the "expectation of life." Abraham is described as having lived only to 175 years, Joseph and Joshua to 110, Moses to 120; even at that age "his eye was not dim nor his natural force abated." We cannot say that under ideal conditions all these terms are impossible; indeed, Metchnikoff is disposed to regard them as probable; for great ages are still occasionally recorded, although it is doubtful if any as considerable as these are ever substantiated. That the expectation of life was better then than now would be inferred from the apologetic tone adopted by Jacob when questioned by Pharaoh as to his age: "The days of the years of my pilgrimage are a hundred and thirty years; few and evil have the days of the years of my life been, and have not attained unto the days of the years of the life of my fathers in the days of their pilgrimage." David, to whom, before the advent of the modern statistician, we owe the idea that seventy years is to be regarded as the normal period of life,³⁰ is himself merely stated to have "died in a good old age." The periods recorded for the Kings show a considerable falling-off as compared with the Patriarchs; but not a few were cut off by violent deaths, and many lived lives which were not ideal. Amongst eminent Greeks and Romans few very long lives are recorded, and the same is true of historical persons in mediæval and modern history. It is a long life that lasts much beyond eighty; three such linked together carry us far back into history. Mankind is in this respect more favoured than most mammals, although a few of these surpass the period of man's existence.³¹ Strange that the brevity of human life should be a favourite theme of preacher and poet when the actual term of his "erring pilgrimage" is greater than that of most of his fellow creatures!

The End of Life.

The modern applications of the principles of preventive medicine and hygiene are no doubt operating to lengthen the average life. But even if the ravages of disease could be altogether eliminated it is certain that at any rate the fixed cells of our body must eventually grow old and ultimately cease to function; when this happens to cells which are essential to the life of the organism, general death must result. This will always remain the universal law, from which there is no escape. "All that lives must die, passing through nature to eternity."

Such natural death unaccelerated by disease—is not death by disease as unnatural as death by accident?—should be a quiet, painless phenomenon, unattended by violent change. As Dastre expresses it, "The need of death should appear at the end of life, just as the need of sleep appears at the end of the day." The change has been led gradually up to by an orderly succession of phases, and is itself the last manifestation of life. Were we all certain of a quiet passing—were we sure that there would be "no moaning of the bar when we go out to sea"—we could anticipate the coming of death after a ripe old age without apprehension. And if ever the time shall arrive when man will have learnt to regard this change as a simple physiological process, as natural as the oncoming of sleep, the approach of the fatal shears will be as generally welcomed as it is now abhorred. Such a day is still distant; we can hardly say that its dawning is visible. Let us at least hope that, in the manner depicted by Dürer in his well-known etching, the sunshine which science irradiates may eventually put to flight the melancholy which hovers, bat-like, over the termination of our lives, and which even the anticipation of a future happier existence has not hitherto succeeded in dispersing.

³⁰ The expectation of life of a healthy man of fifty is still reckoned at about twenty years.

³¹ "Hominis ævum ceterorum animalium omnium superat præter admodum paucorum."—Francis Bacon, *Historia vitæ et mortis*, 1637.

THE diagonal braking system introduced by Argylls, Limited, acts, we are informed, equally and simultaneously on all four wheels, and not on two of them; the effect is claimed to be an even pull without "dithering" or any tendency to skid.

THE ninth International Otological Congress was held in Boston, Mass., on August 12th to 16th, under the presidency of Dr. Clarence J. Blake. The number of practitioners who attended was 410, of whom 25 were official representatives of foreign countries. The next congress will be held at Halle in Germany in 1915 under the presidency of Dr. Alfred Denker.

An Address

ON

THE INFLUENCE OF MUSCULAR EXERCISE AND OPEN AIR ON THE BODILY FUNCTIONS.

DELIVERED AT THE PHYSIOLOGICAL SECTION OF THE BRITISH ASSOCIATION.

BY

LEONARD HILL, M.B., F.R.S.,

LECTURER ON PHYSIOLOGY, LONDON HOSPITAL MEDICAL SCHOOL, PRESIDENT OF THE SECTION.

LAST year the distinguished President of this Section raised us to the contemplation of the workings of the soul. I ask you to accompany me in the consideration of nothing higher than a stuffy room. Every one thinks that he suffers in an ill-ventilated room owing to some change in the chemical quality of the air, be it want of oxygen, or excess of carbon dioxide, the addition of some exhaled organic poison, or the destruction of some subtle property by passage of the air over steam-coils or other heating or conducting apparatus. We hear of "devitalized" or "dead" air, and of "tinned" or "potted" air of the battleship. The good effects of open-air treatment, sea and mountain air, are no less generally ascribed to the chemical purity of the air. In reality the health-giving properties are those of temperature, light, movement, and relative moisture of the surrounding atmosphere; and leaving on one side those gross chemical impurities which arise in mines and in some manufacturing processes, and the question of bacterial infection, the alterations in chemical composition of the air in buildings where people crowd together and suffer from the effects of ill-ventilation have nothing to do with the causation of these effects.

Satisfied with the maintenance of a specious standard of chemical purity, the public has acquiesced in the elevation of sky-scrapers and the sinking of cavernous places of business. Many have thus become cave-dwellers, confined for most of their waking and sleeping hours in windless places, artificially lit, monotonously warmed. The sun is cut off by the shadow of tall buildings and by smoke—the sun, the energizer of the world, the giver of all things which bring joy to the heart of man, the fitting object of worship of our forefathers.

The ventilating and heating engineer hitherto has followed a great illusion in thinking that the main objects to be attained in our dwellings and places of business are chemical purity of the air and a uniform draughtless summer temperature.

Life is the reaction of the living substance to the ceaseless play of the environment. Biotic energy arises from the transformation of those other forms of energy—heat, light, sound, etc.—which beat upon the transformer, the living substance (B. Moore). Thus, when all the avenues of sense are closed, the central nervous system is no longer aroused and consciousness lapses. The patient who lost one labyrinth by disease, and, to escape unendurable vertigo, had the other removed by operation, was quite unable to guide his movements or realize his position in the dark. Rising from bed one night, he collapsed on the floor and remained there helpless till succour arrived.

A sense organ is not stimulated unless there is a change of rate in the transference of energy; and this to be effectual must occur in most cases with considerable quickness. If a weak agent is to stimulate, its application must be abrupt (Sherrington). Thus the slow changes of barometric pressure on the body-surface originate no skin sensations, though such changes of pressure, if applied suddenly, are much above the threshold value for touch. A touch excited by constant mechanical pressure of slight intensity fades quickly below the threshold of sensation. Thus the almost unbearable discomfort which a child feels on putting on for the first time a "natural" wool vest fades away and is no longer noticed with continual wear. Thomas à Becket soon must have become oblivious to his hair

shirt, and even to its harbingers. It is not the wind which God tempers to the shorn lamb, but the skin of the lamb to the wind. The inflow of sensations keeps us active and alive and all the organs working in their appointed functions. The cutaneous sensations are of the highest importance. The salt and sand of wind-driven sea air particularly act on the skin, and through it braces the whole body. The changing play of wind, of light, cold, and warmth stimulate the activity and health of mind and body. Monotony of sedentary occupation and of an overwarm still atmosphere endured for long working hours destroys vigour and happiness, and brings about the atrophy of disuse. We hear a great deal of the degeneration of the race brought about by city life, but observation shows us that a drayman, navvy, or policeman can live in London, or other big city, strong and vigorous, and no less so than in the country. The brain worker, too, can keep himself perfectly fit if his hours of sedentary employment are not too long, and he balances these by open-air exercise. The horses stabled, worked, and fed in London are as fine as any in the world; they do not live in windless rooms heated by radiators.

