	incisors	
24	12	18	9	7

Quite early in the course of formation of these temporary teeth another analogous set of tooth-buds are formed for the second or permanent set, destined in their proper season to replace the temporary. The times of eruption of the permanent teeth are in *years* as follows:

molars			bicuspids		canine	incisors	
17 to 25	12 to 13	6	10	9	11	8	7

The teeth are very liable to disease, especially to a form of decay called caries. Dental caries in children is far more prevalent than it should be. The enamel is first attacked. The moisture of the mouth always contains bacteria. Such germs flourish in warm moist places screened from light, hence the mouth forms a suitable hothouse for them. They feed upon the débris of food liable to remain in the mouth after eating, and decompose it and produce acids from it. The acids and the germs together tend to soften and erode the enamel. A small pit or hole in the enamel is thus started; in this the germs collect and growing within it they enlarge it, and finally corrode it through to the dentine underneath. The dentine is then exposed and the process that has been painless until then is generally after that accompanied by attacks of pain. The dentine exposed to cold or acids, or to pressure, evidences its sensitivity by giving pain. The process continues further by the attacking germs invading the dentine through the dentinal tubules; ultimately they enter the tooth-pulp itself. Inflammation of the tooth-pulp follows, and as a result an abscess frequently forms at the deep end of the fang of the tooth at the bottom of its socket within the jaw itself.

Dental caries brings important disabilities for a child's school activities. The child with dental caries is an ailing child. The tenderness of the diseased teeth and the recurrent attacks of pain which they cause are prone to prevent the proper mastication of food and to cause indigestion. Moreover the child tends to prefer soft pulpy farinaceous food to other and more nutritious because less liable to give it pain. The aching of the teeth breaks its rest at night and tends to prevent its enjoyment of, and even its participation in, playground games by day. The irritation of the carious teeth causes an excessive flow of watery saliva, and the repeated swallowing of this is apt to upset the stomach. The tenderness of the teeth and gum makes the child apt to forego proper use of the tooth-brush and to leave its mouth uncleansed. Moreover the decayed teeth harbour large numbers of germs, and the saliva and the breath tend to become foul and evil-smelling. Malnutrition and anæmia only too commonly ensue. In addition, besides this damage to general health, the caries usually leads to complete loss of some of the teeth themselves; and this is of itself a serious matter and unfits for certain callings in adult life. Thus it excludes from service in the Navy and the Army.

Hygienic rules of very simple character can do much to protect children from serious dental caries. The chief cause of caries seems to be the unchecked luxuriance of growth of bacteria in the mouth with insufficient removal of the fermenting food-débris which promotes and accompanies their excess. The bacterial decomposition of particles of food, especially of starchy food, allowed to remain hour after hour between and around the teeth, seems to be the main predisposing cause of the disease. This cause is probably especially active during sleep when the germinating bacteria and food particles lie undisturbed and unremoved. Cleaning of the mouth should really be performed after every meal, but it is especially necessary after the last meal of the day before retiring for the night. We clean our teeth in the morning for our own sakes; at night we should clean them for theirs. Mr Pedley writes, "the habit of giving bread or other starchy food to a child in bed at night should be entirely prohibited."

It is a prevalent notion that the temporary teeth do not require to be cleaned. This is wrong, for not only do the milk teeth deserve care as serving mastication during a most important period of child growth, but carious temporary teeth often infect the germs of the permanent teeth which are to follow. Cleanliness in regard to the mouth early acquired as a habit is a good hygienic asset for later life. Tooth-brush drill is as needful as any gymnastic exercise for the preservation of health. The teeth should be cleansed all over, and should be brushed not only from side to side but up and down; some of the food particles between the teeth can be removed only in this way. Precipitated chalk is a good tooth powder, much better than some much advertised and most expensive tooth-powders which are deleterious because acid.

Metabolism and Excretion.

The food substances thus prepared and absorbed are by means of the blood-stream carried to all parts and organs of the body. Some of them are stored temporarily, especially in the liver, as a reserve from which the executive organs such as the muscles and brain can from minute to minute by means of the blood obtain them as required. From this new material the living cells of every organ obtain fresh stores of energy, and from it is manufactured by them their own living substance and all the varied and often specific bodies which some of the organs produce for the use of other fellow organs.

The intake of the new material provided by the food, the elaboration of it, and its actual incorporation by the living cells which are to use it as pabulum for their life-work forms one side of its chemical and physiological history in the body, the assimilative side. And then the other or dissimilative begins. In this the incorporated material is broken down, step by step, and its available energy set free and turned to account for the purposes of the body's life. In the earlier stages of this process many chemical substances are formed and are then further decomposed and again further and further, until finally all that remains are compounds of which the body can make no more use at all, and these are shed by the excretory organs. These final substances are simple and comparatively few, the chief being carbon dioxide exhaled from the lungs at each expiration, urea, a condensed compound of ammonia and carbon dioxide, excreted by the kidneys and dissolved in the urine, and water excreted by the lungs in the breath, by the kidneys in the urine, and by the skin as perspiration. In this great process of dissimilation intra-cellular ferments and oxygen are the main agents in the long and manifold series of chemical decompositions. It is carried out in such a way that at no stage are there set free either markedly acid, or markedly alkaline products. Neither of these can the cells of the body tolerate; their life processes would be upset thereby, and the vital chemistry meets this necessity. The excreta ejected daily from the bowel are chiefly the altered and unabsorbed remnants of the digested food, mixed with some of the secretions of the intestinal glands and liver. These are many of them harmful and their regular daily ejection as a matter of routine is of importance to health.

CHAPTER XX.

THE TEMPERATURE OF THE BODY.

THE temperature of the body is a delicate index to its healthy working, since departure from its normal temperature is an early and reliable sign in a great number of different forms of illness. The body's warmth, its maintenance and adjustment, is the pivot round which turn numerous problems of hygiene concerned with the warming and ventilation of school-rooms and the suitable clothing of children.

ANIMAL HEAT.

Our body's warmth is not in constant evidence to our consciousness, yet the simple touching of the forehead with the finger at any time suffices to demonstrate it to our sense. The warmth of the body is due to the chemical decompositions accompanying the life of its cells. The cell-theory shows that in the warmth of the body we have to deal not with one seat of heat production but with countless microscopic furnaces, in some of which the rate of oxidation is much faster than in others. Coldness is the absolutest sign of death.

Since our body is warmer than most of its surroundings heat drains from it. The lower the temperature of the air around it the more quickly will the drainage go on. When we leave the fireside to go out on a cool day we might expect our body temperature to fall owing to increased escape of heat from it; conversely we might expect that on returning to the warm room the body temperature would rise. Yet the body temperature during health is said, and on good grounds, to remain constant and not to vary. Again, the amount of heat produced by the body varies according to the activity of its organs. For instance during muscular exercise much of the energy liberated by the muscles expends itself within the body as heat. We might therefore expect that the temperature of the body would rise when we increase its muscular work, for instance when from reading a book we turn to riding a bicycle. Yet it does not do so, or does so hardly appreciably. Hence a routine observation in case of suspected illness is "to take the temperature," because departure from the normal temperature is so sure an indication of disease.

Surface and Deep Temperature.

