liver substance called *pons hepatis*. The under surface of the left lobe is smooth, and overlaps the anterior surface of the stomach. The under surface of the right lobe is divided into smaller lobes by fissures and fossæ. Starting from about the middle of the longitudinal fissure is the *portal* or *transverse fissure*, which extends for from 3 to 4 inches across the under surface of the right lobe. It is the gate (*porta*) of the liver, the *hilus* or fissure of entrance into the organ of the portal vein, hepatic artery, hepatic duct, and hepatic nerves and lymphatics. A short distance to the right of that part of the longitudinal fissure in which the round ligament lies, is the *fossa for the gall bladder*, which is a depression on the under surface of the right lobe extending from the anterior border to the transverse fissure: in it the gall bladder lies. Extending somewhat obliquely from the posterior border of the liver, towards the transverse fissure, is a deep *fossa for the inferior vena cava*. Opening into the vena cava as it lies in this fossa are the trunks of the large hepatic veins from the substance of the liver. A portion of liver substance, which is bounded by the gall bladder, the longitudinal fissure, the transverse fissure, and the anterior border, forms a four-sided lobe called *lobus quadratus*. Another portion, bounded by the transverse fissure, the posterior border, the vena cava, and the longitudinal fissure, is the *lobus Spigelii*. A thin prolongation of liver substance continuous with the lobus Spigelii, and running obliquely between the fossa for the inferior cava and the transverse fissure, is the *lobus caudatus*.

Structure of the Liver.—The liver is a solid organ, of a brownish-red colour. It is composed of the ramifications of the portal vein, of the portal capillaries, the hepatic vein, the hepatic artery, the hepatic duct, of secreting cells, nerves, and lymphatics. These several structures are bound together by connective tissue, and the organ is invested by the peritoneum. The liver possesses two coats, a serous and a fibrous.

The *serous* or *external coat* is a part of the peritoneal membrane, and forms an almost complete investment for the liver. It is reflected from the transverse fissure as the gastro-hepatic omentum, and from the upper surface and the posterior border as the falciform, coronary, and right and left lateral ligaments of the liver.

The *fibrous coat*, or tunica propria, is immediately subjacent to the serous coat. When carefully raised from the liver delicate processes of areolar tissue may be seen to pass from its deep surface into the substance of the organ. At the transverse fissure it is prolonged into the liver as a very distinct sheath, enveloping the portal vein, hepatic artery, hepatic duct, nerves, and lymphatics. This sheath is named the *capsule of Glisson*, and is prolonged throughout the substance of the organ, along the ramifications of the portal vein and the structures that accompany it.

Lobules of the Liver.—To the naked eye the substance of the liver does not present a homogeneous aspect, but is mottled, and mapped out into multitudes of small areas or lobules,—the *hepatic lobules* or *leaflets*. The lobules of the liver are irregular polygons, and vary in size from $\frac{1}{20}$th to $\frac{3}{20}$ths of an inch. In man and the mammalia generally the lobules are imperfectly separated from each other by the interlobular vessels and duct, and a scarcely appreciable quantity of areolar connective tissue. In the pig, camel, and polar bear, each lobule is circumscribed by a definite capsule of connective tissue.

As a lobule of the liver is a liver in miniature, and as the structure of the entire liver is the sum of the structure of its lobules, it will be necessary to examine with care the constituent parts of a lobule, and the arrangement of the vessels, duct, and nerves which pass to and from it. An hepatic lobule is composed of blood-vessels, secreting cells, and bile-ducts, with perhaps nerves and lymphatics. The blood-vessels will first be considered.

The *portal vein* conveys to the liver the venous blood from the stomach, spleen, pancreas, gall bladder, and small and large intestine. It ascends to the transverse fissure, and before it enters the liver divides into two branches, one for the right and one for the left lobe. In its course within the liver, the portal vein divides and subdivides after the manner of an artery. It is closely accompanied by the hepatic artery and duct, and, along with them, is invested by the fibrous sheath, called Glisson's capsule. The terminal branches of the portal vein run between the lobules, and are named, from their position, the *interlobular* branches. The interlobular branches lie around the circumference of a lobule, and anastomose with each other. They partly terminate directly in a capillary network situated within the lobule, and partly give off fine branches, which enter the lobule before they end in the capillary network. The *intralobular capillaries* form a close network, and converge from the periphery of the lobule, where they spring from the interlobular branches of the portal vein, to the centre of the lobule, where they terminate in the *intralobular* or *central vein*, one of the rootlets of the hepatic vein. In man, where the lobules are not separated from each other by a distinct capsule, the capillaries of one lobule to some extent communicate with those of adjacent lobules.

FIG. 9.—Transverse section through the hepatic lobules. *i*, *i*, *i*, interlobular veins ending in the intralobular capillaries; *c*, *c*, central veins joined by the intralobular capillaries. At *a*, *a* the capillaries of one lobule communicate with those adjacent to it.

The *hepatic artery* closely accompanies the portal vein, and divides into two branches, for the right and left lobes. It is the nutrient artery of the liver, and gives off three series of branches:—(*a*) *vaginal branches*, which are distributed to the walls of the portal vein, the hepatic duct, and to Glisson's capsule, probably also to the wall of the hepatic vein; they end in a capillary network in these structures, from which *vaginal veins* arise that terminate in the portal vein; (*b*) *capsular branches*, which are distributed to the fibrous coat of the liver, and end in a capillary network, from which arise *capsular veins* that join the portal vein; (*c*) *interlobular branches* of the hepatic artery lie along with the interlobular branches of the portal vein, and end in the capillary network within the lobules.