The hardy men of the North were evolved to stand the vagaries of climate—cold and warmth—a starved or full belly have been their changing lot. The full belly and the warm sun have expanded them in lazy comfort; the cold and the starvation have braced them to action. Modern civilization has withdrawn many of us from the struggle with the rigors of Nature; we seek for and mostly obtain the comfort of a full belly, and expand all the time in the warm atmosphere afforded us by clothes, wind-protected dwellings, and artificial heat—particularly so in the winter, when the health of the business man deteriorates. Cold is not comfortable, neither is hunger; therefore we are led to ascribe many of our ills to exposure to cold, and seek to make ourselves strong by what is termed good living. I maintain that the bracing effect of cold is of supreme importance to health and happiness; that we become soft and flabby, and less resistant to the attacks of infecting bacteria in the winter, not because of the cold, but because of our excessive precautions to preserve ourselves from cold; that the prime cause of "cold" or "chill" is not really exposure to cold, but to the overheated and confined air of rooms, factories, and meeting-places. Seven hundred and eleven survivors were saved from the *Titanic* after hours of exposure to cold. Many were insufficiently clad, and others wet to the skin. Only one died after reaching the *Carthage*, and he three hours after being picked up. Those who died perished from actual cooling of the body. Exposure to cold did not cause in the survivors the diseases commonly attributed to cold.

Conditions of city and factory life diminish the physical and nervous energy, and reduce many from the vigorous health and perfectness of bodily functions which a wild animal possesses to a more secure, but poorer and far less happy, form of existence. The ill-chosen diet, the monotony and sedentary nature of daily work, the windless uniformity of atmosphere, above all, the neglect of vigorous muscular exercise in the open air and exposure to the winds and light of heaven—all these, together with the difficulties in the way of living a normal sexual life, go to make the pale, undeveloped, neurotic, and joyless citizen. Nurture in unnatural surroundings, not Nature's birthmark, moulds the criminal and the wastrel. The environment of childhood and youth is at fault rather than the stock; the children who are taken away and trained to be sailors, those sent to agricultural pursuits in the Colonies, those who become soldiers, may develop a physique and bodily health and vigour in striking contrast to their brothers who become clerks, shop assistants, and composers.

Too much stress cannot be put on the importance of muscular exercise in regard to health, beauty, and happiness. Each muscle fills with blood as it relaxes, and expels this blood on past the venous valves during contraction. Each muscle, together with the venous valves, forms a pump to the circulatory system. It is the function of the heart to deliver the blood to the capillaries, and the function of the muscles—visceral, respiratory, and skeletal—to bring it back to the heart. The circulation is contrived for a restless mobile animal; every vessel is arranged so that muscular movement furthers the flow of blood.

The pressure of the blood in the veins and arteries under the influence of gravity varies with every change of posture. The respiratory pump, too, has a profound influence on the circulation. Active exercise, such as is taken in a game of football, entails endless changes of posture, varying compressive actions—one with another struggling in the rough and tumble of the game—forcible contractions and relaxations of the muscles, and a vastly increased pulmonary ventilation; at the same time the heart's action is accelerated and augmented and the arterial supply controlled by the vasomotor system. The influence of gravity, which tends to cause the fluids of the body to sink into the lower parts, is counteracted; the liver is rhythmically squeezed like a sponge by the powerful respiratory movements, which not only pump the blood through the abdominal viscera, but thoroughly massage these organs, and kneading these with the omentum clean the peritoneal cavity and prevent constipation. At the same time the surplus food metabolic products, such as sugar and fat, stored in the liver, are consumed in the production of energy, and the organs swept with a rapid stream of blood containing other products of muscular metabolism which are necessary to the inter-relation of chemical action. The output of energy is increased very greatly; a resting man may expend 2,000 calories per diem; one bicycling hard for most of the day expended 8,000 calories, of which only 4,000 was covered by the food eaten.

Such figures show how fat is taken off from the body by exercise, for the other 4,000 calories comes from the consumption of surplus food products stored in the tissues. While resting a man breathes some 7 litres of air, and uses 300 c.cm. of oxygen per minute, against 140 litres and 3,000 c.cm. while doing very hard labour. The call of the muscles for oxygen through such waste products as lactic acid impels the formation of red corpuscles and haemoglobin. The products of muscular metabolism in other ways not yet fully defined modify the metabolism of the whole body.

Exposure to cold, cold baths, and cold winds has a like effect, accelerating the heart and increasing the heat production, the activity of the muscles, the output of energy, the pulmonary ventilation, and intake of oxygen and food. In contrast with the soft, pot-bellied, over-fed city man, the hard, wiry fisherman trained to endurance has no superfluity of fat or tissue fluid. His blood volume has a high relative value in proportion to the mass of his body. His superficial veins are confined between a taut skin and muscles, hard as in a racehorse trained to perfection. Thus the adequacy of the cutaneous circulation and loss of heat by radiation rather than by sweating is assured. His fat is of a higher melting-point, hardened by exposure to cold. In him less blood is derived to other parts, such as adipose tissue, skin, and viscera. He uses up the oxygen in the arterial blood more completely and with greater efficiency; for the output of each unit of energy his heart has to circulate much less blood (Krogh); his blood is sent in full volume by the well-balanced activity of his vasomotor system to the moving parts. Owing to the perfect co-ordination of his muscles, trained to the work, and the efficient action of his skin and cutaneous circulation—the radiator of the body—he performs the work with far greater economy and less fatigue. The untrained man may obtain 12 per cent. of his energy output as work, against 30 per cent., or perhaps even 50 per cent., obtained by the trained athlete. Hence the failure and risk suffered by the city man who rushes straight from his office to climb the Alps. On the other hand, the energetic man of business or brain worker is kept by his work in a state of nervous tension. He considers alternative lines of action, but scarcely moves. He may be intensely excited, but the natural muscular response does not follow. His heart is accelerated, and his blood pressure raised, but neither muscular movements and accompanying changes of posture, nor the respiratory pump materially aid the circulation. The activity of his brain demands a rapid flow of blood, and his heart has to do the circulatory work, as he sits still or stands at his desk, against the influence of gravity. Hence a high blood pressure is maintained for long periods at a time by vasoconstriction of the arteries in the lower parts of the body and increased action of the heart; hence, perhaps, arise those degenerative changes in the circulatory system which affect some men tireless in their mental activity.

