In one instance, at least, Dr. W. Philip found that its place could be supplied by galvanism. He cut the principal nerves going to the stomach, and the secretion of gastric juice was completely stopped; but the secretion was restored when a galvanic pile was made to communicate with the lower extremities of the nerves. Of late years it has been discovered that the operations of galvanism are much more various and subtle than was formerly supposed, and it therefore seems not unreasonable to conjecture that its agency may be important also in secretion.

Suitable views of the liver will be found in Lizars's Coloured Plates, page 86, and of the kidneys, at page 88.

SECTION VI.

EXHALATION AND ABSORPTION—THE SKIN.

105. By exhalation is meant the escape of some portion of the contents of the blood-vessels (generally little altered), probably through pores in their sides. When a fluid, coloured with vermillion, is injected into the blood-vessels of a dead animal, the fluid portion will pass out of them, and is said to be exhaled, while the vermillion is retained; or when a solution of phosphorus is thrown into the veins of a living animal, in a few seconds fumes of phosphorous acid are given off from its lungs. By absorption is meant the removal of the soft or hard parts of the body, or of substances placed in contact with these parts. When a fat person becomes lean, or the fluid in a dropsical person's belly has disappeared, the fat and the fluid are said to have been absorbed.

106. The three most important exhaling and absorbing surfaces, are the intestinal canal, the lungs, and the skin; but these processes are active also in the chest, belly, and other cavities. We have already explained the structure

183. Define exhalation and absorption.
184. Instances of both.

of the intestinal canal and lungs, and the skin will be treated of at the close of this section, so that it will be necessary at present only to say, that the skin has a thin outer covering, called the cuticle, or epidermis (the part raised by blistering), which has no feeling, and little vitality; and another thicker part underneath, called the true skin (the part which tanners convert into leather), which is plentifully supplied with nerves, blood-vessels,&c.

107. From what has been said, it will be seen that the mechanism of exhalation is very simple, the fluid merely passing through the sides of its vessels. In every part of the system an active absorption is carried on by the same means, the fluid removed merely passing through the sides of the veins, to be carried off by the internal current. It was at one time supposed that absorption was exclusively carried on by a system of vessels, which received the name of absorbents; but this is now known to be quite incorrect. Allusion has already been made to one portion of these absorbent vessels, connected with digestion, which are called lacteals (Fig. 13). Similar vessels in other parts of the body (some of which are seen in Fig. 13, *h*) receive the name of lymphatics, from a fluid called lymph, which they convey; and in their course towards the thoracic duct (Fig. 13, *g*), in which they almost all terminate, they pass through glandular bodies, found in numbers in the hams, groins, armpits, on the sides of the neck, &c. It is these glands about the neck that so often swell and inflame when there is disease of the gums, or eruptions on the head, or when there exists a highly scrofulous habit of body.

108. The veins appear to take up all fluid matters indiscriminately that are brought in contact with them; the lacteals take up principally (if not solely) chyle; the office of the lymphatics seem to be chiefly to mould the different parts of the body into their proper forms, and the lymph contained in them is probably the removed animal matters which, it is supposed, may undergo some changes while passing through the lymphatics and their glands, that ren-

185. Sources of the chief exhalations from the body.
186. Define lymphatics, their office, and course.
187. Name the several instruments of absorption.

der them fit to be mingled with the blood. From the late researches of Fohmann, Panizza, and Lanth, it would appear that the lymphatics commence by minute plexuses, and that these at their origin do not communicate with the arteries and veins, but begin by shut extremities. In the frog, and in some other reptiles, there have been discovered parts, connected with the lymphatics, that pulsate irregularly, like hearts. The frog has four of these, which seem to be used for propelling the lymph.

109. Absorption and exhalation, in a healthy state, generally balance each other, so that a full-grown person's weight, notwithstanding the quantity of food consumed, will frequently, for years, vary only a few pounds. The conditions which promote the one, generally impede the other. When the body is saturated with fluid, absorption goes on slowly; but exhalation, under the same circumstances, takes place rapidly. M. Magendie found that when a quantity of water was thrown into an animal's veins, absorption was either much impeded, or altogether suspended; and, on the other hand, when the blood-vessels were partly emptied by bleeding, the effects of a poison, that usually showed themselves at the end of the second minute, were distinctly perceived before the thirtieth second. A frog, kept for some time previously in dry air, when its legs are immersed in water, will in a short time absorb nearly its own weight of the fluid.