The discrepancy between the statement that the body-temperature in health remains constant and the natural expectation that it would fluctuate is however partly a matter of words. We must distinguish between two regions of temperature in the body, its surface temperature and its deep temperature. The temperature of the surface of the body is lower than that of the parts inside. Thermometry shows that the temperature of the outside of the body varies from point to point; that of the face may differ considerably from that of the hands. It is usually lower on the hand than on the shoulder, on the face than on the trunk. It varies also greatly from time to time. The surface temperature of the ears or finger-tips may be much lower at one time than at another, and the one hand may be warmer or cooler than the other. But at a small depth below the body's surface its temperature is practically alike throughout. It is the circulation of the blood which thus equalises the temperature everywhere within the depth of the body. The heat produced in the organs not only diffuses through all parts of it but is conveyed and distributed everywhere by the currents of the everywhere circulating blood. Just as the heating of a building by hot water pipes is partly a mechanical problem so in the warming of the body there is a mechanical factor, the circulation of the blood, distributing the heat.

Distribution of Heat by the Circulation.

To realise how the circulation equalises the deep temperature throughout the body we have to remember that in certain organs the blood is warmed whereas in others it is cooled. The blood that streams close under the skin, so close indeed that its tint is faintly visible, is cooled in so doing by the relative coolness of the skin itself. This cooled blood on returning by the veins is mixed with warmer blood from other parts and the cooler and the warmer are thoroughly commingled in the heart. The most active heat-producers in the body, its chief furnaces, are the muscles and great internal glands such as the liver; in these large quantities of blood are warmed just as in the skin large quantities of blood are cooled. The blood from all sources is mixed in the heart and by the heart re-dispersed to all parts anew. The circulation thus continually equalises the temperature of the blood and dispenses the equably warmed blood to warm the whole of the body. It succeeds in that way in keeping all the internal parts at one common temperature. But the surface at most parts is not kept at the same height of temperature nor at an equable temperature owing to the vicissitudes of exposure there.

Constancy of the Deep Temperature.

When the physician says that the temperature of the healthy body remains constant he refers to the deep temperature. He lays more stress on the deep temperature than on the surface temperature for several reasons. The surface temperature is much more difficult to measure accurately. The deep temperature can be measured easily with accuracy, and is also a much clearer indication of health or illness. The very fact of its striking constancy during health argues that its constancy is of high importance to health. A man may travel from the pole to the equator and so long as he remains in health his deep temperature will not alter. And in this he resembles all warm-blooded animals, better called animals of constant temperature. The chemical processes necessary to life and especially delicately adjusted in warm-blooded animals seem to require for their due performance and due rate of performance a standard temperature; and this standard temperature in ourselves is 36·5° C. (98·6° F.). If this temperature is altered by a couple of degrees or more the working of the body at once suffers.

The Clinical Thermometer.

The deep temperature is conveniently measured by a thermometer called a *clinical thermometer*. It is a mercurial thermometer and the bulb containing the mercury is placed in the mouth under the tongue and the lips are then closed over it. The thermometer is a maximum one; the delicate capillary tube up which the thread of mercury runs as the mercury expands on warming is specially narrowed at one point between the bulb and the stem so as to offer more friction to the mercury there. As the temperature rises the expansion of the mercury pushes some of the fluid metal through this constriction up the stem; but when the temperature falls again and the mercury shrinks the thread of mercury above the constriction does not run back into the bulb again, instead of doing that it remains and the mercury thread is therefore broken at that point, and the top of it stays at the highest point it had reached, namely the point it attained when the temperature was highest. This allows the temperature which the instrument has reached when in the mouth to be read off correctly after the instrument has been withdrawn. Before putting the instrument into the mouth to take an observation it is necessary to see that the thread of mercury above the constriction does not already extend too high: it should be shaken back toward the bulb so as not to be above the mark on the scale which corresponds with the normal deep temperature 98·6° F. The scale usually ranges from 95° F. up to 110° F., for clinical thermometers are so constructed as to give readings over merely the particular range of temperature which the body in health and disease exhibits. This allows them to be made of conveniently small size, although each degree of their scale is long enough to be subdivided into easily-read tenths of a degree.

It is important that the thermometer should register quickly, that is, that the bulb after insertion into the mouth should acquire quickly the same temperature as the tongue and other parts against which it lies when in the mouth. To ensure this the bulb is made as small as possible so that it and the mercury in it rapidly warm through to the temperature of their surroundings. Many clinical thermometers are so made as to assume their temperature in half a minute. Quick thermometry is important with children, for a child may be restive and object to the procedure and endanger the instrument and itself by breaking the instrument when in the mouth.

The closed mouth samples very fairly the deep temperature of the body. The deep temperature can also be taken by placing the thermometer in the naked arm-pit and bringing the arm to the side so as to surround the instrument completely. The arm-pit then soon acquires a temperature nearly as high as that of the deep regions of the body. But the procedure is longer than if the mouth is used. After each observation the instrument should of course be carefully cleansed with water, and that water must not be hot or the instrument may be spoilt.

The deep temperature of a healthy person although it remains practically the same as observed from morning to morning or from afternoon to afternoon does normally exhibit a small and regular rise and fall, less than 1° C., during each twenty-four hours. This diurnal variation is greatly increased in some diseases.

Regulation of the Deep Temperature.

That the deep temperature remains the same in spite of differences in rate of heat production, as for instance during rest and muscular exercise respectively and in spite of changes in the warmth and coldness of the body's surrounding, evidently means that the body has some means of regulating the escape of heat from it, and of regulating its heat production. Its power of regulating the amount of heat escaping from it is very marked, and to understand it we must turn to the channels by which the escape of heat from the body takes place. The chief channel is the skin, and the next most important is the lung.

Heat escapes from the skin in several ways. The heat actually produced by the living cells of the skin itself is not very great and the skin owes its warmth chiefly to the warm blood which is brought it by its arteries and that after passing through the rich network of capillaries in the lower layer of the skin enters the veins and returns again to the heart. A scratch or cut in the skin even when not deep bleeds as we all know, and shows us how near to the surface the capillary network comes; and it is that network seen through the semi-transparent skin and nails which causes the pink colour of the skin. The skin receives heat from the blood and from the surface of the skin this heat is conducted to the air or other material in contact with that surface. The amount of heat thus conducted from the skin to the air will be greater according as the temperature of the skin is higher than that of the air. If the temperature of the skin remain the same the heat-loss will be greater when the air is cold than when it is warm; and the temperature of the air remaining the same the heat-loss will be greater when the temperature of the skin is high, that is to say when the skin is flushed with blood. Also, the amount of heat conducted away from the skin by the air will be greater when the air, instead of remaining at rest on the surface of the body, moves over it as in draught, for then the air warmed by the skin is not allowed to remain in contact with it but is continually replaced by a fresh supply of cooler air. Also the amount of heat conducted away from the skin will be greater when the air is moist, because moist air conducts heat better than dry air. Heat also escapes from skin not only by conduction but by radiation. Heat, as we know, radiates from and between all objects possessing temperature, and the balance of the exchange is such that the warmer object radiates more into the cooler object than it receives from it in return. So that in a room each person is radiating heat upon the walls and furniture and receiving from them less radiant heat in return. If, though the air of the room is warm, its walls are still cold after a winter night, the body may lose a good deal of heat by radiation upon those cold surfaces. And since the amount of radiation from the skin will be greater when its temperature is higher, the amount of heat radiated from the skin like the amount conducted from it, will be greater when the skin is flushed with blood than when it has less blood.