We know that the bench-worker who stands on one leg for long hours a day may suffer from degeneration and varicosity of the veins in that leg. Long continued high arterial pressure, with systolic and diastolic pressures approximately the same, entails a stretched arterial wall, and this must impede the circulation in the vaso vasorum, the flow of tissue lymph in, and nutrition of, the wall. Since his sedentary occupation reduces the metabolism and heat production of his body very greatly, the business man requires a warmer atmosphere to work in. If the atmosphere is too warm it reduces his metabolism and pulmonary ventilation still further; thus he works in a vicious circle. Exhausting work causes the consumption of certain active principles—for example, adrenalin, and the reparation of those must be from the food. To acquire certain of the rarer principles expended in the manifestation of nervous energy more food may have to be eaten by the sedentary worker than can be digested and metabolized. His digestive organs lack the kneading and massage, the rapid circulation and oxidation of foodstuffs which is given by muscular exercise. Hence arise the digestive and metabolic ailments so common to brain workers.

Mr. Robert Milne informs me that of the thousands of children which have passed through Barnardo's Homes—there are 9,000 in the homes at any one time—not one after entering the institution and passing under its regimen and the care of his father, Dr. Milne, has developed appendicitis. Daily exercise and play, adequate rest, a regular simple diet, have ensured their immunity from this infection. It pays to keep a horse healthy and efficient; it no less pays to keep men healthy. I recently investigated the case of clerks employed in a great place of business, whose working hours are from 9 a.m. to 6 p.m. on three days, and 7 a.m. to 9 p.m. on the other three days of each week, and, working such overtime, they make £1 to £2 a week; these clerks worked in a confined space—forty to fifty of them in 8,200 cubic feet, lit with thirty electric lamps, cramped for room, and overheated in warm summer days. It is not with the chemical purity of the air of such an office that fault is to be found, for fans and large openings ensured this sufficiently. These clerks suffered from their long hours of monotonous and sedentary occupation, and from the artificial light, and the windless, overwarm, and moist atmosphere. Many a girl cashier has worked from 8 to 8.30, and on Saturdays from 8 to 10, and then has had to balance her books, and leave perhaps after midnight on Sunday morning. Her office is away in the background—confined, windless, artificially lit. The Shops Act has given a little relief from these hours. What, I ask, is the use of the State spending a million a year on sanatoriums and tuberculin dispensaries, when those very conditions of work continue which lessen the immunity and increase the infection of the workers?

The jute industry in this town of Dundee is carried out almost wholly by female and boy labour. "The average wages for women are below 12s. in eight processes, and above 12s., but under 18s., for the remaining five processes." The infant mortality has been over 170 per 1,000. The Social Union of Dundee reported in 1905 that of 885 children born to 240 working mothers, no fewer than 520, or 59 per cent., died—and almost all of them were under 5 years of age. The life of these mothers was divided between the jute factory and the one-roomed tenement. Looking such conditions squarely in the face, I say it would be more humane for the State to legalize the exposure of every other newborn infant on the hillside rather than allow children to be slowly done to death. The conditions, as given in the report, contravene those rights of motherhood which the meanest wild animal can claim.

Isolation hospitals, sputum-pots, and antispitting regulations will not stamp out tuberculosis. Such means are like shutting the door of the stable when the horse has escaped. Flügge has shown that tubercle bacilli are spread by the droplets of saliva which are carried out as an invisible spray when we speak, sigh, cough, sneeze. Sputum-pots cannot control this. The saliva of cases of phthisis may teem with the bacilli. The tuberculin reaction tests carried out by Hamburger and Monti in Vienna show that 94 per cent. of all children aged 11 to 14 have been infected with tubercle. In most the infection is a mere temporary indisposition. I believe that the conditions of exhausting work,

and amusement in confined and overheated atmospheres, together with ill-regulated feeding, determine largely whether the infection, which almost none can escape, become serious or not. Karl Pearson suggests that the death statistics afford no proof of the utility of sanatorium or tuberculin dispensaries, for during the very years in which such treatment has been in vogue, the fall in the mortality from tuberculosis has become less relatively to the fall in general mortality. He opines that the race is gradually becoming immune to tubercle, and hence the declination in the mortality curve is becoming flattened out—that Nature is paramount as the determinant of tuberculosis, not nurture. From a statistical inquiry into the incidence of tuberculosis in husband and wife and parent and child, Pearson concludes that exposure to infection as in married couples is of little importance, while inborn immunity or diathesis is a chief determinant. Admitting the value of his critical inquiries and the importance of diathesis, I would point out that in the last few years the rush and excitement of modern city life has increased, together with the confinement of workers to sedentary occupations in artificially lit, warm, windless atmospheres. The same conditions pertain to places of amusement, eating-houses, tube railways, etc.

Central heating, gas radiators, and other contrivances are now displacing the old open fire and chimney. This change greatly improves the economical consumption of coal and the light and cleanliness of the atmosphere. But in so far as it promotes monotonous, windless, warm atmospheres, it is wholly against the health and vigour of the nation. The open fire and wide chimney ensure ventilation, the indrawing of cold outside air, streaky air—restless currents at different temperatures, which strike the sensory nerves in the skin and prevent monotony and weariness of spirit. By the old open fires we were heated with radiant heat. The air in the rooms was drawn in cool and varied in temperature. The radiator and hot-air system give us a deadly uniformly heated air—the very conditions we find most unsupportable on a close summer's day.

In Labrador and Newfoundland, Dr. Wakefield tells me, the mortality of the fisherfolk from tuberculosis is very heavy. It is generally acknowledged to be 4 per 1,000 of the population per annum, against 1.52 for England and Wales. Some of the Labrador doctors talk of 7 and even 8 per 1,000 in certain districts. The general death-rate is a low one. The fishermen fish off shore, work for many hours a day in the fishing season, and live with their families on shore in one-roomed shanties. These shanties are built of wood, the crannies are "stogged" with moss, and the windows nailed up, so that ventilation is very imperfect. They are heated by stoves and kept at a very high temperature—for example, 80° F. Outside in the winter the temperature may be 30° below freezing. The women stay inside the shanties almost all their time, and the tuberculosis rate is somewhat higher in them. The main food is white bread, tea stewed in the pot till black, fish occasionally, a little margarine, and molasses. The fish is boiled and the water thrown away. Game has become scarce in recent years; old, dark-coloured flour—spoken of with disfavour—has been replaced by white flour. In consequence of this diet beri-beri has become rife to a most serious extent, and the hospitals are full of cases. Martin Flack and I have found by our feeding experiments that rats, mice, and pigeons cannot be maintained on white bread and water, but can live on wholemeal, or on white bread in which we incorporate an extract of the sharps and bran in sufficient amount. Recent work has shown the vital importance of certain active principles present in the outer layers of wheat, rice, etc., and in milk, meat, etc., which are destroyed by heating to 120° C. A diet of white bread or polished rice and tinned food sterilized by heat is the cause of beri-beri. The metabolism is endangered by the artificial methods of treating foods now in vogue. As to the prevalence of tuberculosis in Labrador, we have to consider the intermarriage, the bad diet, the over-rigorous work of the fishermen, the overheating of and infection in the shanties. Dr. Wakefield has slept with four other travellers in a shanty with father, mother, and ten children. In some there is scarcely room on the floor to lie down. The shanties are heated with a stove on which pots boil all the time; water runs

down the windows. The patients are ignorant, and spit everywhere—on bed, floor, and walls. In the schools the heat and smell is most marked to one coming in from the outside air. In one school 50 cubic feet per child is the allowance of space. The children are eating all day long, and are kept in close, hot confinement. They suffer very badly from decay of the teeth. Whole families are swept off with tuberculosis, and the child who leaves home early may escape, while the rest of a family dies. Here, then, we have people living in the wildest and least populated of lands with the purest atmosphere suffering from all those ill results which are found in the worst city slums—tuberculosis, beri-beri, and decayed teeth.