The *hepatic vein* arises within the substance of the liver from the intralobular capillaries. In the centre of each lobule is the *intralobular* or *central vein*. It traverses the axis of the lobule, and leaves it to join a small vein running immediately under the bases of adjacent lobules, which, from its position, is named the *sublobular vein*. Adjacent sublobular veins then join together, and form larger vessels, which are the *trunks* of the *hepatic vein*, or

FIG. 10.—Vertical section through two hepatic lobules of a pig. *c*, *c*, central veins receiving the intralobular capillaries; *s*, sublobular vein; *ct*, interlobular connective tissue forming the capsules of the lobules; *i*, *i*, interlobular veins.

the *hepatic venous canals*. These trunks run towards the posterior border of the liver, and open into the inferior vena cava.

From this description of the vascular arrangements within the liver, it will be seen that the intralobular capillaries are continuous with three vascular trunks,—two which carry blood to them, the portal vein and the hepatic artery, and one which conveys the blood away from them, the hepatic vein. The communication in each case is so free that the capillaries can be artificially injected from any one of these vessels.

The *secreting cells* of the liver, *hepatic cells*, form the proper parenchyma of the organ. They are situated within the lobules, and occupy the spaces of the capillary network. The cells vary in diameter from $\frac{1}{840}$th to $\frac{1}{1030}$th inch; they have the form of irregular polyhedrons, with from four to seven sides, and with the angles sometimes sharp, at other times rounded. They do not appear to possess definite walls, but have a distinct nucleus. The cell protoplasm is granular, and usually contains fat drops, and yellow particles, apparently bile pigment. The general arrangement of the cells is in rows or columns, and when sections are made through a lobule, transverse to the long axis of the central vein, the columns of cells are seen to converge from the periphery to the centre of the lobule, and to form a network.

FIG. 11.—Transverse section through lobules of human liver to show the columns of secreting cells. *c*, *c*, central veins; *i*, interlobular vein with a fine sheath of connective tissue. × 10.

By many observers the cells are regarded as in contact with the intralobular capillaries, without the intervention of an intermediate membrane. By others, and more especially by Lionel Beale, the secreting cells are regarded as inclosed in a tubular network, the wall of which is formed by a basement membrane. Beale states that the diameter of the network is usually about $\frac{1}{1000}$th of an inch in most mammals. According to this view, the cells are not in direct contact with the capillary blood-vessels, but separated from them by the basement membrane. In some parts of the lobule Beale has been able to demonstrate the basement membrane as distinct from the wall of the capillaries, but usually they are incorporated together. At the periphery of the lobule the membrane becomes continuous with the wall of the interlobular duct.

The *hepatic* or *bile duct* is the tube that conveys the bile out of the liver. It leaves the transverse fissure as two branches, one from the right, another from the left lobe, which almost immediately unite at an acute angle. It closely accompanies within the liver the ramifications of the portal vein and hepatic artery, and its terminal branches pass between the lobules to form the *interlobular branches* of the duct. If the hepatic duct be injected, not only does the injection fill the interlobular ducts, but it flows into a set of excessively minute passages within the lobules themselves. These passages are arranged so as to form a polygonal network, which may appropriately be called the *intralobular biliary network*. This network has a most intimate relation to the polyhedral hepatic calls, for the passages lie between the flattened sides of adjacent cells, so that each cell is inclosed in a mesh of the network. The German observers, who first directed attention to these passages, named them *bile-capillaries*, but it is probable that they are merely intercellular passages bounded by the protoplasm of the hepatic cells.

The intralobular biliary network differs from the intralobular blood capillary network, not only in the character of the fluid conveyed, but in other important particulars. The bile passages have a tranverse diameter of about $\frac{1}{10}$th of that of the blood capillaries; the passages are in relation to the sides of the cells, the blood capillaries to their angles, so that the two systems of networks are not in contact with each other, but are separated by intervening hepatic cell substance; the passages have not, in all probability, an independent wall, such as is possessed by the blood capillaries. As these passages can be injected from the hepatic duct, and as they convey bile from the interior of the lobule into the duct, it is obvious that they must be continuous with the lumen of the interlobular branches of the duct, at the periphery of the lobules.

The wall of the larger bile ducts is formed of a fibro-elastic tissue, with a proportion of non-striped muscular fibre; it is lined by a columnar epithelium. Opening into the larger ducts are numerous orifices, which communicate with branched cæcal tubes and follicles, situated within and clustered around the walls of the larger ducts, often in considerable numbers. Some of these appendages to the duct doubtless serve as glands for the secretion of mucus, but others are probably, as Beale supposed, mere diverticula of the duct, in which the bile may be temporarily retained, as in the gall bladder.

The *lymphatics* of the liver form a superficial and a deep set. The superficial set ramifies beneath the serous coat, where they form a network. The deep lymphatics accompany the portal vein and hepatic artery as far as the intervals between the lobules, where they form *interlobular lymphatics*, which, like the corresponding branches of the portal vein, run around the lobule.