The amount of heat escaping from the skin could therefore be regulated if the body had a means of regulating the amount of blood passing through the skin and this it has. When the surroundings of the body are cold the blood supply to the skin is diminished so that the temperature of the skin-surface falls, with the result that other things being equal less heat is conducted from it and less heat radiated from it. When we pass from a warm room into the cold outdoors on a cool day, the greater coldness of the outdoor surroundings tends to rob us of more heat than when we were within the warm room, but at the same time a reduction in the blood supply of the skin occurs and tends to diminish the heat escape. And this reaction to the changed surroundings is in a healthy child such as to make the two opposite changes of air and skin neutralise. The compensation thus effected by the skin in most cases is at first a slight over-compensation so that the change in the skin rather more than neutralises the contrary tendency in the surroundings and the deep temperature slightly rises for a short time.

Conversely when a child comes from the outside cold into a warm room the warmer surroundings tend to rob his body of less heat than did those outside. But the blood supply of the skin is immediately increased and this tends to allow more heat than before to escape from it: and this latter change is so graded as to neutralise the tendency of the changed surroundings to diminish the heat loss. The result is that the heat loss of the body in the room adjusts itself to be the same as before. Hence passing from a cold place to a warm and *vice versa* does not alter the amount of heat escape from the body.

Evaporation of water from the Skin.

But alterations in the amount of the skin's blood supply are not the only means of regulating the heat loss through the skin's channel. When the stress threatened by external or internal heat is greater than ordinary the body calls into play the cooling power of the sweat glands. If we examine with a magnifying glass the surface of the skin we see that it is patterned over with little ridges and furrows. The ridges are crossed at frequent intervals by tiny valleys and in these latter are minute points on which when the skin perspires minute beads of moisture can be seen. Each such point is the mouth of a tiny tubelet which when traced downward can be followed into the deep layer of the skin where it ends as a coiled tube of cells, a sweat gland, which when active separates water from the blood. This sweat, which is water containing a little salt, on reaching the surface of the skin evaporates, in other words, is changed into water vapour which passes into the air. To change water from its liquid to its vaporous state requires a considerable amount of heat as we see when we apply a flame to water in a kettle. The heat is absorbed by the water when it expands into vapour. In the evaporation of the sweat on the skin the heat required for the transformation to the vaporous state is taken from the skin. In this way the skin is cooled, and the blood flowing through its deep layers is cooled. The amount of evaporation depends not only on the amount of sweat which is poured out but on the dryness of the air in contact with skin. When the air is humid the evaporation is retarded. Hence the power of the skin to cool the body by perspiration is less in wet climates than in dry climates. This it is which makes the heat of the climate of the west coast of Africa more difficult to support than that of equally hot climates where however the air is dry.

The perspiration of the skin is always going on, but under ordinary circumstances the amount of sweat secreted is so small that what is secreted is immediately evaporated and the skin is not actually wet. But when the sweat glands are more active the water collects more rapidly, even in a dry climate, than it disappears.

Returning therefore to a concrete instance of the temperature regulation we arrive at the following explanation.

A child enters a warm schoolroom from outdoors on a cold wet morning. Were it not for the heat-regulating mechanism of the body its temperature would rise, since the drain of heat from it must be less in the warm dry air than in the cold wet air, and the heat checked in its escape must collect in the body and raise the temperature of the child. We have seen that this tendency to check its heat-overflow is counteracted by the opening of the blood-vessels of the skin so that more heat escapes from it by radiation and conduction and by increased perspiration robbing more heat from the skin by evaporation.

The Nervous System and the Regulation of the Body Temperature.

This regulation of the blood-supply and of the sweat-glands of the skin is effected by the nervous system. On entering a warm room the temperature of the skin rises owing to the warm air in contact with it and the retention of heat in it which in cooler air would escape. This rise of skin-temperature acts on certain skin-nerves which communicate with nerve-centres in the spinal cord, and these spinal centres in their turn are connected with centres in the brain. Of these latter one, the vasomotor, is constantly acting on a number of spinal centres whence run nerves to the blood-vessels of the skin with power to restrain the blood-flow through them. The warming of the skin excites the skin nerves which pass *to* the spinal centres and these latter through their communications with the brain lessen (*inhibit*) the action of the vasomotor centre there in regard to its restraint on the blood-flow through the skin. The skin vessels dilate therefore and the skin is flushed with blood and so more warm blood flows through the skin and more heat escapes from it. Similarly there are nerves which govern the activity of the sweat-glands, and the same stimulus which causes the skin vessels to flush causes also the sweat-glands to secrete more perspiration, moistening the skin more and increasing the removal of heat from the skin by evaporation.

And all this is done by the nerves without any conscious direction on the part of the brain. All that either child or adult is aware of is that on entering the warm room he "feels warm," that is, his skin-temperature rises and gives him a sensation of warmth. These nerves which can feel warmth or cold are given to the skin only. Of our deep temperature we have no direct consciousness; our deep organs have no sense-organs which can tell us of their temperature. That is what we might expect, because our deep temperature should never alter and does not so long as we are in health, and since nerves are to tell us of *changes*, no deep temperature sense-nerves have been evolved. And even the skin nerves which report on temperature since they are mainly concerned with changes soon lapse into quietude when the changed condition which at first stimulated them continues. So that even in a few minutes after entering the warm room we no longer notice the warmth though it struck us at our first entering. If the feeling of heat continue we may be sure that the temperature of the skin is still rising, and that means that the stress of the heat of the room is too great to be easily counteracted by the body, so that the flushing and perspiring is increasing and also perhaps that in spite of those efforts the heat is actually causing the deep temperature to rise. In that case the situation requires to be met either by cooling the child or by cooling the room. That a person who comes from the cold into a warm room should feel the heat even acutely for a short time is usually merely evidence that the normal healthy reaction of the skin to the change is taking place as it should and is a good guarantee that the safeguarding of the deep temperature from alteration is taking place. For this feeling of heat not quickly to subside however is an indication that either the room is too warm or that the person's heat-regulating reflex is too poor and inadequate, as it is in many weakly persons, to properly meet the ordinary changes that offer no difficulty to the more robust. And the same persons who cannot adjust to heat usually also fail to adjust to cold, etc. On passing from a warm room to the cold the reverse process to that just examined takes place. The temperature of the skin falls. This stimulates afferent nerves which through their connections with the spinal cord and lower parts of the brain exalt the action of the centres constricting the skin-vessels and depress that of the centres causing the sweat-glands to secrete. In result the skin grows colder still and less heat escapes from it and less blood goes through it to be cooled, so that the internal temperature of the body is maintained despite the greater cold outside. The cutaneous nerve-endings originating the sensation of cold soon become adapted to their new and lower temperature and cease to report it, so that the cold sensation lapses. And thus the person who at first felt the cold ceases to notice it and becomes adapted to it and without any fall of his deep temperature. Should he still continue to feel cold that fact is evidence that his adaptation is not sufficient to fully meet the cold of his new surroundings; and is a warning that if not relieved he runs the risk of a fall in his deep temperature, in common parlance, of taking a chill.