The bad diet probably impels the people to conserve their body heat and live in the over-warm, confined atmosphere, just as our pigeons fed on white bread sit, with their feathers out, huddled together to keep each other warm.

The metabolism, circulation, respiration, and expansion of the lung are all reduced. The warm, moist atmosphere lessens the evaporation from the respiratory tract, and therefore the transudation of tissue lymph and activity of the ciliated epithelium. The unexpanded parts of the lung are not swept with blood. Everything favours a lodgement of the bacilli, and lessens the defences on which immunity depends. In the mouth, too, the immune properties of the saliva are neutralized by the continual presence of food, and the temperature of the mouth is kept at a higher level, which favours bacterial growth. Lieutenant Siem informs me that recently in Northern Norway there has been the same notable increase in tuberculosis. The old cottage fireplaces with wide chimneys have been replaced with American stoves. In olden days most of the heat went up the chimney, and the people were warmed by radiant heat. Now the room is heated to a uniform moist heat. The Norwegians nail up the windows and never open them during the winter. At Lofoten, the great fishing centre, motor boats have replaced the old open sailing and row boats. The cabin in the motor boat is very confined, covered in with watertight deck, heated by the engine, crowded with a dozen workers. When in harbour the fishermen used to occupy ill-fitted shanties, through which the wind blew freely; now, to save rent, they sleep in the motor-boat cabins.

Here, again, we have massive infection, and the reduction of the defensive mechanisms by the influence of the warm, moist atmosphere.

The Norwegian fishermen feed on brown bread, boiled fish, salt mutton, margarine, and drink, when in money, beer and schnapps; there is no gross deficiency in diet, as in Labrador, and beri-beri does not attack them. They return home to their villages and longshore fishing when the season is over. The one new condition which is common to the two districts is confinement in stove-heated, windless atmospheres. In old days the men were crowded together, but in open boats or in draughty shanties, and had nothing but little cooking stoves.

The conditions of great cities tend to confine the worker in the office all day, and to the heated atmosphere of club, cinema show, or music-hall in the evening. The height of houses prevents the town dweller from being blown upon by the wind, and, missing the exhilarating stimulus of the cool, moving air, he repels the dull uniformity of existence by tobacco and by alcohol, or by indulgence in food, for example, sweets, which are everywhere to his hand, and by the nervous excitement of business and amusement. He works, he eats, and is amused in warm, windless atmospheres, and suffers from a feeble circulation, a shallow respiration, a disordered digestion, and a slow rate of metabolism.

Many of the employments of modern days are detestable in their long hours of confinement and monotony. Men go up and down in a lift all day, and girls in the bloom of youth are set down in tobacco stalls in underground stations, and their health and beauty there fade, while even the blow-flies are free to bask in the sun. In factories the operatives feed machines, or reproduce the same small piece of an article day after day. There is no art, or change, no pleasure in contrivance and accomplishment. The miner, the fisherman, even the sewerman, face difficulties, changing risks, and are developed as men of character and strength. Contrast the sailor with the steward on a steamer, the drayman outside with the

clerk inside who checks the goods delivered at some city office, the butcher and the tailor, the seamstress and the market woman, and one sees the enormous difference which a confined occupation makes. Monotonous sedentary employment makes for unhappiness because the inherited functional needs of the human body are neglected, and education—when the outside field of interest is narrowed—intensifies the sensitivity to the bodily conditions. The sensations arising within the body—proprioceptive sensations—come to have too large a share in consciousness in comparison with exteroceptive. In place of considering the lilies how they grow, or musing on the beauty and motions of the heavenly bodies, the sedentary worker in the smoke-befouled atmosphere, with the limited activity and horizon of an office and a disturbed digestion, tends to become confined to the inward consideration of his own viscera and their motions.

Many of the educated daughters of the well-to-do are no less confined at home; they are the flotsam and jetsam cast up from the tide in which all others struggle for existence—their lives are no less monotonous than the sweated sempstress or clerk. They become filled with "vapours," and some seek excitement not in the cannon's mouth, but in breaking windows, playing with fire, and hunger strikes. The dull monotony of idle social functions, shopping, and amusement, no less than that of sedentary work and an asexual life, impels to a simulated struggle—a theatrical performance, the parts of which are studied from the historical romances of revolution. Each man, woman, and child in the world must find the wherewithal for living, food, raiment, warmth, and housing, or must die or get some other to find it for him. It seems to me as if the world is conducted as if ten men were on an island—a microcosm—and five sought for the necessities of life, hunted for food, built shelters and fires, made clothes of skins, while the other five strung necklaces of shells, made loin-cloths of butterfly wings, gambled with knuckle-bones, drew comic pictures in the sand, or carved out of clay frightening demons, and so beguiled from the first five the larger share of their wealth. In this land of factories, while the many are confined to mean streets and wretched houses, possessing no sufficiency of baths and clean clothing, and are ill fed, they work all day long, not to fashion for themselves better houses and clothing, but to make those unnecessaries such as "the fluff" of women's apparel, and a thousand trifles which relieve the monotony of the idle and bemuse their own minds.

The discovery of radium and its disintegration as a source of energy has enabled the physicist to extend Lord Kelvin's estimate of the world's age from some thirty to a thousand million years. Arthur Keith does not hesitate to give a million of these years to man's evolution. Karl Pearson speaks of hundreds of thousands of years. The form of the human skull, the brain capacity of man, his skill as evidenced by stone implements and cave drawings of animals in action, was the same tens of thousands of years ago as now. For ages primitive man lived as a wild animal in tropical climes, discovered how to make fire, clothe himself in skins, build shelters, and so enable himself to wander over the temperate and arctic zones. Finally, in the last few score of years, he has made houses draughtless with glass windows, fitted them with stoves and radiators, and every kind of device to protect himself from cold, while he occupies himself in the sedentary pursuits and amusements of a city life. How much better, to those who know the boundless horizon of life, to be a frontiersman and enjoy the struggle, with body hardened, perfectly fit, attuned to Nature, than to be a cashier, condemned to the occupation of a sunless, windless, pay-box. The city child, however, nurtured and educated in confinement, knows not the largeness and wonders of Nature, is used to the streets with their ceaseless movement and romantic play of artificial light after dark, and does not need the commiseration of the country mouse any more than the beetle who lives in the dark and animated burrows of his heap. But while outdoor work disciplines the body of the countryman into health, the town man needs the conscious attention and acquired educated control of his life to give him any full measure of health and happiness.

Experimental evidence is strongly in favour of my argument that the chemical purity of the air is of no importance. Analyses show that the oxygen in the

worst-ventilated school-room, chapel, or theatre is never lessened by more than 1 per cent. of an atmosphere; the ventilation through chink and cranny, chimney, door and window, and the porous brick wall, suffices to prevent a greater diminution. So long as there is present a partial pressure of oxygen sufficient to change the haemoglobin of the venous blood into oxyhaemoglobin there can arise no lack of oxygen.