The *nerves* of the liver arise from the cœliac plexus of the sympathetic and from the left pneumogastric. They accompany the portal vessels in their distribution, and supply the muscular coats of the vessels.

Gall bladder.

The *Gall Bladder* is a reservoir for the bile, situated in a fossa on the under surface of the right lobe of the liver, and in a notch in its anterior border (fig. 8). It is pyriform in shape; its larger end, or fundus, projects beyond the anterior border; its opposite end, or neck, gives origin to the *cystic duct*, which is directed towards the transverse fissure; after a course of $1\frac{1}{2}$ inch it joins the hepatic duct, and forms the common bile duct, *ductus communis choledochus*. At its neck, the gall bladder bends on itself in a sigmoid curve. The gall bladder is 3 or 4 inches long, and can hold from one to two ounces of bile. It is attached to the liver partly by areolar tissue, and partly by the peritoneum, which is reflected over its free surface.

Structure.—In addition to its partial *serous coat*, the gall bladder has a fibrous and mucous coat. The *fibrous coat* consists of interlacing bands of connective tissue, with which non-striped muscular fibres are sparingly intermingled. The *mucous membrane* lining the gall bladder is deeply bile-stained, and presents on its free surface an alveolar appearance, due to the presence of multitudes of minute folds, which form a reticulum with intermediate depressions. The surface is covered by columnar epithelium. The mucous lining of both the neck of the gall-bladder and cystic duct is thrown into folds, which in the duct have an oblique direction, and form the spiral valve. Racemose glands, for the secretion of mucus, occur in the wall of the gall bladder, cystic duct, and common bile duct. The gall bladder is supplied with blood by the cystic branch of the hepatic artery. It receives lymphatics and nerves continuous with those which belong to the liver.

The *common bile duct*, formed by the junction of the cystic and hepatic ducts, is about 3 inches long, and conveys the bile into the duodenum. It lies in the gastro-hepatic omentum between its two layers, having the hepatic artery to its left, and the portal vein behind it. It then inclines behind the duodenum to the inner side of its descending part, where it comes into relation with the pancreatic duct. The two ducts then run together in an oblique direction through the wall of the duodenum, and open on the summit of a papilla, by a common orifice, about the junction of the descending and transverse portions of the duodenum.

The PANCREAS is an elongated gland which lies in relation to the posterior wall of the abdomen, in front of the first lumbar vertebra, and extends obliquely from the right lumbar region through the epigastrium into the left hypochondriac region. It is from 6 to 8 inches long, and whilst its dilated right extremity, or *head*, occupies the horse-shoe curve of the duodenum, and is attached by areolar tissue to the descending and transverse portions, its attenuated left extremity, or *tail*, is in relation to the spleen. A prolongation of the gland, named the *accessory* or *lesser pancreas*, usually surrounds the superior mesenteric artery at its origin.

Structure.—The pancreas is one of the compound racemose glands, and resembles generally in structure the mucous and salivary glands of the mouth and the glands of Brunner (fig. 5). It is sometimes called the abdominal salivary gland, and its secretion flows into the duodenum, and assists in the process of chylification. It has a yellowish creamy colour, and is divided into distant lobules by septa of connective tissue. The excretory duct, or *duct of Wirsung*, is completely surrounded by the lobules, and extends from the tail to the head of the gland, receiving in its passage the numerous secondary ducts, and increasing gradually in size. It leaves the head of the gland, comes into relation with the common bile duct, and with it pierces obliquely the posterior wall of the descending part of the duodenum, to open by a common orifice about the junction of the descending and transverse portions. Sometimes the duct from the accessory part of the pancreas opens independently into the duodenum, a little above the common hepatico-pancreatic orifice. The finest ducts within the gland terminate in the *acini*, or *gland-vesicles*, of the lobules. These acini contain the secreting cells, which have a somewhat cubical form. The ducts are lined by a columnar epithelium, and mucous glands are situated in the mucous membrane lining the duct of Wirsung. The pancreas receives its supply of blood from the splenic, superior mesenteric, and hepatic arteries. Its veins join the splenic and superior mesenteric veins, and through them contribute to the formation of the portal vein. Its blood capillaries are abundantly distributed on the walls of the gland vesicles. Lymph vessels are found in the connective tissue between the lobules. The nerves are derived from the solar plexus, and accompany the arteries.

THE TEETH.—The teeth are calcified organs developed in connection with the mucous membrane of the mouth. Their primary use is that of biting and grinding the food; but in man they serve as aids to speech, and in many animals act as instruments of offence and defence.

Arrangement and Form of the Teeth.—Teeth are present in the greater number of the Mammalia, in which class they are implanted in sockets in the alveolar arches of the bones of the upper and lower jaws, and form only a single row in each arch. In a few mammals, as the toothed whales and the sloths, only one generation of teeth is produced, and when these drop out they are not replaced by successors; these animals are called Monophyodont. In the majority of the Mammalia, however, there are two generations of teeth,—a temporary or milk set, which are deciduous, and are replaced by a permanent or adult set; these animals are called Diphyodont. But in speaking of two generations of teeth it is not to be supposed that all the teeth in the adult jaw have had temporary predecessors, for the molar or back teeth have only a single generation. A few mammals, as the toothed whales, have the teeth uniform in size, shape, and structure, and are named Homodont; but, in the majority of the Mammalia, the teeth in the same jaw vary in size, form, and structure, and they are therefore called Heterodont. In every Heterodont mammal, possessing a complete dentition, four groups of teeth are found, which are named incisor, canine, premolar, and molar teeth. Each of these teeth possesses a *crown*, which projects into the cavity of the mouth, and a *fang* lodged in the socket in the jaw; at the junction of the crown and fang there is usually a constriction named the *neck* of the tooth.