110. We have already spoken of the absorbing powers of the intestinal canal. The next in importance, as an absorbing surface for external substances, is in the lungs, and, of course, the matters absorbed are generally conveyed in the form of vapour. When a fluid poison, however, is injected into the windpipe, it acts with fearful rapidity. It is through this surface that substances diffused in the atmosphere usually produce their effects on the system. The vapour of turpentine, breathed along with the air of a room, may be detected in the urine within a short time afterwards, and the concentrated vapour of such poisons as prussic acid will instantly kill an animal if inhaled. It is

188. Relative amount of these two processes.
189. Proofs of absorption in the lungs.

probable also that the various poisons which produce fever, measles, small-pox, and other infectious disorders, are in this way introduced into the body, the smallest quantity frequently sufficing for this purpose. We can conceive the small quantity of the poison required, when we notice that the least particle of the matter of small-pox, placed in a scratch on the skin, gives rise to the same disease. In proof of the action of poisons, when inhaled by the lungs, the following facts may be stated:

111. M. Magendie contrived some experiments, in which dogs were confined in the upper part of a barrel, the lower part being filled with putrefying animal substances, which were separated from the dogs by a grating. Confinement in this situation, from the absorption of the putrid effluvia, produced death generally about the tenth day. The animals took food, and were even lively, but became much emaciated before death. The same physiologist produced symptoms exactly resembling those of yellow fever, by injecting a few drops of putrid water into the veins of dogs.

112. A nurse in one of the Dublin hospitals, apparently in excellent health, was desired by the physician to assist a patient, labouring under fever, to turn in bed. Being very feeble, he endeavoured to support himself by placing his arms round the nurse's neck, when she suddenly drew back, struck by the offensive odour from his person, and exclaiming that she had caught fever. She instantly became cold, pale, and ghastly, and, appearing about to faint, had to be removed to her room. Malignant fever, of a very severe description, succeeded, and lasted for thirteen days.

113. In the island of St. Lucia, in the West Indies, two boatmen were employed hauling their canoe up on the beach, close to a dangerous swamp, when they perceived a small cloud of vapour approaching, which gradually enveloped them. One immediately fell down insensible, and the other was so much affected as to be unable to render

190. Examples of poisons thus acting.
191. Instances of poisonous exhalations.

him any assistance. The vapour soon passed away, and both men recovered so far as to be able to walk home. The one most affected, however, was seized with fever, and died within forty hours afterwards.

114. Repeated instances occur in the West Indies of twenty or thirty workmen being employed in cutting drains or canals in these infectious swamps, nine out of ten of whom will be seized in a few days with the most dangerous forms of tropical fever. Chiefly from these pestilential fevers, also, the probability of life to Europeans in the West Indies is very low. It appears, from the most accurate army returns, that a young man's chance of life, which in this country would probably be about forty years, is reduced in Jamaica to about seven years.

115. In such marshy districts as the fens in Lincolnshire, or the Pontine marshes near Rome, the poison diffused in the atmosphere operates with intensity chiefly after sunset, and produces dreadfully fatal fevers and agues. We see also, in the natives of these districts, the effects which the slow operation of the poison produces on the health. Their appearance in highly infected districts is miserable in the extreme. Stunted in their growth, with swollen bellies, stupid expression, and jaundiced complexions, they linger out a miserable existence, and can anywhere, at a glance, be recognised. Happily their sufferings terminate life quickly. In Rome, chiefly from this cause, the annual mortality of the whole population is stated at one in twenty-five, while in the whole of England and Wales Mr. Rickman states that it is only one in sixty. It is a curious circumstance that these poisons generally lie latent or inactive in the body for some time. In the fevers of this country, the latent period may vary from a few days to some weeks: while in marsh fever, a person will often have left the infected district, six, twelve, or more months, before he is seized with it.

116. We have entered into these details in order that it may be seen, 1st, that unnecessary exposure to air infected with the poison of fever, is both improper and highly

192. Reflections deduced therefrom.

dangerous; and, 2dly, to show how important to health is pure air, attention to cleanliness, and the removal of all putrefying animal and vegetable matters from the vicinity of our dwellings. In a very filthy part of Constantinople, called the Jews' quarter, the plague constantly prevails more or less, and the same may be said of typhus fever in some confined and dirty parts of London, Edinburgh, Glasgow, and most other large towns.