At sea-level the pressure of oxygen in the pulmonary alveolar air is about 100 mm. Hg. Exposed to only half this pressure the haemoglobin is more than 80 per cent. saturated with oxygen.

In noted health resorts of the Swiss mountains the barometer stands at such a height that the concentration of oxygen is far less than in the more ventilated room. On the high plateau of the Andes there are great cities: Potosi with a hundred thousand inhabitants is at 4,165 metres, and the partial pressure of oxygen there is about 13 per cent. of an atmosphere in place of 71 per cent. at sea-level; railways and mines have been worked up to altitudes of 14,000 to 15,000 ft. At Potosi girls dance half the night, and toredors display their skill in the ring. On the slopes of the Himalayas shepherds take their flocks to altitudes of 18,000 ft. No disturbance is felt by the inhabitants or those who reach these great altitudes slowly and by easy stages. The only disability to a normal man is diminished power for severe exertion, but a greater risk arises from want of oxygen to cases of heart disease, pneumonia, and in chloroform anaesthesia at these high altitudes. The newcomer who is carried by the railway in a few hours to the top of Pike's Peak or the Andes may suffer severely from mountain sickness, especially on exertion, and the cause of this is want of oxygen. Acclimatization is brought about in a few days' time. The pulmonary ventilation increases, the bronchial tubes dilate, the circulation becomes more rapid. The increased pulmonary ventilation lowers the partial pressure of carbon dioxide in the blood and pulmonary air, and this contributes to the maintenance of an adequate partial pressure of oxygen. Haldane and Douglas say that the percentage of red corpuscles and total quantity of the haemoglobin increases, and maintain that the oxygen is actively secreted by the lung into the blood, but the C method by which their determinations have been made has not met with unqualified acceptance. If waste products, which arise from oxygen want, alter the combining power of haemoglobin, this alteration may not persist in shed blood; for these products may disappear when the blood is exposed to air. Owing to the combining power of haemoglobin the respiratory exchange and metabolism of an animal within wide limits is independent of the partial pressure of oxygen. On the other hand, the process of combustion is dependent not on the pressure but on the percentage of oxygen. Thus the aeroplanist may become seized with altitude sickness from oxygen want, while his gas engine continues to carry him to loftier heights.

The partial pressure of oxygen in a mine at a depth of 3,000 ft. is considerably higher than at sea-level, and if the percentage is reduced to 17, while the firing of fire-damp and coal dust is impossible, there need be in the alveolar air of the lungs no lower pressure of oxygen than at sea-level. Thus the simplest method of preventing explosions in coal mines is that proposed by J. Harger—namely, to ventilate them with air containing 17 per cent. of oxygen.¹ There is little doubt that all the great mine explosions have been caused by the enforcement of a high degree of chemical purity of the air. In the old days, when ventilation was bad, there were no great dust explosions. Mr. W. H. Chambers, general manager of the Cadeby mine, where the recent disastrous explosion occurred, with the authority of his great and long practical experience of fiery mines, told me that the spontaneous combustion of coal and the danger of explosion can be wholly met by adequate diminution in ventilation. The fires can be choked out while the miners can still breathe and work. The Coal Mines Regulation Act enforces that a place shall not be in a fit state for working or passing therein if the air contains either less than 19 per cent. of oxygen or more than 1½ per cent. of carbon dioxide. A mine liable to spontaneous combustion of coal may be exempted from this regulation by order of the Secretary of State.

The regulations impel the provision of such a ventilation current that the percentage of oxygen is sufficient for the

spread of dust explosions along the intake airways, with the disastrous results so frequently recorded. If the mine were ventilated with air containing 17 per cent. of oxygen in sufficient volume to keep the miners cool and fresh, not only would explosions be prevented, but the mines could be safely worked and illuminated with electricity, and miners' nystagmus prevented, for this is due to the dim light of the safety lamp. The problem possibly may be solved by purifying and cooling the return air, and mixing and circulating this with a sufficiency of fresh air.

Owing to the fact that the percentage of CO₂ is the usual test of ventilation, and that only a very few parts per 10,000 in excess of fresh air are permitted by the English Factory Acts, it is generally supposed that CO₂ is a poison, and that any considerable excess has a deleterious effect on the human body. No supposition could be further from the truth.

The percentage of CO₂ in the worst ventilated room does not rise above 0.5 per cent., or at the outside 1 per cent. It is impossible that any excess of CO₂ should enter into our bodies when we breathe such air, for whatever the percentage of CO₂ in the atmosphere may be, that in the pulmonary air is kept constant at about 5 to 6 per cent. of an atmosphere—by the action of the respiratory centre. It is the concentration of CO₂ which rules the respiratory centre, and to such purpose as to keep the concentration both in the lungs and in the blood uniform (Haldane), the only result from breathing air containing 0.5 to 1 per cent. of CO₂ is an inappreciable increase in the ventilation of the lungs. The very same thing happens when we take gentle exercise and produce more CO₂ in our bodies.

At each breath we rebreathe into our lungs the air in the nose and large air tubes (the dead-space air), and about one-third of the air which is breathed in by a man at rest in dead-space air. Thus, no man breathes in pure outside air into his lungs. When a child goes to sleep with its head partly buried under the bed-clothes, and in a cradle confined by curtains, he rebreathes the expired air to a still greater extent, and so with all animals that snuggle together for warmth's sake. Not only the newborn babe sleeping against its mother's breast, but pigs in a sty, young rabbits, rats, and mice clustered together in their nests, young chicks under the brooding hen, all alike breathe a far higher percentage than that allowed by the Factory Acts.

To rebreathe one's own breath is a natural and inevitable performance, and to breathe some of the air exhaled by another is the common lot of men who, like animals, have to crowd together and husband their heat in fighting the inclemency of the weather.

In the Albion Brewery we analysed on three different days the air of the room where the CO₂ generated in the vats is compressed and bottled as liquid carbonic acid. We found from 0.14 to 0.93 per cent. of CO₂ in the atmosphere of that room. The men who were filling the cylinders and turning the taps on and off to allow escape of air must often breathe more than this. The men engaged in this occupation worked twelve-hour shifts, having their meals in the room. Some had followed the same employment for eighteen years, and without detriment to their health. It is only when the higher concentrations of CO₂ are breathed, such as 3 to 4 per cent. of an atmosphere, that the respiration is increased, so that it is noticeable to the resting individual; but percentages over 1 per cent. diminish the power to do muscular work, for the excess of CO₂ produced by the work adds its effect to that of the excess in the air, and the difficulty of co-ordinating the breathing to the work in hand is increased.

Haldane and Priestley found that with a pressure of 2 per cent. of an atmosphere of CO₂ in the inspired air the pulmonary ventilation of a man at rest was increased 50 per cent., with 3 per cent. about 100 per cent., with 4 per cent. about 200 per cent., with 5 per cent. about 300 per cent., and with 6 per cent. about 500 per cent. With the last, panting is severe, while with 3 per cent. it is unnoticed until muscular work is done, when the panting is increased 100 per cent. more than usual. With more than 6 per cent. the distress is very great, and headache, flushing, and sweating occur.