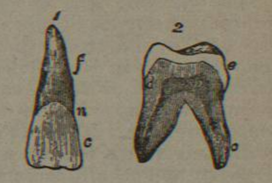


FIG. 12.—1, A human upper incisor tooth. *c*, the crown; *n*, neck; *f*, the fang. 2, a section through a molar tooth; *e*, cap of enamel; *c*, cement; *d*, dentine; *p*, pulp cavity.

In man the dentition is Diphyodont and Heterodont. The single row of teeth in each alveolar arch of the human jaw is characterized by the crowns of the teeth being of almost equal length, and by the absence of any great interspace, or *diastema*, between the different teeth, or of irregularities in the size of the interspaces, so that the teeth form an unbroken series in each jaw. The span of the upper dental arch is slightly bigger than that of the lower, so that the lower incisors fit within the upper, and the lower molars, being inclined obliquely upwards and inwards, are somewhat overlapped by the upper molars. The upper and lower dental arches terminate behind in line with each other, and the teeth are equal in number in the two jaws.

Man possesses 32 teeth in his permanent dentition, arranged in four groups, viz.—8 incisors, 4 canines, 8 premolars or bicuspids, and 12 molars. The number and arrangement of the permanent teeth in the two jaws is expressed in the following formula:—

$$\begin{array}{cccc|cccc} \text{m.} & \text{pm.} & \text{c.} & \text{in.} & \text{in.} & \text{c.} & \text{pm.} & \text{m.} \\ 3 & 2 & 1 & 2 & 2 & 1 & 2 & 3 \\ \hline 3 & 2 & 1 & 2 & 2 & 1 & 2 & 3 \end{array} = 32.$$

Man possesses only 20 teeth in his milk or temporary dentition, and their arrangement is expressed in the following formula:—

$$\begin{array}{ccc|ccc} \text{m.} & \text{c.} & \text{in.} & \text{in.} & \text{c.} & \text{m.} \\ 2 & 1 & 2 & 2 & 1 & 2 \\ \hline 2 & 1 & 2 & 2 & 1 & 2 \end{array} = 20.$$

If the temporary and permanent formulæ be compared with each other, it will be seen that, while the incisors and canine teeth correspond in numbers in both dentitions, in the temporary dentition there is an absence of premolars, and the molar teeth are only eight, instead of twelve, in number. The characters of the permanent teeth will now be considered.

The *incisor teeth*, eight in number, are lodged in the front of the jaws, two on each side of the mesial plane. The upper incisors project downwards and forwards, the lower are directed almost vertically upwards. The oblique direction of the upper incisors in the Negroes, Kaffres, and Australians adds to the prognathic form of the face possessed by these races. The central pair of upper incisors are larger than the lateral; whilst the lateral pair of lower incisors are larger than the central pair, which are the smallest incisor teeth. The crowns of the incisor teeth are chisel-shaped, and adapted for biting and cutting the food. When the crown is first erupted the cutting edge is minutely serrated, but the serrations soon wear down by use. The fangs are long and simple,—being in the upper incisors round and fusiform, in the lower laterally compressed, and sometimes marked by a longitudinal groove. Although the human incisors are, as the name implies, cutting, chisel-shaped teeth, in many mammals the incisors are greatly modified in form, as for example in the tusks of the elephant. The determination of the incisor teeth does not depend, therefore, on their form, but on their position in the jaws. The name incisor is given to all the teeth situated in the pre-maxillary portion of the upper jaw, and in the anterior end of the lower jaw, whatever their shape may be.

The *canine* or *unicuspid teeth*, four in number, one on each side of the mesial plane of each jaw, are placed next the lateral incisors. They are bigger than the incisor teeth, and the upper canines, which are sometimes called the eye-teeth, are larger than the lower; the fangs of the upper canines are lodged in deep sockets in the superior maxillæ, which extend towards the floor of each orbit. The crowns of these teeth are thick and conical; the fangs are long, single, conical, compressed on the sides where they are marked by a shallow groove. In many mammals these teeth are developed into large projecting tusks.

The *premolar* or *bicuspid teeth*, eight in number, two on each side of the mesial plane of each jaw, lie immediately behind the canines, and the upper bicuspids are somewhat larger than the lower. The crown is quadrilateral in form, and convex both on the inner and outer surfaces. It possesses two cusps, of which the outer or labial is larger and more projecting than the inner, palatal, or lingual cusp. The fangs of the upper bicuspids are single and laterally compressed, often bifid at the point into an outer and inner segment; in the lower bicuspids the fangs are rounded, and taper to a single point.