117. In man, the absorbing powers of the skin are much more limited than those of the lungs. When the cuticle is entire, indeed, it appears to absorb almost none, unless the substance be rubbed on it with force, or be of a very irritating nature. When the cuticle is removed, however, it absorbs readily. This is the reason why the most virulent poisons can be handled with impunity, only while the cuticle is entire. Surgeons often suffer severely from this cause, when, in opening dead bodies, they accidentally puncture or cut themselves, even in the slightest degree. The poison introduced by the cut part inflames it dreadfully, and death not unfrequently occurs within a few days. It is for the same reason that a slight scratch must be made through the cuticle before a child can be inoculated.

118. The exhaling powers of both the skin and the lungs are very considerable. In winter, we notice the watery vapour coming from the lungs condensed by the cold air; in summer, we see how much fluid escapes from the skin in the form of perspiration. Independently of this, however, from thirty to sixty ounces of watery fluid are calculated to pass off daily from the skin in the form of insensible perspiration. This insensible perspiration may be seen to be condensed, when the point of the finger is moved along the surface of a looking-glass, at about the distance of an eighth of an inch, and also when we handle any polished steel instrument; or, still more decisively, when the arm is confined in a glass jar. It is the condensation of this insensible perspiration that makes the inner surface of a M'Intosh cloak damp when worn in frosty weather

193. Effects of the cuticle in preventing absorption.
194. Danger of wounds or abrasions of the skin
195. Insensible perspiration, its extent.

Dr. Smith has performed some interesting experiments on the subject of exhalation, from the skin and lungs jointly. Eight workmen in the Phœnix Gas-works, London (where they must work hard, and be exposed to a high temperature at the same time), were weighed before going to work, and immediately afterwards. In one experiment, in November, they continued to work for an hour and a quarter, and the greatest loss sustained by any one man was two pounds fifteen ounces. In another experiment, in the same month, one man lost four pounds three ounces in three quarters of an hour; and in an experiment of the same kind, in June, one man lost no less than five pounds two ounces in an hour and ten minutes.

119. We shall conclude this section, by stating a few other circumstances connected with the structure and functions of the skin. We have mentioned that the external layer of the skin is called the cuticle. M. Breschet, a French author, who has very carefully investigated the structure of the skin, considers the cuticle to be of the same nature as the horny matter which forms the nails, the hairs, feathers, horns, &c., of animals. It is secreted by particular organs, and when intended to be coloured, it is mixed with colouring matter (which also is secreted by distinct organs) while in a fluid state. The arrangement of the cuticle, in different parts of the human body, is well worthy of attention. Where feeling is to be exercised, it is thin and delicate; over the joints it is lax and movable; on the palms of the hands and soles of the feet, even in the infant, it is thick and hard, and these properties are greatly increased by constant use. Simple as this last provision may appear, it seems doubtful whether the want of it would not have interfered materially with the exercise of many of our most useful arts.

120. Between the cuticle and the true skin, formerly mentioned as the part of animals that is tanned, is found the layer that gives the colour to the different varieties of

196. Experiments on the amount of insensible perspiration and exhalation from the lungs and skin.
197. What of the cuticle and its distribution?

the human species, &c. (*rete mucosum*). In Europeans it is generally of a light colour, in Negroes it is black, and in other races it is intermediate, or of other shades. The colour of the Negro does not depend on the blackening of the cuticle by the sun, for his cuticle is seen to be as transparent as a European's when raised by a blister; and we observe, also, that the secretion of the black colouring matter does not take place in the Negro child until a day or two after birth.