Divers who work in diving dress and men who work in compressed air caissons constantly do heavy and continuous labour in concentrations of CO₂ higher than 1 per cent. of an atmosphere, and so long as the CO₂ is kept below 2 to 3 per cent. they are capable of carrying out efficient work.

In the case of workers in compressed air it is important to bear in mind that the effect of the CO_2 on the breathing depends on the partial pressure and not on the percentage of this gas in the air breathed.

By a series of observations made on rats confined in cages fitted with small, ill-ventilated sleeping chambers, we have found that the temperature and humidity of the air—not the percentage of carbon dioxide or oxygen—determines whether the animals stay inside the sleeping room or come outside. When the air is cold they like to stay inside, even when the carbon dioxide rises to 4 to 5 per cent. of an atmosphere. When the sleeping chamber is made too hot and moist they come outside.

The sanitarian says it is necessary to keep the CO_2 below 0.01 per cent., so that the organic poisons may not collect to a harmful extent. The evil smell of crowded rooms is accepted as unequivocal evidence of the existence of such. He pays much attention to this and little or none to the heat and moisture of the air. The smell arises from the secretions of the skin, soiled clothes, etc. The smell is only sensed by and excites disgust in one who comes to it from the outside air. He who is inside and helps to make the "fogg" is both wholly unaware of and unaffected by it. Flügge points out, with justice, that while we naturally avoid any smell that excites disgust and puts us off our appetite, yet the offensive quality of the smell does not prove its poisonous nature. For the smell of the trade or food of one man may be horrible and loathsome to another not used to such.

The sight of a slaughterer and the smell of dead meat may be loathly to the sensitive poet, but the slaughterer is none the less healthy. The clang and jar of an engineer's workshop may be unendurable to a highly strung artist or author, but the artificers miss the stoppage of the noisy clatter. The stench of glue-works, fried-fish shops, soap and bone-manure works, middens, sewers, become as nothing to those engaged in such, and the lives of the workers are in no wise shortened by the stench they endure. The nose ceases to respond to the uniformity of the impulse, and the stench clearly does not betoken in any of these cases the existence of a chemical organic poison. On descending into a sewer, after the first ten minutes the nose ceases to smell the stench; the air therein is usually found to be far freer from bacteria than the air in a school-room or tenement.

If we turn to foodstuffs we recognize that the smell of alcohol and of Stilton or Camembert cheese is horrible to a child, while the smell of putrid fish—the meal of the Siberian native—excites no less disgust in an epicure, who welcomes the cheese. Among the hardiest and healthiest of men are the North Sea fishermen, who sleep in the cabins of trawlers reeking with fish and oil, and for the sake of warmth shut themselves up until the lamp may go out from want of oxygen. The stench of such surroundings may effectually put the sensitive, untrained brain worker off his appetite, but the robust health of the fisherman proves that this effect is nervous in origin, and not due to a chemical organic poison in the air.

Ventilation cannot get rid of the source of a smell, while it may easily distribute the evil smell through a house. As Pettenkofer says, if there is a dung-heap in a room, it must be removed. It is no good trying to blow away the smell.

Flügge and his school bring convincing evidence to show that a stuffy atmosphere is stuffy owing to heat stagnation, and that the smell has nothing to do with the origin of the discomfort felt by those who endure it. The inhabitants of reeking hovels in the country do not suffer from chronic ill health, unless want of nourishment, open-air exercise, or sleep come into play. Town workers who take no exercise in the fresh air are pale, anaemic, listless. Sheltered by houses they are far less exposed to winds, and live day and night in a warm, confined atmosphere.

The widespread belief in the presence of organic poisons in the expired air is mainly based on the statements of Brown-Séquard and d'Arsonval, statements wholly unsubstantiated by the most trustworthy workers in Europe and America. These statements have done very great mischief to the cause of hygiene, for they led ventilating engineers and the public to seek after chemical purity, and neglect the attainment of adequate coolness and movement of the air. It was stated that the condensation water

obtained from expired air is poisonous when injected into animals. The evidence on which this statement is based is not only not worthy of credence, but is absurd—for example, condensation water has been injected into a mouse in a quantity equivalent to injecting 5 kilograms into a man weighing 60 kilograms. No proper controls were carried out. It is recognized now that any distilled water contaminated by bacterial products may have a toxic effect. Flack and I have for fourteen weeks kept guinea-pigs and rats confined together in a box and poorly ventilated, so that they breathed air containing 0.5 to 1.0 per cent. of CO_2 . The guinea-pigs proved wholly free from anaphylactic shock on injecting rat's serum. Therefore they were not sensitized by breathing the exhaled breath of the rats for many weeks, and we are certain that no foreign protein substance is absorbed in this way. It has been proved by others, and by us, that animals so confined do well so long as they are well fed and their cages kept clean, light, cool, and dry. It is wholly untrue that they are poisoned by breathing each other's breath. The only danger arises from droplet contagion in cases of infective disease.

To study the relative effect of the temperature and chemical purity of the atmosphere I constructed a small experimental chamber of wood fitted with large glass observation windows and rendered air-tight.

On one side of the chamber were fixed two small electric heaters, and a tin containing water was placed on these in order to saturate the air with water vapour. On another side of the chamber was placed a large radiator, through which cold water could be circulated when required, so as to cool the chamber. In the roof were fixed three electric fans, one big and two small, by means of which the air of the chamber could be stirred. The chamber held approximately 3 cm. of air. In one class of experiments we shut within the chamber seven or eight students for about half an hour, and observed the effect of the confined atmosphere upon them. We kept them until the CO_2 reached 3 to 4 per cent., and the oxygen had fallen from 17 to 16 per cent. The wet-bulb temperature rose meanwhile to about 80° to 85° F., and the dry bulb a degree or two higher. The students went in chatting and laughing, but by-and-by, as the temperature rose, they ceased to talk and their faces became flushed and moist. To relieve the monotony of the experiment we have watched them trying to light a cigarette, and, puzzled by their matches going out, borrowing others only in vain. They had not sensed the diminution of oxygen, which fell below 17 per cent. Their breathing was deepened by the high percentage of CO_2 , but no headache occurred in any of them from the short exposure. Their discomfort was relieved to an astonishing extent by putting on the electric fans placed in the roof. Whilst the air was kept stirred the students were not affected by the oppressive atmosphere. They begged for the fans to be put on when they were cut off. The same old stale air containing 3 to 4 per cent. CO_2 and 16 to 17 per cent. O_2 was whirled, but the movement of the air gave relief, because the air was 80° to 85° F. (wet bulb), while the air enmeshed in their clothes in contact with their skin was 98° to 99° F. (wet bulb). If we outside breathed through a tube the air in the chamber we felt none of the discomfort which was being experienced by those shut up inside. Similarly, if one of those in the chamber breathed through a tube the pure air outside he was not relieved.

R. A. Rowlands and H. B. Walker carried out a large number of observations in the chamber, each acting as subject in turn.

They recorded the effect on the respiratory ventilation and on the pulse-rate both when resting and when working. The work consisted in pulling a 20-kilogram weight about 1 metre high by means of a pulley and rope.

In some of the experiments the exhaled carbonic acid was absorbed, and in others carbonic acid was put into the chamber. The subjects inside could not tell when the gas was introduced, not even if the percentage were suddenly raised by 2. The introduction of this amount of the gas made no sensible difference to them, but increased their pulmonary ventilation.