The *molar* or *multicuspid teeth*, twelve in number, are placed three on each side of the mesial plane of each jaw. They are the most posterior teeth, are the largest of the series, and as a rule decrease in size from the first to the last; the crowns of the lower molars are somewhat bigger than those of the upper molars. The last molar tooth does not erupt until the end of puberty, and is called *dens sapientiæ*, or *wisdom tooth*. The crowns are broad, quadrilateral, and convex both on the inner and outer surfaces. The first and second upper molars have four cusps projecting from the angles of the grinding or masticating surface, and an oblique ridge often connects the large anterior internal cusp with the posterior external cusp; in the upper wisdom teeth, the two inner or palatal cusps are frequently conjoined. The first lower molar has five cusps, the fifth being interposed between the two posterior cusps; in the second lower molar the fifth cusp is usually absent, or only rudimentary in size, but in the lower wisdom tooth it is often present. The fangs of the first and second upper molars are three in number, and divergent; two on the outer or buccal side, one on the inner or palatal side; in the upper wisdom the fangs are frequently partially conjoined, though trifid at the point. The fangs of the first and second lower molars are two in number, an anterior and a posterior, of which the anterior is the larger; they usually curve backwards in the jaw; in the lower wisdom the fangs are usually conjoined, but bifid at the point.

The crowns of all the teeth become more or less flattened by use, so that the incisors lose their sharp cutting edge, and the cusps of the premolars and molars are worn away.

The temporary or milk teeth are smaller than the permanent teeth. They are more constricted at the neck, where the crown joins the fang, especially in the milk molars, the fangs of which also diverge more widely than in the permanent set. The second temporary molar is bigger than the first. The crown of the first upper molar has three cusps, two buccal, one palatal; that of the second four cusps. The crown of the first lower molar has four cusps; that of the second five, three of which are buccal, two lingual. The temporary teeth lie more vertically in the jaws than the permanent.

The *alveolus*, or socket for the lodgment of the single fanged teeth, is a single socket; in the multi-fanged teeth, the socket is divided into two or three compartments, according to the number of the fangs. The socket is lined by the *alveolo-dental periosteum*, which is continuous at the mouth of the socket with the periosteal covering of the jaw, and with the deeper fibrous tissue of the gum, where it embraces the neck of the tooth. The alveolo-dental periosteum is formed of retiform connective tissue, on the one hand connected with the surface of the cement, on the other with the more fibrous periosteum lining the bony wall of the socket (fig. 15). It is vascular, its vessels being continuous with those of the gum, the pulp-vessels, and the bone. It receives nerves from those going to the pulp. The fang fits accurately in the socket, and through a hole at the tip of the fang the blood-vessels and nerves of the tooth pass into the pulp-cavity of the tooth.

Structure of the Teeth.—Each tooth is composed of the following hard structures—dentine, enamel, and cement or crusta petrosa; occasionally other substances, named osteodentine or vasodentine, are present. In a tooth which has been macerated, an empty space exists in its interior, called the pulp-cavity, which opens externally through the hole at the tip of the fang; but in a living tooth this cavity contains a soft, sensitive substance named the pulp.

The *Dentine*, or *Ivory*, makes up the greater part of each tooth; it is situated both in the crown, where it is covered by the enamel, and in the fang, where it is invested by the crusta petrosa; whilst the pulp cavity in the centre of the tooth is a cavity in the dentine. The dentine is composed of an intimate admixture of earthy and animal matter in the proportion of 28 of the animal to 72 of the earthy. The animal matter is resolved on boiling into gelatine; the earthy matter consists mostly of salts of lime.

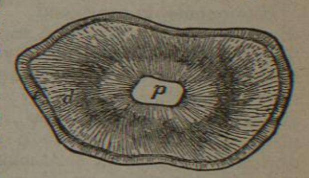


FIG. 13.—Transverse section through the crown of a tooth. *p*, pulp cavity; *d*, dentine; *e*, enamel.

If thin slices through the dentine of a macerated tooth be examined microscopically, it will be seen to consist of a hard, dense, yellowish-white, translucent *matrix*, penetrated by minute canals, called *dentine tubes*. The dentine tubes commence at the pulp cavity, on the wall of which they open with distinct orifices. They radiate in a sinuous manner from the pulp cavity through the thickness of the dentine, and terminate by dividing into several minute branches; this division takes place in the crown of the tooth immediately under the enamel, and in the fang of the tooth immediately under the crusta petrosa. In their course the dentine tubes branch more than once in a dichotomous manner, and give off numbers of extremely minute collateral branches. The transverse diameter of the dentine tubes near the pulp cavity is $\frac{1}{4500}$th inch, but that of their terminal branches is much more minute.

If the dentine be examined in a fresh tooth, the tubes will be seen to be occupied by soft, delicate, thread-like prolongations of the pulp. The passage of processes of the pulp into the dentine tubes was first seen by Owen in the examination of the tusk of an elephant; but the soft contents of the dentine tubes have been made the subject of special investigation by J. Tomes in the human and other mammalian teeth, and have been named the *dentinal fibrils*.

In sections through the dentine of dried teeth, it is not uncommon to find, near its periphery, irregular, black spaces containing air. These spaces freely communicate with each other. As the dentine which forms their boundary has not unfrequently the appearance of globular contours, they were named by Czermak the *interglobular spaces*. In a fresh tooth they are not empty, but are occupied by a soft part of the matrix, which is traversed in the usual manner by the dentine tubes. This matrix is apparently imperfectly calcified dentine, which shrinks up in a dried tooth, and occasions an air-containing space. A layer of small irregular spaces situated in the peripheral part of the dentine in the fang, immediately under the crusta petrosa, and sometimes named the *granular layer*, is apparently of the same nature as the interglobular spaces.