A further problem which the body has to solve in maintaining the constancy of its temperature is presented by the variations in the amount of heat produced within the body at different times. For instance, active muscular exercise considerably increases the amount of heat generated by the body. It is estimated that while a person of sedentary occupation, such as an office clerk, produces 2500 calories a day, a man of the same weight but doing hard outdoor work, *e.g.* a Canadian lumber-man, produces about 4500 calories a day. But the (deep) body temperature is the same in both. The child running in the playground produces more heat than when seated in the classroom, but its body-temperature is practically the same in both cases. The regulation is effected chiefly by the skin. The skin of the child at active play is flushed and warm, and its sweat-glands actively secreting. Conduction, radiation and evaporation are removing heat from it much more rapidly and copiously than when under like external conditions it is seated quietly in class. In the latter case, it may feel cold though the air is actually not so cold as outside in the playground where the child felt warm. If the child's feeling of cold continue, a fair inference is that its skin-temperature is continuing to fall and that the skin-mechanism for keeping the deep temperature at proper height is under undue strain. Simple means for relieving this strain are extra clothing so as to lessen the heat-drain from the skin, or a few minutes' muscular exercise to increase the heat-production in the body, or the raising of the room-temperature in which the child is seated.

Clothing and Body-temperature.

We can see now the way in which clothing acts on the body temperature. Man's clothing helps him to withstand cold in the same way that fur or feathers helps animals provided with them. Clothing like fur lessens the heat loss from the skin by lessening the radiation and conduction. The fur entangles a layer of air next the skin and keeps it relatively still, so that it becomes warm and conducts away less heat from the skin surface. It similarly lessens the amount of evaporation of the sweat and therefore the loss of heat by evaporation. The still layer of air next the skin becomes moist and the perspiration on the skin surface under it consequently dries less.

The clothes keep a layer of relatively motionless warm moist air next the skin, and so restrain the loss of heat from the body. Tight clothing tends to be less warm than loose, for instance a tight glove protects the hand less from cold than does a loosely fitting one because it does not allow a warm air space next the skin and further it tends to impede the free circulation of blood through the skin. The fingers become clumsy and numb owing to the impairment of the touch organs in the skin. A surgeon before using his fingers for a delicate examination or operation sometimes immerses his hands in warm-water in order that their acuteness of touch, etc., may be greater.

The clothing of children should be light, loosely fitting, and should protect the body and chest and the thighs and shoulders leaving freedom for the limbs and neck. Some materials, especially wool, are capable of absorbing moisture without themselves becoming moist.

The child has a larger skin surface than has the adult relatively to the size of its body. When two solid figures of similar shape but different size are compared as to surface and bulk the surface alters as the square but the bulk as the cube. Since the body throughout its length and breadth is producing heat and is losing that heat from its surface, when we turn from the adult to the child we see that while its furnace decreases as the cube its surface does so only as the square, so that the heat-draining surface of the child is relatively larger in comparison with its furnace than is that of the adult. Moreover the child's skin is relatively thin as the blood in it comes nearer to the surface, hence the brighter rosy colour. All this means that the escape of heat is relatively greater in the child than the adult. Now the greatest item of expenditure in the body's energy balance sheet is the quantity of food burned to maintain the body temperature. The expenditure of energy by the body occurs almost wholly in two main ways, (1) in the form of heat, maintaining the body temperature, (2) in the form of mechanical work, such as moving the body and manual labour. The former is much the larger in amount. Even during a day of active muscular exercise the quantity spent in mechanical work amounts to only a fifth of that expended in heating the body. Now this largest item is particularly and disproportionately heavy in the child. To keep up the temperature the child's furnace must burn so to say more brightly than that of the adult, and especially is that true for an ill-clad child in a cold wet climate like our own.

CHAPTER XXI.

MUSCLE AND NERVE.

In the welding together of the cell-commonwealth of the body into one organised whole, a transcendent factor is the nervous system. This system is built up of elongated cells, *neurons*, set end to end so as to form lines, and along these lines which are delicate threadlets of living matter wavelets of activity, nervous *impulses*, are from time to time transmitted. The function of the system may be likened to that of a telegraph network by which messages are sent from one part to another in a populous country putting distant places and persons into communication one with another.

The Central Exchange; its ingoing and outgoing Paths.

The general arrangement of the nervous system may be sketched as follows. A great *central nervous organ*, protected in a bony casing, extends lengthwise along the body. This is the spinal cord in the spine and the brain in the skull. This central organ somewhat resembles a vast telephone-exchange. Into it run from various regions of the body nerve-threadlets altogether about 3,000,000 in number. Every one of the threadlets comes from some special cell-group, large or small, in this or that region of the body, and this cell-group constitutes a so-called *receptive* or *sense-organ*. These are the threadlets which *conduct* nervous impulses *into* the central exchange from the receptive organs whenever the latter are *excited*; for instance from the ear when waves of sound impinge upon that organ and excite it. Most of the sense organs whence start these ingoing lines lie on the outer surface of the body because the receptive organs are chiefly developed there, for instance the eye, and ear, and the organs of touch, and temperature sensation. Some lines however start for the exchange from the internal viscera, and not a few from sense organs in the muscles and joints (muscular sense) within the body.

On entering into the central nervous organ these ingoing lines make connection with great numbers of other lines leading about from one part to another of the central exchange itself. And the arrangement of these internal lines shows that the exchange itself, though it is a connected unity, is in effect a series of exchanges, and that these are put together on an understandable plan. In the first place, ranged regularly along its length, and therefore along the length of the body, is a chain of local exchanges each receiving and for many ordinary purposes competently and completely dealing with the incoming nerve-lines from that particular region (segment) of the body. Then, superposed upon these local exchanges, there are others which deal with certain groups and combinations of the local centres or exchanges. These lie mostly in the parts of the brain next to the spinal cord. The brain, though in some ways very different from the spinal cord and in higher animals, especially in man, much more voluminous, is fundamentally much like it, and the two are merely parts of one organ which in the head, where it is called brain, has come to manage not only its own local segments directly, but many other segments as well indirectly by influencing their local exchanges. But there are many ranks in the hierarchy of the sub-centres composing the whole central exchange. Over the lower sub-centres are set others, and over these latter others still, and so on, until finally there is reached a vast nervous exchange, the cerebral cortex, the supreme of all. This in man is larger than all the rest of the central nervous system taken together. It is the organ which in its most perfected form is man's unique characteristic and gives him his degree of mastery of the world. And the nervous impulses brought into any local centre may according to circumstances either remain confined within the limits of that local centre, or may be transmuted and transmitted to higher centres, even to the highest, the cerebral cortex itself. It is only in the last case probably that any conscious experience results, for in man consciousness without reaction of the cerebral cortex does not appear to arise.

Besides the ingoing threadlets entering the central nervous exchange there are also a great number, perhaps a million, outgoing threadlets which carry nervous impulses from the exchange outward to muscles and glands, and preponderantly to the former. As all the ingoing (*afferent*) threads pass direct to the purely local exchanges and are connected with the superior exchanges only by relays, so all the outgoing (*efferent*) threads start from the local exchanges solely, and superior centres can only get at an outgoing thread by making connection with the local centre to which it belongs and whence it starts. Yet, such is the completeness of the organisation of the whole exchange that it appears that any ingoing line can get into touch with any one of all the outgoing lines, though with some much more easily than with others.

Nervous Action.

The events directly connected with the activity of the nervous system are of two kinds sharply separable each from the other. The one kind is made up of all those phenomena such as sensations, perceptions and mental processes exhibited in intellect, in short of reactions of *consciousness*. For all these it appears that in man the great supreme central nervous exchange, the *cerebral cortex*, in whole or in part is a requisite. All the conscious events of our daily life imply nervous reactions in which the cerebral cortex is involved and participates.