In every one of the experiments they suffered from the heat, and the putting on of the fans gave great relief, and in particular diminished the pulse-rate during and after the working periods. The relief became much greater

when cold water was circulated through the radiator and the temperature of the chamber lowered 10° F.

The subjects wore only a vest, pants, and shoes in most of these experiments. When they wore their ordinary clothing the effect on the frequency of the pulse was more marked and the discomfort from heat and moisture much greater.

I have made observations on men dressed in the Fleuss rescue apparatus for use in mines, and exposed in a chamber to 120° F. dry bulb and 95° F. wet bulb. The skin temperature rises to the rectal temperature and the pulse is greatly accelerated—for example, to 150—and there arises danger of heat-stroke. The conditions are greatly relieved by interposing on the inspiratory tube of the apparatus a cooler filled with carbonic acid snow. The cool inspired air lowers the frequency of the heart and makes it possible for the men to do some work at 95° F. wet bulb, and to endure this temperature for two hours.

The observations made by Pembrey and Collis on the weaving-mill operatives at Darwen show that the skin of the face may be 4° to 13° F. higher in the mill when the wet bulb is 71° F. than at home when the wet bulb temperature is about 55° F. The tendency of the warm, humid atmosphere of the mill is to establish a more uniform temperature of the body as a whole (surface and deep temperatures), and to throw a tax upon the power of accommodation as indicated by the rapid pulse and low blood pressure.

The mill workers are wet with the steam blown into the sheds, their clothes and bodies are moist, and the long hours of exposure to such uncomfortable conditions are most deleterious to physical vigour and happiness. The operatives asked that they might be allowed to work without steam injectors and with diminished ventilation, so that the mill rooms became saturated with moisture evaporated from the bodies of the operatives. The old regulations, while forbidding more than 6 parts in 10,000 CO₂, put no limit to the wet-bulb temperature, and this often became excessive on hot summer days. The operatives were quite right. Less ventilation and a lower wet bulb is far better than ample ventilation and a high wet bulb. The permissible limit of CO₂ has now been raised to 11 parts in 10,000, and the wet-bulb temperature is to be controlled within reasonable limits.

The efficiency of workers in mills, mines, tunnels, stoke-holes, etc., is vastly increased by the provision of a sufficient draught of cool and relatively dry air, so as to prevent overtaxing of the heat-regulating mechanism. Mr. F. Green informs me that by means of forced draught the stoke-hole of an Orient steamer is rendered the coolest place when the ship is in the tropics.

The electric fan has vastly improved the conditions of the worker in the tropics. I would suggest that each clerk should have a fan just as much as a lamp on his desk. It will pay the employer to supply fans.

In the modern battleship men are confined very largely to places artificially lit and ventilated by air driven in by fans through ventilating shafts. The heat and moisture derived from the bodies of the men, from the engines, from cooking ranges, etc., lead to a high degree of relative moisture, and thus all parts of the ironwork inside are coated with granulated cork to hold the condensed moisture and prevent dripping.

The air smells with the manifold smells of oil, cooking, human bodies, etc., and the fresh air driven in by fans through the metal conduits takes up the smell of these, and is spoken of by the officers with disparagement as "tinned" or "potted" air. This air is heated when required by being made to pass over radiators. Many of the officers' cabins and offices for clerks, typewriters, etc., in the centre of a battleship have no portholes, and are only lit and ventilated by artificial means. The steel nature of the structure prevents the diffusion of air which takes place so freely through the brick walls of a house. The men in their sleeping quarters are very closely confined, and as the openings of the air conduits are placed in the roof between the hammocks, the men next to such openings receive a cold draught, and are likely to shut the openings. To sleep in a warm moist "fugg" would not much matter if the men were actively engaged for many hours of the day on deck and there exposed to the open air and the rigours of sea and weather. In the modern warship most

of the crew work for many hours under deck, and some of the men may scarcely come on deck for weeks or even months. Considering the conditions which pertain, it seems to be of the utmost importance that all the men in a battleship should be inspected at short intervals by the medical officers so that cases of tuberculosis may be weeded out in their incipency. The men of every rating should do deck drill for some part of every day. In the Norwegian navy every man, cooks and all, must do gymnastic drill on deck once a day. In the case of our navy, with voluntary service, the men should welcome this in their own interest.

In a destroyer visited by me twelve men occupied quarters containing about 1,700 cubic feet of air. There was a stove with iron pipe for chimney, from which fumes of combustion must leak when in use, and a fan which would not work. When the men are shut down the moisture is such that boots, etc., go mouldy, and the water drips off the structure. The cooling effect of the sea-water washing over the steel shell of the boat is beneficial in keeping down the temperature in these confined and ill-ventilated quarters. On the manœuvring platform in the engine-room the wet-bulb temperature reaches a very high degree owing to the slight escape of steam round the turbines. Commander Domville was kind enough to send me the wet and dry bulb temperatures taken there on a number of days. The wet bulb was found to be never below 80° F., sometimes reached 95° and even 98° F. It is impossible for officers to work at these temperatures without straining the heat-regulating mechanism of the body and diminishing their health and working capacity. If such wet-bulb temperatures are unavoidable, means should be provided, such as fans, which would alleviate the discomfort and fatigue caused thereby. A supply of compressed air fitted with a nozzle might be arranged and used occasionally to douche the body with cool air. I have tried this plan and found it very effectual, and can recommend the compressed-air bath as the substitute for a bracing cold wind.

The suitability of the clothing is of the greatest importance, not only to the comfort but to the efficiency of man as a working machine—for example, power of soldiers to march. On a still day the body is confined by the clothes as if by a chamber of stagnant air, for the air is enclosed in the meshes of the clothes and the layer in contact with the skin becomes heated to body temperature and saturated with moisture.

The observations of Pembrey show that himself and four soldiers, marching in drill order on a moderately warm day, lost more water and retained more water in their clothes than on another similar day when they worked with no jacket on. The average figures were: Loss of moisture 1,600, against 1,200 grams, and water retained in clothes 254, against 109 grams. With no jacket the pulse was, on the average, increased 28 against 41 in drill order, and rectal temperature 1° against 1.5° F. The taking off of the jacket or throwing open of the jacket and vest very greatly increase the physiological economy of a march. It is absurd that on a hot summer day Boy Scouts should march with a coloured scarf knotted round their necks. Nothing should be worn for ornament or smartness which increases the difficulty of keeping down the body temperature. The power to march and the efficiency of an army depend on prevention of heart stagnation and avoidance of fatigue of the heart.

I conclude, then, that all the efforts of the heating and ventilating engineer should be directed towards cooling the air in crowded places and cooling the bodies of the people by setting the air in motion by means of fans. In a crowded room the air confined between the bodies and clothes of the people is almost warmed up to body temperature and saturated with moisture, so that cooling of the body by radiation, convection, and evaporation becomes reduced to a minimum. The strain on the heat-regulating mechanism tells on the heart. The pulse is accelerated, the blood is sent in increased volume to the skin, and circulates there in far greater volume, while less goes through the viscera and brain. As the surface temperature rises, the cutaneous vessels dilate, the veins become filled, the arteries may become small in volume, and the blood pressure low, the heart is fatigued by the extra work thrown upon it. The influence of the heat stagnation is shown by the great acceleration of the pulse when work is

done and the slower rate at which the pulse returns to its former rate on resting.