The *Enamel* is the brilliant white layer which forms a cap on the surface of the crown of a tooth. It is thickest on the cutting edge or grinding surface of the crown, and thins away towards the neck, where it disappears. It is not only the hardest part of a tooth, but the hardest tissue in the body, and consists of 96·5 per cent. of earthy and of 3·5 per cent. of animal matter. The earthy matter consists almost entirely of salts of lime. The great hardness of the enamel admirably adapts it as a covering for the cutting edge, or grinding surfaces, of the crowns of the teeth.

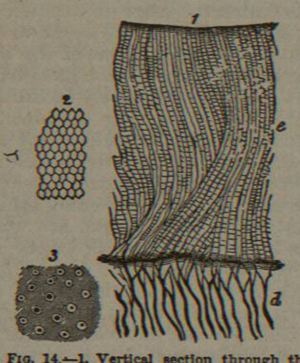


FIG. 14.—1, Vertical section through the enamel and immediately subjacent dentine; *e*, enamel rods; *d*, branched termination of dentine tubes. 2, transverse section through the enamel rods. 3, transverse section through dentine tubes and matrix. × 300.

The enamel is composed of microscopic rods,—the *enamel fibres*, or *enamel prisms*. These rods are set side by side in close contact with each other; one end of each rod rests on the surface of the dentine, the other reaches the free surface of the crown. The rods do not all lie parallel to each other, for whilst some are straight, others are sinuous, and the latter seem to decussate with each other. The rods are marked by faint transverse lines, and are solid structures in the fully formed enamel. When cut across transversely, they are seen to be hexagonal or pentagonal, and about $\frac{1}{5000}$th inch in diameter.

The free surface of the enamel of an unworn tooth is covered by a thin membrane, named the *cuticle of the enamel*, or *Nasmyth's membrane*. This membrane can be demonstrated by digesting an unworn tooth in a dilute mineral acid, when it separates as a thin flake from the free surface of the crown. It is a horny membrane, which resists the action of acids. Its deep surface is pitted for the ends of the enamel rods. As the crown of the tooth comes into use, Nasmyth's membrane is worn off, and the enamel itself by prolonged use is thinned and worn down. In persons who live on hard food, that requires much mastication, it is not uncommon to find the grinding surface of the crowns of the molar teeth worn down quite flat, and the dentine exposed.

The *Cement, Crusta Petrosa*, or *Tooth Bone*, forms a thin covering for the surface of the fang of a tooth, and extends upwards to the neck. It is of a yellowish colour, and is usually thickest at the point of the fang; though in the multifanged teeth it sometimes forms a thickish mass at the point of convergence of the fangs. It possesses the structure of bone, and consists of a lamellated matrix with perforating fibres, lacunæ, and canaliculi. The lacunæ are irregular in size and mode of arrangement, and vary also in the number of the canaliculi proceeding from them. Sometimes the canaliculi anastomose with the branched terminations of the dentine tubes. In the thin cement situated near the neck of the tooth the lacunæ are usually absent. If the jaw with its contained teeth be softened in acid, and sections be made so as to show the teeth *in situ*, there is no difficulty in recognizing the cellular masses of nucleated protoplasm within the lacunæ, which resemble in

FIG. 15.—Section through the socket and fang of a tooth. *b*, the bony wall of a socket, its lacunæ containing the bone corpuscles; *f*, the fibrous, and *r*, the reticulated portion of the alveolo-dental periosteum, in which transversely divided vessels, *v*, *v*, may be seen; *c*, the cement, the lacunæ of which contain the bone corpuscles; *d*, the dentine. × 450.

appearance the corresponding structures in the adjacent bone. Haversian canals are only found in the cement when it acquires unusual thickness. In old teeth the cement thickens at the tip of the fang, and often closes up the orifice into the pulp cavity; the passage of the nerves and vessels into the pulp is thus cut off, and the nutrition of the tooth being at an end, it loosens in its socket and drops out.

Osteo-dentine and *Vaso-dentine* do not exist as normal structures in human teeth, though they occur in various animals. They may appear, however, as abnormalities in the human teeth, and are found on the inner wall of the pulp cavity. Osteo-dentine consists of dentine structure, intermingled with lacunæ and canaliculi. If vascular canals, like the Haversian canals of bone, are formed in it, then the name vaso-dentine is applied.