The other class of events which the nervous system produces are effects in glands or muscles, modifications in the secretory activity of the former, in the contractile activity of the latter. The nervous reactions which end in glandular and muscular effects may or may not be accompanied by events of the other or conscious kind. Their unaccompaniment by consciousness is more frequent than might at first sight appear. Such unconscious reactions of the nervous system are termed *reflexes*, and some of them are not only very finely and delicately adjusted but are of high importance and utility. The simplest of them involve merely the local nervous exchanges (centres); the more complex involve higher centres as well and some involve even the cerebral cortex itself.

It is thus seen that a sense-organ, for instance the eye, may by the reaction of its ingoing nerve-threads evoke a sensation, in which case it is actually a *sense-organ*, or may evoke merely a reflex and no sensation, for instance when it merely contracts the pupil, and in the latter case it is acting not really as a sense-organ, but merely as a *reflex-producing* organ. The difference depends on whether or no the nerve-impulses started by it wander in the central nervous exchange to those parts of it whose working touches consciousness. Some, therefore, of the dealings of the nervous system are unconscious and some conscious. The unconscious lie outside the nervous machinery concerned with consciousness; but the conscious involve always besides the nervous machinery to which consciousness is adjunct some of the nerve machinery which works apart from consciousness. The actions of the conscious machinery are based on actions of the subconscious, and always find expression ultimately through these latter.

Muscle as the instrument of nerve.

In either case the physiological outcome of nervous action so predominantly uses muscle as its instrument of expression that something must now be said about muscle and its properties. *Muscles* are masses of specialised cells developed whereever in the body mechanical movements on any considerable scale, and sometimes on a quite minute scale have to be performed. The muscle-cells are called *muscle-fibres*, and have the power of shortening themselves even against considerable resistance. This active shortening is called *contraction*. The fibres are set together in strings which shorten when the fibres contract. When the strings run ringwise round tubes as in the intestine, the arteries, the heart, etc., the tube narrows, displacing its contents. When the strings are attached to bones their shortening pulls on the bone and moves it, as when the finger is bent. The muscle-fibre obtains its energy for contraction by chemically decomposing rich chemical compounds in it supplied it by the blood. The sugar glucose seems its chief pabulum for this purpose; it oxidises it, producing carbonic acid. The immediate means by which it executes its shortening seems to be the transference of water from the long axis to the transverse axis of the fibre so that the fibre becomes shorter and thicker.

Wherever there is muscle there is nerve; but there are various kinds of muscle, and the relation of these to the nervous system are severally somewhat different. The contractions of the muscles of the viscera and of the blood-vessels and heart, though partly under control by the central nervous exchange, are not ordinarily initiated from these. In the case of these muscles the central nervous system merely regulates their contractions which arise and proceed as events largely apart from it. This being so its regulative influence upon them is exercised in two directions, the one *augmentative*, increasing and quickening the contractions, the other *inhibitory*, lessening or suppressing the contractions.

But it is different with the muscles which clothe and move the bony frame of the body, the *skeletal muscles*, the only muscles which the man in the street recognises as such. Skeletal muscle never contracts of itself; it does so only at the direct behest of the great central nervous system. Hence if the nerve passing to it from that centre is severed this muscle is paralysed, and if allowed to remain so, dwindles and passes almost out of all recognition as muscle.

An old saying declares that all mankind can do is to move things. For this man's only executant in the last resort is his muscles. Imagine this item of the human machinery arrested for a single day. Not a train started or stopped, not a tram running, not a step taken, not a letter written, not a word uttered. A world of sense, feelings, thought, all robbed of their effect. This is what Carlyle expressed with the crudity of an aphorism when he wrote, "the end of man is an action, not a thought." Skeletal muscle works the world because it is the only medium through which effect can be given to mind. And the central nervous system not only brings it into action but can arrest (*inhibit*) its action. With skeletal muscle however this latter is done not by special inhibitory nerves going to the muscle itself, but, since the muscle contracts only when its nervous centre excites it, by nerves which run to that centre and restrain that centre's action, nerves which inhibit nerves. And these nerves are so arranged that they in this way inhibit the motor centres of some muscles while they at the same time excite the motor centres of other muscles (*reciprocal innervation*).

Every phase and degree of activity of a skeletal muscle depends on and simply mirrors the activity of the local nervous exchange whence it receives its motor nerve. The changes in the activity of the local nerve-centre which the muscle so constantly and faithfully reflects need not however react on consciousness. Many complex muscular acts executed and regulated by even large groups of these local centres are not consciously but merely reflexly performed. The same muscles and the same sets of local centres may at one time execute conscious acts, for instance, willed acts, and at another pure reflex acts which do not involve consciousness at all. Thus, there are the rhythmic alternating movements of the chest which ventilate the lungs, the inspiratory and expiratory movements of breathing. These involve and require the delicately co-ordinated action of many muscles which have to contract at the same time in duly proportioned intensity for duly proportioned periods, and then to cease from activity also with proper harmony, and yet again harmoniously recommence contraction. Yet, as we all know, their action involving as it does the nervous action of many nerves and nerve-centres scattered through wide regions of the great central nervous organ goes on unceasingly without our paying attention to it or being even aware of it unless we choose to watch it, as we can, chiefly however by its outward signs, the heaving of the chest, the air currents through the nostrils, and so forth. It goes on equally well too during those periods when the healthy regularly recurrent unconsciousness of sleep overtakes our mind. The respiratory movements are essentially *reflex*. But they can be consciously modified and controlled, as when we voluntarily take a deep breath, or for the purposes of speech or singing volitionally prolong the movement of expiration. In this case the higher nerve-centres of the cortex are at work and influence the lower reflex centres. And on the other hand the purely reflex movements of ordinary breathing are often modified reflexly, as for instance when some irritant beyond the pale of the will induces the deep inspiration and violently explosive expiration which we call a cough or sneeze, and will occur even despite the efforts of the will.

It is to be noted that such a reflex is a useful reaction; a feature of all reflexes is their utility. They are for that reason termed purposive. Their machinery and their automatic and machine-like character contribute usually to their usefulness for meeting needs and crises often of sudden and almost always of habitual or common occurrence and common and fateful not only now but through vast æons of the past history of the race.

And there are many grades and degrees of reflexes in this respect. Some are wholly unconscious and unmodifiable by will; as for instance the contraction of the pupil when light is thrown into the eye. Others habitually unconscious but yet capable of being attended to and modified though not altogether arrested by will, as the breathing movements. Others still, which are usually initiated or arrested by the will, but yet when started proceed automatically although frequently modified by the will from time to time during their occurrence. Examples of these latter are *standing* and *walking*.

Standing.