The increased percentage of carbonic acid and diminution of oxygen which has been found to exist in badly ventilated churches, schools, theatres, barracks, is such that it can have no effect upon the incidence of respiratory disease and higher death-rate, which statistical evidence has shown to exist among persons living in crowded and unventilated rooms. The conditions of temperature, moisture, and windless atmosphere in such places primarily diminishes the heat loss, and secondarily the heat production—that is, the activity of the occupants, together with total volume of air breathed, oxygen taken in and food eaten. The whole metabolism of the body is thus run at a lower plane, and the nervous system and tone of the body is unstimulated by the monotonous, warm, and motionless air. If hard work has to be done it is done under conditions of strain. The number of pathogenic organisms is increased in such places, and these two conditions run together—diminished immunity and increased mass influence of infecting bacteria.

The volume of blood passing through, and of water vapour evaporated from, the respiratory mucous membrane must have a great influence on the mechanisms which protect this tract from bacterial infection. While too wet an atmosphere lessens evaporation, a hot dry atmosphere dries up the mucous membrane. As the immunizing powers depend on the passage of blood plasma into the tissue spaces, it is clear that a proper degree of moisture is important. The temperature, too, must have a great influence on the scavenger activity of the ciliated epithelium and leucocytes in the mucous membrane of the nose.

In the warm, moist atmosphere of a crowded place the infection from spray sneezed coughed, or spoken out is enormous. On passing out from such an atmosphere into cold moist air the respiratory mucous membrane of the nose is suddenly chilled, the blood vessels constricted, and the defensive mechanism of cilia and leucocyte checked. Hence the prevalence of colds in the winter. In the summer the infection is far less. We are far more exposed to moving air, and the sudden transition from a warm to a cold atmosphere does not occur. We believe that infection is largely determined by (1) the mass influence of the infecting agent; (2) the shallow breathing and diminished evaporation from, and flow of tissue lymph through, the respiratory tract, in warm, moist confined air. Colds are not caught by exposure to cold *per se*, as is shown by the experience of arctic explorers, sailors, shipwrecked passengers, etc.

We have very great inherent powers of withstanding exposure to cold. The bodily mechanisms become trained and set to maintain the body heat by habitual exposure to open-air life. The risk lies in overheating our dwellings and overclothing our bodies, so that the mechanisms engaged in resisting infection become enfeebled, and no longer able to meet the sudden transition from the warm atmosphere of our rooms to the chill outside air of winter. The dark and gloomy days of winter confine us within doors, and, by reducing our activity and exposure to open air, depress the metabolism; the influence of smoke and fog, gloom of house and streets, cavernous places of business and dark dwellings, intensify the depression. The immunity to a cold after an infection lasts but a short while, and when children return, after the summer holidays, to school and damp, chill autumn days, infection runs around. The history of hospital gangrene and its abolition by the aseptic methods of Lister—likewise the history of insect-borne disease—show the great importance of cleanliness in crowded and much occupied rooms. The essentials required of any good system of ventilation are, then, (1) movement, coolness, proper degree of relative moisture of the air; (2) reduction of the mass influence of pathogenic bacteria. The chemical purity of the air is of very minor importance, and will be adequately insured by attendance to the essentials.

As the prevention of spray (saliva) infection by ventilation is impossible in crowded places, it behoves us to maintain our immunity at a high level. We may seek to diminish the spray output of those infected with colds by teaching them to cough, sneeze, and talk with a handkerchief held in front of the mouth, or to stay at home until the acute stage is past.

In all these matters nurture is of the greatest importance, as well as Nature. A man is born with physical and mental capacities small or great, with inherited characteristics, with more or less immunity to certain diseases, with a tendency to longevity of life or the opposite; but his comfort and happiness in life, the small or full development of his physical and mental capacities, his immunity, and his longevity of life are undoubtedly determined to a vast extent by nurture.

By nurture—use the word in its widest sense to include all the defensive methods of sanitary science—plague, yellow fever, malaria, sleeping sickness, cholera, hospital gangrene, etc., can be prevented by eliminating the infecting cause; small-pox and typhoid by this means, and also by vaccination; and most of the other ills which flesh is supposed to be heir to can be kept from troubling by approximating to the rules of life which a wild animal has to follow in the matter of a simple and often spare diet, hard exercise, and exposure to the open air.

There is nothing more fallacious than the supposition commonly held that over-feeding and over-coddling indoors promote health. The two together derange the natural functions of the body. He who seeks to save his life will lose it.

The body of a newborn babe is a glorious and perfect machine, the heritage of millions of years of evolution.

Not in entire forgetfulness,
And not in utter nakedness,
But trailing clouds of glory do we come.

Shades of the prison house begin to close
Upon the growing Boy.

The ill-conditioned body, anaemic complexion, and undersized muscles, or the fat and gross habit, the decay of the teeth, the disordered digestion, the nervous irritability and unhappiness are the result of "Nurture"—not Nature.

In institutions children may be disciplined to vigorous health. After leaving school they are set adrift to face monotonous work in confined places, amusement in music-halls and cinema shows in place of manly exercise in the open air, injudicious diet, alcohol, and tobacco—everything which the trainer of an athlete would repel.

And custom lie upon him with a weight
Heavy as frost, and deep almost as life.

REFERENCE.

¹ *Trans. Inst. of Mining Engineers*, 1912.

THE Italian Minister of Posts and Telegraphs has appointed a commission to study the effects of the telephone service in relation to hygiene.

DR. LÉON LABBÉ, member of the French Senate, in speaking of the number of victims of professional duty in the French Army Medical Service, says that in the last eighty years 548 medical officers have been killed in battle, while 399 have died of plague, yellow fever, typhoid, and cholera. In the Crimea the French army lost 18.22 per cent. of its medical officers, while the loss of combatant officers was 14.17 per cent. In the Mexican expedition the army lost 20 per cent. of its medical officers and 4 per cent. of its combatant officers from yellow fever.

A YEAR ago, at the suggestion of the Italian Minister of Public Instruction, a commission was appointed to study the question of publishing the complete writings of Leonardo da Vinci. The first step was to obtain photographic reproductions of all the material preserved in Italy and other countries in public and private libraries. Commendatore Gino Modigliani has offered a sum of £4,000 towards the expenses of this undertaking. Leonardo was an anatomist as well as an artist and an engineer; and it is held by some that he anticipated much of the original work in anatomy which is usually attributed to Vesalius.

THE first meeting of the International Paediatric Association will be held in Paris, the opening day being fixed for October 7th. Two questions are proposed for discussion: infantile anaemias and forms of acute poliomyelitis. Each discussion will be opened by four reports, as follows:—Infantile anaemias: (a) digestive origin (Czerny); (b) chronic infective diseases (Benvendorff); (c) parasites of the blood (Jemma); (d) anaemias in general (Tixier). Acute poliomyelitis: (a) epidemiology (Wickmann); (b) pathological anatomy and experimental research (Zapper); (c) symptomatology (Müller); (d) surgical treatment (Ombrédanne).