The *Pulp* of the tooth is one of its most important constituents. It is a soft substance occupying the cavity in the dentine, or the pulp cavity, and is destroyed in a macerated and dried tooth. It consists of a very delicate gelatinous connective tissue, in which numerous cells are imbedded. Those which lie at the periphery of the pulp are in contact with the dentine wall, and form a layer, named by Kölliker the *membrana eboris*. As the cells of this layer play a part in the formation of the dentine similar to that performed by the osteoblast cells in the formation of bone, Waldeyer has named them *odontoblasts*. The odontoblasts are elongated in form, and their protoplasm gives off several slender processes; some enter dentine tubes to form the soft dentinal fibres already described; one passes towards the centre of the pulp, to become connected with more deeply-placed pulp cells; whilst others are given off laterally to join contiguous cells of the odontoblast layer. The pulp contains the nerves and blood-vessels of the tooth, which pass into the pulp, through the foramen at the point of the fang. The vessels form a beautiful plexus of capillaries. The nerves are sensory branches of the fifth cranial nerve. They enter the pulp as medullated fibres, which divide into very fine non-medullated fibres, that form a network in the peripheral portions of the pulp. The pulp of the tooth is the remains of the formative papilla, out of which the dentine or ivory has been produced. In adult teeth changes that lead to the production of osteo-dentine and vaso-dentine may take place in it. Through the dentinal fibres an organic connection is preserved between the dentine and the pulp, and

the sensitiveness exhibited by the dentine in some states of a tooth is not necessarily due to the passage of nerves into it, but to its connection with the sensitive dentine pulp.

Development of the Teeth.—In studying the development of the teeth, not only has the mode of formation of the individual teeth to be examined, but the order of succession of the different teeth both in the temporary and permanent series.

The teeth are developed in the mucous membrane or gum, which covers the edges of the jaws of the young embryo, and their formation is due to a special differentiation in the arrangement and structure of portions of the epithelial and sub-epithelial tissues of that membrane. The enamel is produced from the epithelium, and the dentine, pulp, and cement from the sub-epithelial connective tissue.

The development of the *temporary teeth* will first be considered. If a vertical section be made through the mouth of a young human

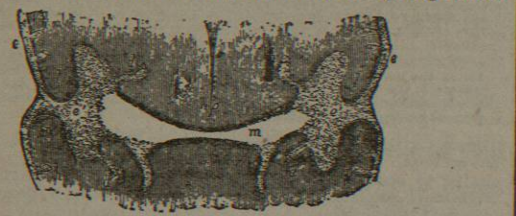


FIG. 16.—Vertical transverse section through the mouth of a young human embryo. *np*, naso-palatine region: *t*, tongue; *m*, mouth; *l*, *l*, *l*, *l*, lips; *d*, *d*, primitive dental grooves with epithelial contents in upper gum; *d'*, *d'*, similar structures in lower jaws; *e*, *e*, cuticular epiblast; *h*, *h*, hair follicles; *e'*, epiblast prolonged into the mouth.

embryo about the sixth or seventh week, its cavity may be seen to be lined by a stratified epithelium, continuous with the layer of stratified epiblast forming the cuticle of the face. Along the edge of the gum, corresponding in position to that of the future jaws, the epithelium is of some thickness, and an involution of the epithelium into the subjacent connective tissue has taken place. Owing to this involution a narrow furrow or groove in the connective tissue is produced, which constitutes the *primitive dental groove* of Goodsir. This groove is not, however, an empty furrow, but is occupied by the involuted epithelium. The sub-epithelial connective tissue is soft and gelatinous, and abounds in corpuscles, which are especially abundant in the connective tissue at the bottom of the groove, where the *dental papillæ* are produced. These papillæ are formed, at the bottom of the groove, by an increased development and growth of the corpuscles of the subjacent connective tissue. The base of each papilla is continuous with the subjacent connective tissue, and the apex projects into the deeper parts of the involuted epithelium.

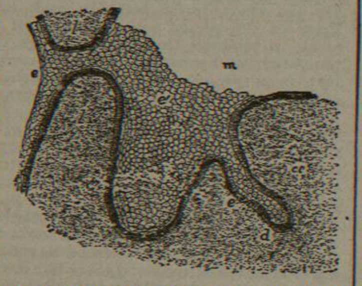


FIG. 17.—A more highly magnified view of a section through the same jaw as fig. 16; *ct*, sub-epithelial connective tissue of the gum; *d*, primitive dental groove; *e''*, its epithelium; *e'*, epithelium lining *m*, the cavity of the mouth; *l*, *l*, lips; *e*, the epiblast cuticle. The deepest layer of the epithelium consists of columnar cells.

As a papilla increases in breadth and length the groove widens and deepens, and the involuted epithelium, increasing in quantity, expands over the apex and sides of the papilla, so as to form a hood-like covering or cap for it. The cap of epithelium constitutes the *enamel organ*, whilst the papilla is the *formative pulp* for the dentine and permanent pulp. Whilst these changes are taking place in the epithelium and the connective tissue at the bottom of the groove, no commensurate widening occurs at its upper part, which remains for a time relatively narrow, but retains within it a narrow string of epithelial cells, continuous on the one hand with the epithelial lining of the mouth, and on the other with the enamel organ. This epithelial string forms the *neck of the enamel organ*. After a time, however, the growth of the connective tissue forming the lips of the primitive groove causes the neck of the enamel organ to atrophy, so that all communication between the enamel organ and the superficial epithelium is cut off; and the embryo tooth, being now completely inclosed in a cavity or sac, formed by the gelatinous connective tissue of the gum, has entered on what Goodsir termed its *saccular* stage of development.

FIG. 18.—Vertical section through the gum to show the formation of the dental papilla. *e'*, the epithelium covering the gum; *n*, the neck of *en*, the enamel organ; *p*, the dental papilla; *ct*, sub-epithelial connective tissue. Magnified.

When inclosed in its sac the embryo tooth, though perfectly soft, acquires a shape which enables one to recognize to what group of teeth it belongs. After a time it begins to harden and to exhibit the characteristic tooth structure.