The maintenance of the erect posture demands the appropriate co-operation of many muscles and many nerves and nerve-centres, of lower local centres regulating the action of the muscles in their own particular district of the body, and of higher centres co-ordinating the actions of the several local centres. But there is clear evidence that the whole act can be performed in absence, and after destruction of the highest, the cortical, brain-centres. The child is commonly said to learn to stand, and in learning a muscular act, that is acquiring it by voluntary effort, the cortical centres are probably always required. But careful observations on children reveal instances in which children who for some reason have been prevented from attempting to stand, have at a period later than that at which children ordinarily learn to do so suddenly under some provocation stood and stood perfectly on this first opportunity. This indicates that the act is an inherited one which in due time post-natally develops with hereditary perfection. In man and some other animals it is not complete at birth; in many animals it is, for instance the chick can stand when it emerges from the egg. What we must understand by a child's learning to walk is therefore that under encouragement to practise, the child, by its efforts, assists and probably antedates the full development of a nervous and muscular act which in due course even without such aid will arrive at completion because an ancestral heritage. And this early and inherited completeness of the act without real need of acquirement by effort and practice argues the essentially reflex nature of it. When we assume the erect posture we are commonly aware that we do so, we will to do so; and again when we relinquish it. Yet its maintenance demands over and over again no attention from us, we may forget all about it, though we perceive it at once in many ways if occasion arises for us to do so. Many animals can and do stand while sleeping. In all these respects it is a reflex act.

And all this applies almost equally to the act of *stepping* in its various forms of walking and running. Stepping is an act closely related to that of standing. In it certain rhythmic actions of the muscles and nerve-centres, especially of the limbs, are so to say grafted upon that steady continuous action of the muscles, nerves and nerve-centres which in standing maintains the body erect.

Standing is maintained by a steadily continued mild activity of all those nerves and nerve-centres which actuate the particular muscles whose contraction counteracts the weight of the body and its several parts against their tendency to drop toward the ground, as gravitation would make them do. Thus the head jointed to the top of the spine tends to fall forwards at that joint, and the steady mild contractions of muscles at the back of the neck counteract this; hence the nodding of the head when onset of sleep begins to relax the steady activity of the nerve-centres that maintains the *tonus* of these muscles. Again the trunk carrying the neck and head is itself so carried on the hip-joints that it tends by its own weight to fall forward over those joints. This falling forward is prevented by the steady action of muscles attached to the back of the pelvis, the lowest part of the trunk, muscles which tie the pelvis to the back of the thigh bones. The nerve-centres of these muscles communicate just sufficient influence to them to make them contract enough to counteract that component of the superincumbent body-weight which would pull the body forward. Again, at the ankle the line of gravity of the body falls in front of the axis of that joint, and hence there exists the tendency to fall forward over it. But the muscles of the calf, under the steady though slight discharge of nervous impulses to them from their nervous centres, keep up a contraction just sufficing to prevent that falling forward, and counteract the influence of the body's superincumbent weight. Similarly the jaw is prevented from dropping; its fall is a well-known accompaniment of death. And similarly the upper eyelid is kept lifted, except for the rapid blinking movement which washes dust from the front of the eyeball from time to time throughout the waking day.

Nor is this all. The slightest change, even unconscious, in the standing posture alters the distribution of the weight of the body on the feet, and requires corresponding slight changes in the degree of *tonus* of the contracting muscles and their nerve centres. A pencil fixed to the top of the head and made to write on a paper spread above it shows that in standing the body is constantly slightly swaying to this side or that. The muscles are constantly checking little slips towards falling. These corrections proceed as automatically and reflexly and unconsciously as does the rest of the maintenance of the act. An important part in these reflex corrections is done under the guidance of a portion of the ear, the oldest and non-hearing portion of the ear: a portion which is specially entrusted with the reflex regulation, and also the perception of the positions of the head in space. The same organ which when we are subjected to the rolling and pitching of a ship and all the consequent rapidly changing unwonted positions of the head in space, causes giddiness and sea-sickness.

WALKING.

The step consists primarily of a movement of the leg, a movement divisible into two phases which alternate. In one of these, the *extension phase*, the foot is in contact with the ground and the limb straightens (extends) at knee, at hip, and finally at ankle, giving a push off from the ground and thus propelling the body forwards and a little upwards. This phase furnishes the propulsive force of the step. The phase immediately following this is the *flexion phase.* In it the hip and knee and ankle all flex, that is bend, slightly folding the limb up and thus withdrawing the foot from the ground. The foot thus lifted is swung forward clear of the ground by flexion of the hip, so that on the flexion subsiding the foot meets the ground at a point further forward than that at which it stood before. The extension phase then re-ensues and propels the body forward from this new place as from a *point d'appui.* And these two phases of the step divide the step period about equally between them, for while the propulsive extension is going on in one limb the flexion or clearing phase is going on in the other and *vice versa.*

The nerve-centres, nerves, and muscles which execute standing are those which also execute the extension phase of the step. They show in the two cases this difference only, that in the step they act for a short period which rhythmically recurs resting between whiles, and during that short period act with considerable intensity, whereas in standing they act less intensely but without intermitting. But in the flexion phase of the step another and quite different set of nerve-centres, nerves, and muscles become active, a set whose effect is exactly opposed to that employed in the extension phase and in standing. When this previously resting " flexion " set is brought into play the influence which puts it into action puts the "extension" set whose action would be opposed to it, to rest.

In walking therefore the steady continual action of the nerve-centres which during standing merely keep the limbs straightened and prevent them from doubling up under the weight of the body is alternately intensified so as to actually push the body upward and forward and then inhibited so as to allow antagonist nerve-centres to bend the limb and replace it for its next propulsive act. The activity of these centres is thus alternately reinforced and suppressed. While this is the case with the nerve-centres ruling the legs, with the many other nerve-centres which during standing maintain that act in other parts, keeping the head erect on the neck, the neck on the body, the body on the hips, and so on, walking brings no such interruption of their steadily continued action. Indeed walking and running may be described simply as the postural or tonic act of standing with engrafted upon it regularly rhythmic movements alternating in the legs.

If we liken the resting state of the nervous system with its continual slow oxidation to that of a damped black-hot furnace we can picture its state in the performance of "standing" as one with certain dimly but steadily glowing points scattered through the lower part of the brain and along the length of the spinal cord. When we start walking a number of these glowing points suddenly brighten into greater activity and oxidation, and then after a brief moment suddenly undergo extinction as another set not previously visible glows up. And then a moment later these latter darken again while those just previously extinguished once more reglow. And so the alternation goes on, the rhythm of the phasic glow alternating in the two sets, and the set which is glowing for one limb is at any moment the converse of the set which is glowing for the other limb.

The prolonged action of nerve-centres induces *fatigue* in them. The fatigue ensues the more quickly the more intense their activity. What is commonly called muscular fatigue is essentially fatigue of nerve-centres. If we compress with the hand a strong spring until with the greatest effort we can compress it no longer, our force being tired out, on applying an electric current to the employed muscles themselves we find little or no evidence of fatigue in *them*. It is the nerve-centres that have temporarily struck work. And not all nerve-centres tire with equal rapidity; as a rule the higher centres tire sooner than the inferior ones; and it is these former which restful sleep especially restores. Thus an unwonted posture of the arm such as holding it horizontally, when maintained by willed action tires rapidly, but the natural and reflex posture of standing can be long maintained without appreciable fatigue. In standing and other postures the intensity of action of the nerve-centres is relatively slight as compared with that required for executing movements. Muscular movements which the body continues to perform over long periods are almost always rhythmic. The heart for instance may in a sense be said to maintain its pumping action throughout life. But in doing so its contraction is continually followed by a pause of restful relaxation. Fatigue is thus avoided. Similarly the nerve-centres which actuate the movement of the chest for respiration go on life-long. But the inspiratory centres rest when the expiratory act, and the expiratory when the inspiratory act. So also with walking. During the extensor phase of the step the flexor centres rest, and during the flexor phase the extensor centres rest. They cannot help doing so because the same influence which excites the one to activity inhibits the other, puts the other so to say to sleep. And these two results are reflexly so linked together that the greater the activity of the one the deeper the sleep of the other (reciprocal innervation). Indeed the surest way of giving one set of nerve-centres and muscles rest is to drive the antagonistic centres and muscles into full activity. Hence it is that such an act as walking can be so long maintained without fatigue. And this is the natural basis of the hygienic fact that a free swing of the limb is essential to good walking. A cramped attitude in which the limb is never fully straightened is conducive to fatigue because it means that the flexor centres are never fully inhibited, never fully set to rest.