121. The *cutis*, or true skin, is the third and most important layer. Besides its uses already referred to, it has a very large supply of blood sent to it; is a surface of great sensibility, intimately sympathizing with the internal organs; and, from its exposed situation and extent, is peculiarly liable to be affected by external influences. Perhaps no other surface in the body is so much concerned in the production of internal inflammatory disorders, and perhaps the agents that above all others tend to produce these, are the various degrees, and especially the sudden applications, of heat and cold. When heat is applied suddenly and extensively, so as to give rise to a burn or scald, the heart's action is frequently extinguished within a few hours, even although the burn, in any one portion, is altogether superficial and unimportant. Mr. John Hunter gives a striking proof of the effects produced by a sudden change of temperature on the skin. He took an eel, which was swimming in water a little above 30 degrees, and plunged it into water about 60 degrees, a temperature in which it habitually lives with ease. The sudden change, however, gave such a shock to its system, that the animal instantly expired.* In these cases the

* We lately met with a case exemplifying the effect of sudden change of temperature. A person who had been treading snow in an ice-house felt his feet uncommonly cold. To remedy this, he plunged them into water somewhat heated. The consequence was, the little toe of one foot and part of the great toe of the other mortified, and had to be cut off.

198. Define the rete mucosum, and the cutis.
199. Importance of the skin and its functions.
200. Illustrations of the mischiefs of sudden change of temperature.

effect seems to be produced principally through the agency of the nervous system, for an account of which we must refer to Section VIII.; but when the application of cold produces its injurious effects, the blood that is forced, by the constricted vessels, from the surface, upon the internal parts, probably also overloads them, and impedes the due performance of their functions. When the body is exposed for some time to a great degree of cold, the tendency to sleep becomes almost irresistible. Under these circumstances, to use the words of Dr. Solander, quoted by Captain Cook, "whoever sits down will sleep, and whoever sleeps will wake no more." These words were used by Dr. Solander during an excursion in Terra del Fuego, with Sir Joseph Banks and nine other individuals, when the cold was intense. Notwithstanding Dr. Solander gave the precaution, he was the first to feel the effects of the cold, and his companions were obliged to yield so far to his entreaties as to allow him to sleep for five minutes. With the utmost difficulty he was roused. Two black servants also slept, and perished. Exposure to a lesser degree of cold acts differently. Every one knows the power of cold draughts of air, of cold or damp feet, the wearing of damp clothes, or sleeping in damp sheets, in giving rise to inflammations, even in persons whose surface has a vigorous circulation, and is therefore not easily chilled. When the circulation on the surface is languid, these causes act with tenfold force; and hence in all such constitutions it is of the utmost moment, 1st, that the skin should at all seasons be protected from sudden chills by warm (the best are flannel) coverings; and, 2dly, that sea-bathing, a generous diet, and all other means that give permanent vigour to the circulation, should be specially attended to. Under all circumstances, indeed, frequently cleansing the skin, by removing noxious excretions, and allowing the proper exercise of its functions, has a much more important influence on health than is generally imagined.

201. Effects of exposure to cold; illustrations.
202. Danger of applying heat to frozen parts.
203. Practical suggestions.

Good views of the lymphatic vessels will be found in Lizars's Coloured Plates, page 99, and of the skin, at page 82 of the same. Connected with the subject of the skin, the teacher may introduce some instructive lessons on the five varieties of the human species and their distribution. We have found that these lessons are rendered much more impressive by having drawings of these varieties, and also a skeleton map of the globe, of a large size (say six feet by four), coloured so as to indicate their different localities. Thus, the European, or Caucasian, may be left white, the Mongolian coloured yellow, the American red, the Malay brown, and the Ethiopian black. The drawings, and the requisite information as to localities in making this map, will be found in the latter part of Lawrence's Lectures on Man, 8vo edition.

SECTION VII.

LOCOMOTION—THE BONES, MUSCLES, &c.

122. Having now given a short account of the most important functions of the organic or vegetative life, we shall here consider shortly the parts that are immediately concerned in producing the motion of the body. These are the bones and their articulations (joints), and the muscles.

123. The most important of the hard parts in animals are shells, crusts, and bones. The two former, however, are void of vitality, while bone gives every indication of possessing life. In shells, almost no animal matter is found; they are nearly the same in composition as a piece of marble. Crusts (as the lobster's) have a larger proportion of animal matter; and in the composition of bones there is much more. Not only, however, is the earthy matter less in bones; it is also differently combined. In shells and crusts the earth is carbonate of lime (chalk), while in bones the lime is principally united with an acid composed of phosphorus and oxygen, forming phosphate of lime; and it may be remarked, that it is from bones that phosphorus is usually obtained.

124. The quantity of animal matter in different bones, and, consequently, their hardness, varies. In infancy and

204. Name the hard parts of animals.
205. Composition of these.