melted metal; boil the lungs for two hours, cut out the preparation, and varnish with wax dissolved in boiling spirits of wine. A much more delicate preparation can be made in the following manner:— Instead of tin and lead, take the composition called the *fusible metal*,* and pour it into the lungs, and then place these in a large pot of water, to be kept boiling for an hour. The air is thus in a great measure expelled; and as the metal melts at the boiling point of water, it finds its way into the most minute ramifications. When heated, the air in the air-tubes causes the lungs to become buoyant, which prevents the metal getting properly into the lower bronchi. To obviate this, the lungs may be enveloped in a cloth, which should be loaded with heavy weights, to keep them in the upright position. As the metal is extremely brittle when hot, the lungs should not be taken out of the pot till they are cold; then hang them in some place where flies can deposit their eggs, moistening the outside daily, and allow them to remain until the maggots eat away all the flesh; after this, hang them in water until the preparation can be easily cleaned. In making both preparations, about one and a half pounds of metal are required, and the tin filler should be heated to make the metal run the easier. If any of the large branches are broken, any tinsmith will easily solder them. When well managed, preparations we have made in this way have a truly wonderful appearance; the bronchial tubes, though beautifully distinct, and as fine as hairs, presenting almost a solid mass. The existence of air-vesicles has been doubted by some authors, and these preparations seem to us to support this opinion.

Other illustrative figures for this section will be found in Bell's Anatomy, vol. i., page 599; Dr. Smith's Philosophy of Health, vol. i., page 243; "Animal Physiology," in the Library of Useful Knowledge, pages 88, 89, 90, 92, &c., &c.

[Some of the foregoing experiments are unsuited for schools, but models of the respiratory apparatus, made of papier maché by Dr. Azoux, of Paris, can now readily be obtained in this country.]

SECTION V.

SECRETION AND NUTRITION.

98. We have seen, in the preceding sections, that there are arrangements for circulating the blood and for keeping it pure. The great object in these arrangements seems to be, that the substances required in the different parts of

* The *Fusible Metal* may be composed of two parts bismuth, one lead, one tin, and one quicksilver, to be all melted together and well mixed.

the system may be separated from the blood in a proper state. There is a class of bodies, known by the name of glands, whose office appears to be principally to form different secretions. Thus, the liver is a gland, which is said to secrete (separate) bile: the salivary glands, we have seen, secrete saliva; and so on with the others. It would be a mistake, however, to suppose that secretion is performed only by glands, for thin membranes, without any glandular structure, produce numerous secretions; and the deposition of the solid parts of the body takes place without the intervention of any thing like glands. It seems to be the capillary vessels, themselves, in these cases, that are employed; and even in glands, however minutely we examine their structure, there can be detected almost nothing but endless subdivisions of circulating vessels, and ducts for collecting and carrying off the secreted fluid.

99. It will be impossible for us even to refer individually to the numerous substances produced by secretion. We shall, therefore, mention particularly only a few, and make some general observations regarding the whole.

100. The liver (Figs. 12, *l*, and 21, *c*) is the largest gland in the body. We have seen that it secretes the bile, which probably serves important purposes in digestion. The numerous ducts of the liver unite and form one large duct, called the hepatic duct (Fig. 12, *h*), from which the bile passes into the common duct (*i*), or into the gall-bladder (*m*), to be poured, when required, into the upper part of the intestinal canal. The bile is an alkaline fluid, which contains, besides other substances, a peculiar resinous principle. Unlike other secretions, it is formed from the venous blood. The whole veins of the stomach and intestines, instead of going directly to the right side of the heart, first unite to form one great trunk (vena portæ), which divides, like an artery, in the substance of the liver; and

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171. What sources of secretion are pointed out?
172. Define secretion, nutrition, &c.
173. What is peculiar in the structure of the liver?
174. What is the bile and its uses?
175. Describe the circulation of the liver.

these branches, by which the bile is secreted, again unite, and join the veins going to the heart in the ordinary way. In some species the veins going to the kidneys have a similar distribution. From this, and for various other reasons, it is strongly conjectured that the liver assists the lungs in purifying the venous blood, by depriving it of a portion of its carbon; and, accordingly, we always notice the liver larger in animals in proportion as the activity of their lungs diminishes. The carbon uniting with oxygen forms the carbonic acid given off from the lungs: it seems to escape from the liver in union with another gas called hydrogen, forming the resinous and other principles of the bile. We have before stated that less oxygen is consumed, and of course less carbonic acid is produced, when the temperature is high than when it is low. Hence, probably, a chief cause of the diseases of the liver Europeans are liable to in warm climates; for if less carbon be given off at the lungs, more will have to be secreted by the liver; and any part required to do more than its ordinary duty is apt to become deranged. It is thought that about six or eight ounces of bile are ordinarily secreted daily. Another analogous substance, called *urea*, is secreted by the kidneys, which are glands that also probably assist in purifying the blood. It is probable that both the resinous matter in the bile, and the urea in the urine, exist ready formed in the blood, and are merely separated by their respective glands; as, when the kidneys of dogs have been taken away, urea has been detected in the blood, which could not be the case if the kidneys formed it. It sometimes happens, especially in drunkards, that one or both of these glands become diseased, and are incapable of separating the peculiar fluids mentioned; and then these, being retained in the system, act as poisons, producing insensibility and death. In the case of the liver, this forms one cause of jaundice; but jaundice is more commonly caused by an obstruction to the flow of the bile through its ducts. The passage of gall-stones (which are

176. Theory of the liver, assisting to purify the blood.
177. What of the secretion by the kidneys?
178. Examples of the failure of these secretions and effects.

only bile solidified) from the gall-bladder through the common duct (Fig. 12, *i*), is a common cause of obstruction. When the substance of the liver becomes diseased, the flow of blood through its veins is also often obstructed, and this very generally gives rise to dropsy.

101. What has been said must suffice in regard to the larger glands; smaller ones are scattered in almost every part of the body. The whole extent of the intestinal canal, and of the skin, is found to be studded with bodies having a glandular structure, and producing secretions.

102. Some secretions are evidently produced only in particular emergencies, as we see with the increased secretion of bony matter when a limb is broken; other secretions are uncommon in their nature, as in the case of such fishes as the torpedo, or of the firefly, the former of which can produce at pleasure powerful electrical discharges, and the latter a substance that gives out light; while in other instances, again, secretions become unusual in their situation, or of a morbid kind. Of a secretion unusual in its situation a curious instance occurred some years ago in France. A woman who was suckling had the secretion of milk transferred from her breast to one of the lower extremities, from which her child continued to be supplied. Of morbid secretions we have examples in ossification of the valves of the heart, in consumption, in cancerous, brainy, and other tumours, and, unfortunately, in too many other cases.

103. The secretions are much influenced by our mental states. Every one has felt the flow of saliva increased from savoury odours, or the flow of tears from distressing feelings. A cheerful state of mind is peculiarly favourable to the proper performance of the function of secretion; and we therefore learn how important it is to avoid such things as distract, or agitate, or harass us.

104. As to the agent which produces or directs the different secretions, we have no very accurate information.

179. Peculiarities of secretion and number of glands.
180. Curious instance of transfer of secretion.
181. Effects of the mind.
182. What is said of galvanism?

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.