And during walking there is even more of that unconscious repeated adjustment of accessory nervous and muscular action than during standing because the balance of the body shifts more, being rhythmically transferred from one foot to the other.

Relatively simple and reflex as these great acts such as breathing, standing and stepping are, and an ancestral heritage perfected through vast periods of time and transmitted as such to the child, they might be thought so ingrained and immutable as to be beyond the need or reach of education. And this the more so when we remember the ease with which various skilled muscular acts entirely acquired by training simply during the course of the individual life become engrained in the nervous system so as to be largely reflex and of unconscious execution, such as piano-playing, writing, etc., and how difficult they are to change when once habitual. Yet nothing is more certain than that bad ways of executing the old ancestral acts of breathing, standing, stepping and so on are frequently lapsed into especially in childhood. The nervous action accomplishing these is therefore to some extent plastic. And the mere fact that bad habits can be formed in regard to them is a plain guarantee that suitable training can re-correct them.

Movements of Breathing.

In breathing the inspiratory act which should fill the lungs freely can be hampered by hindrance to the free descent of the floor of the chest, the diaphragm. As the diaphragm descends the liver and other abdominal viscera are pushed before it and the abdominal wall is pushed freely forward. The freedom of this necessary movement is hindered by any clothing which too tightly constricts the lower part of the body and the waist. The inspiratory movement filling the chest is also impeded by postures which are stooped and crouched. Inspiration as properly carried out involves a straightening of the whole spine below the neck. It is also assisted by the muscles which pass from the shoulders to the chest, and these are prevented from due play if the shoulders instead of being held well back are allowed to droop forward. A bad habit of breathing prone to be acquired in childhood is that of drawing the breath in through the mouth (*mouth-breathing*) instead of through the nose. One advantage of the latter is that the air is better warmed and moistened before it reaches the larynx and the lungs. The air is also better freed of dust. It is also made to serve as it should the organ of smell. Further, it does not harm the delicate living cells lining the nose adapted by nature to resist its drying and cooling influence, whereas it does harm those of the tongue and mouth since these are not adapted to resist those influences and become dry and cold and in result tend to inflame. The habit of mouth-breathing is probably usually started by some "cold" which temporarily blocks the child's nose with secretion so that the alternative passage of the mouth is adopted for the breathing. This habit if persisted in leads to various well-known symptoms which "mouth-breathers" usually present. The nostrils and the nose remain undeveloped in size owing to their want of exercise in their normal daily functions; they have a pinched appearance. The lips and jaw are kept slightly open, giving a listless undetermined look, the chin remains small, and the lower front teeth tend to lie in a retreated position not meeting but lying behind the teeth of the upper jaw above. The red part of the lips tends to become cracked from dryness. The tongue is liable to be furred under the drying, sometimes dusty, air current to which it is continually exposed. The tonsils, a pair of almond-shaped spongy masses lying one on either side of the passage from the mouth into the throat and consisting of tissue particularly prone to swell and inflame under bacterial attack, enlarge and become "tender," making the throat feel sore. In the same region and also in the upper part of the throat, called the pharynx, there is an overgrowth of similar tissue, forming what are called *adenoids*. These and the swelling of the mucous membrane round about are liable to block the narrow passage (*Eustachian tube*) which connects the ear-drum with the throat. This may cause deafness, in the following way.

The nerve of hearing, which carries into the brain the nerve-currents for hearing, consists of some 14000 threadlets having their outer or receptive ends immersed in water in a little chamber recessed in the deep bone-encased part of the ear. To stimulate the nerve all sounds reaching us through the air must shake this water in which the nerve-ends and their receptive cells lie immersed. A mechanical problem for the ear is therefore the changing of the delicate air-waves of sound into corresponding water-vibrations in the ear. It does this by means of a membrane, the *tympanic membrane*, hung across the path of the air-waves at the bottom of the ear. This membrane when sounds reach it vibrates and in its turn shakes a tiny fairy-like chain of ossicles whose one end rests against the deep side of the membrane while its other end rests against the sac containing the water of the internal ear, and conveys the vibrations truly to it. For the proper transmutation of the air-waves it is of the first importance that the tympanic membrane should have a certain proper shape and tightness. The membrane is often called the *drum-membrane* because it shuts off a part of the ear which thus shut off resembles a minute kettle-drum. To have its suitable tightness and its form the drum-membrane of the ear must be supported by a pressure of air within the drum equal to the pressure of the air on the outside of the drum, that is the barometric pressure of the atmosphere. The equality of the inside with the outside pressure is ensured by the Eustachian tube. This tube connects the ear-drum with the throat. It is opened each time we swallow though at all other times closed. If closed too long the air in it falls to too low a pressure because it becomes rarified by absorption of its oxygen by the blood-vessels of the drum. The pressure of the outside air becoming then relatively excessive bears on the drum and presses the drum-membrane inward and over-stretches and mis-shapes it. The membrane then picks up and transmutes the air-waves poorly and imperfectly with deafness as a result. The deafness which is a frequent temporary accompaniment of a severe cold in the head is brought about in this way, by the blocking of the Eustachian tube by the swelling and excessive secretion of the inflamed membrane lining the tube. The tube is narrow and only too easily blocked. In the mouth-breather with his chronically thickened and inflamed pharynx and tonsils and his probable adenoids the blocking becomes permanent. And one element contributing to his appearance of stupidity and apathy, stupidity and apathy which may not really belong to his nature, is his *Eustachian deafness.*

The first step in the relief of the mouth-breather suffering from adenoids is the removal of the adenoids by the surgeon, an operation not usually severe. But the benefit following that relief should be assured and followed up by the establishing of a correct habit of breathing through the nostrils and with the mouth closed. For this purpose "breathing exercises" such as described in all manuals of physical training, are necessary, and if properly carried through quickly effect great improvement. It is on account of the necessity and success of this part of the treatment that mouth-breathing is mentioned in this chapter on "Nerve and Muscle."

Unnecessary stress may seem to have been laid here on such apparently simple and unskilled acts as standing, stepping and breathing. These habitual acts it must be remembered are the foundations on which rest a superstructure of many in the narrower sense more skilled and technical. Stepping, it was pointed out, is essentially a movement engrafted upon standing. The child that does not stand well will not walk well or run well. So likewise the breathing movements of the chest and throat are the foundation upon which are reared the movements which produce the voice. The chest with the lung within forms the bellows for the reed pipe of the larynx, the producer of all vocal sounds. Good and well-controlled movements of breathing are a basis without which good speaking and good singing are impossible. We can therefore hardly over-state the importance for children of proper execution of these great and fundamental though seemingly simple muscular acts.

Sensory Guidance of Muscular Acts.

The ear has just been touched on, and already in this chapter it was noted that a part, the more primitive and ancient part, of the ear is concerned less with hearing than with regulating the attitudes and movements of the head. Experiment proves that the attitudes and movements of the head so dominate those of the body that the nervous mechanisms of the latter adjust and subordinate themselves to those of head. This must indeed be obvious to anyone who observes the body's ways of doing things. Hence muscular acts involving the body as a whole—and very few do not—demand the co-operation of this fundamental part of the ear; their grace, their balance, their smartness and their harmonious sureness are partly guaranteed by the co-operation of the ear. Hence we are not surprised at the deep connection between rhythmic movement of the body and music, and their intimacy exemplified by dancing. We may be sure that physical exercises should employ rhythm and accentuate and vivify it by musical accompaniment.

Physical exercise is then in part a training of and by a sense, namely that of the ear. Physical exercises which as we have already seen are so largely exercises of nerve-centres are indeed largely a training of sense, for it must not be forgotten that the muscles themselves besides being instruments for maintaining postures and executing movements are delicate sense-organs as well. They contain numbers of sense-organs, which serve what is termed the *muscular sense*, the sense which makes us aware of the positions and tensions and movements of our limbs, and all mobile parts of the body, so that in the dark or with the eyes closed we know how we are standing and whether our arm is extended or no, and which foot is in front of the other, and so on. This is the sense which in co-operation with the ear and even more strictly than that guides the execution of any movement even in its details. The acquisition of any skilled act is achieved always by special training of this sense in regard to that particular act. It is by means of this sense that the skilled typewriter finds the letters on his instrument without even looking at them and the pianist the piano keys.

The muscular sense is not equally developed in all regions of the musculature. In the limb touch is finest in the fingers but muscular sense is finest in the shoulder; therefore it is that if we would draw well on the blackboard free use of the shoulder should be a guiding principle. The delicacy of the muscular sense of the shoulder is well seen in the accuracy of delivery of a cricket ball by a good bowler. The movements of the neck are richly fraught with muscular sensation, and neck movements help to educate movements of the whole trunk and limbs and helpfully amplify them. In children brought up in cities there is a danger that opportunity for the exercise and training of this important sense will be limited and the sense lie dormant and undeveloped, entailing clumsiness and imperfection of muscular action and growth. A definite aim of physical training should be to rescue this sense for the children.

Secondary Effects of Muscular Exercise.

While on the subject of muscular exercise we may note what may be termed its secondary effects. The muscles in their activity produce quantities of heat and carbonic acid. The former, as was said, cause the skin to become flushed and warm with blood; the latter cause the respiratory nerve-centres to increase their action and the filling and emptying of the lungs to be more free. The active muscles themselves also become more richly supplied with blood and take more oxygen. This increased supply of blood persists in them for a time even after their own contractile activity has subsided, and forms a favourable circumstance for their growth. In the growth of muscles the muscle-fibres do not become more numerous but the individual fibres become larger and stronger. The exercise should be pushed just as far as the onset of a slight fatigue and no farther. In the growing healthy child the repair which ensues in the muscle during the rest that follows on exercise tends to be accompanied by actual growth in size and power. It is the extra need for material for repair and growth which the muscles experience after suitable exercise which calls up the appetite for food that should follow on such exercise. Further, muscular exercise reacts on the bones and joints which the muscles pull upon and moulds and strengthens them so that good muscles go usually hand in hand with a well-developed and well-knit bony frame.

Cerebral Cortex.

There is a part of the brain called the great brain or *cerebrum*. The larger part of this in man is a great many-layered surface sheet of neurons called the *cortex*. It is to the activity of the neurons of this cortex that mental processes are due. It may in so far be termed the organ of mind. A touch on the hand of a sleeping child will cause the fingers to move, but there is no evidence that the child perceives the touch.

It does not know it is touched. On waking it has no remembrance of having been touched. The movement was an unconscious reflex. The nerve-impulses which the touch excited in the skin nerves were conducted to the spinal cord and perhaps to certain parts of the brain; but sleep renders the cerebral cortex inert and the nerve-impulses fail to arouse the cortical cells. But if the child is awake it feels the touch, and knows when and where it is touched, and whether it is touched at one place or at two. The touch response of the nervous system in the sleeping child is unconscious, in the waking child it is conscious; in the former case the cerebral cortex was not implicated but in the latter case it is implicated. And if the cortex has to be called into play for the performance of so relatively simple a process as the perceiving of a touch still more is it required for the manifold complex operations which constitute the mental processes of intelligence and reason. Though physiology has many interesting things to say about the cortex it is *psychology*, the study which deals with mental phenomena as objects of scientific enquiry, which is the practical exponent of the chief functions of the cortex.

A point which physiology at once notices about the cerebrum is the relatively vast amount of neural structure which the conscious processes such as we know them in man appear to require. The cortex and the nerve fibres entering and leaving it make up a mass larger than all the rest of the nervous system taken together; and this although there is probably not a single movement of the body that cannot of itself be executed by the nerve centres below the cortex in the lower parts of the brain and in the spinal cord.

Another feature which physiology reveals is the localisation of functions in the cerebrum. Different parts of the cortex are concerned with different functions. Not that this differentiation of function at all resembles the old fantastic guess-work termed phrenology. Nor even that to great fundamental forms of mental processes such as psychology recognises under the terms memory, emotion, will, etc., separate departments of the cortex can be assigned. But physiological experiment and observation show that to the organs of sense certain areas of the cortex are severally and separately assignable. Thus, that the cortex of the extreme hinder end of each cerebral hemisphere is specially connected with the elaboration of visual sensations, the cortex of the upper part of each temporal lobe with hearing, that of the under and front part of each temporal lobe with taste and smell. Destruction of these areas impairs vision, hearing, etc. according as this or that area is the seat of the injury. And there is in the hinder part of the frontal lobe a region of cortex stimulation of which excites movements in the muscles of the opposite half of the body, certain points yielding movements of lips, and tongue, others yielding movements of hand and arm, others again of foot and leg, others again movements of the eyeballs. Destruction of the brain in these places impairs voluntary power to execute these movements. A third point to notice is that in man the right and left halves of the cerebrum appear to be unequal in importance. The right half as mentioned is concerned chiefly with sensations and movements of the left half of the body, and the left cortex with those of the right side of the body. Man is right-handed and therefore injury of the left cerebrum causing as it does a loss of power of the right hand inflicts a heavier disablement than the right cerebrum. But the greater severity of effect of injury of the left than of the right hemisphere amounts to more than that. Articulate speech is perhaps the most salient exclusively human physiological function. Destruction of certain regions in the left cerebrum annuls speech, whereas similar injuries of the right cerebrum do not. This loss of the power of speech is termed aphasia; and there are several forms of aphasia, and these forms throw some light on the cerebral processes involved in speech, and in the comprehension of language.

In one form the patient loses ability to express himself in spoken words although he can repeat words immediately after hearing them. In some cases the power to understand spoken words is lost although he can hear them and can understand written words. And there are cases in which the power to understand written words is lost although the power to understand spoken words is retained. All this indicates that speech involves a power on the part of the cerebral cortex to elaborate and revive the mental images of words as more or less separate visual and auditory memories. The ability to utter words appropriately at will requires the ready recall of these memories by the working of the cortex.

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