The dental papilla is more vascular than the surrounding connective tissue, from the blood-vessels of which its vessels are derived. The papilla abounds in cells, which are, in the first instance, rounded and ovoid in shape. Changes then take place in the cells situated at its periphery, which become elongated and branched, and form layers of cells (odontoblasts). Calcification of the protoplasm of these odontoblasts then occurs, and the peripheral layer of the dentine is produced. In contact with the inner surface of the thin film of dentine, a second layer of odontoblast cells is then arranged, which in their turn calcify, and as the process goes on in successive layers of odontoblasts, the entire thickness of the matrix of the dentine and the dentinal sheaths are produced. But the process of calcification does not apparently take place throughout the whole thickness of the protoplasm of the odontoblasts, for, as Waldeyer pointed out, the axial part of the cells remains undifferentiated as the soft dentinal fibrils of the dentine tubes. As these changes are going on in the peripheral layers of the odontoblasts, the central part of the dental papilla increases in quantity, apparently by a proliferation of its cells; nerve fibres are developed in it, and it persists as the soft pulp of the tooth. The papilla of the tooth has essentially, therefore, the same relation to the formation of dentine that the cellulo-vascular contents of the medullary spaces, in intra-cartilaginous ossification, have to the formation of bone. In both instances the hard matrix is due to a special differentiation of the protoplasm of the formative cells; the dentinal fibrils are the equivalent structures to the soft contents of the lacunæ and canaliculi, and the persistent pulp is equivalent to the cellulo-vascular contents of the Haversian canals.

FIG 19.—Sacculated stage of development of two molar teeth in the cat. *ct*, *ct*, connective tissue forming the sacs for the teeth; *p*, *p*, dental papillæ; the opaque bands, *d*, *d*, mark the commencement of calcification of the dentine; *e*, *e*, internal enamel epithelium; the outer enamel epithelium was not recognizable; *b*, *b*, the bony walls of the alveoli are beginning to form. Magnified.

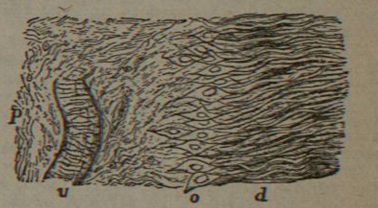


FIG. 20.—Section through the dentine and pulp cavity of a young tooth. *p*, the pulp, with *v*, one of its vessels, and *o*, layers of odontoblast cells giving off processes into *d*, the dentine. × 450.

Prior to the embryo tooth becoming sacculated, changes had taken place in the enamel organ. Those cells of the enamel organ which lie next the dental papilla are continuous, through the neck of the enamel organ, with the deepest layer of cells of the oral epithelium, which cells are elongated columns set perpendicularly to the surface on which they rest. Similarly the cells of the deepest layer of the enamel organ are columns set perpendicularly to the surface of the dental papilla. They undergo a greater elongation, and form six-sided prismatic cells, which Kölliker has named the *internal* or *enamel epithelium*. The cells of the most superficial layer of the enamel organ lie in contact with the vascular connective tissue which encloses the embryo tooth. They form the *external epithelium* of the enamel organ, and slender papillary prolongations of the connective tissue frequently project into this epithelial layer. The cells of the enamel organ, situated between its external and its internal epithelium, become stellate, and form with each other an anastomosing network of cells like those sometimes seen in the gelatinous connective tissue.

After the tooth has become sacculated, and coincident with the transformation of the odontoblast cells of the dental papilla into dentine, calcification begins in the elongated prismatic cells of the internal or enamel epithelium; their protoplasm becomes calcified,

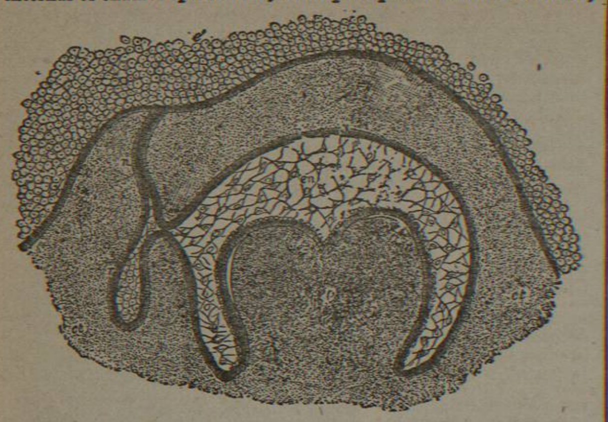


FIG. 21.—Vertical section through the gum in the region of the molar teeth. *p*, the papilla of a milk molar; 1, the inner, 2, the middle, and 3, the outer layers of the enamel organ; *n*, the neck of the enamel organ; *e'*, the superficial epithelium; *ct*, *ct*, *ct*, the sub-epithelial connective tissue which subsequently forms the sac of the tooth; *r*, the cavity of reserve occupied by epithelium, in connection with which the permanent successional tooth is formed. × 300.

and they become the rods or prisms of the enamel. As the hardening takes place from the periphery to the centre of each cell, the axial portion may, as Tomes pointed out, remain soft for some time in the axis of the enamel rod. With the increase in length, and with the calcification of the cells of the enamel epithelium, the stellate gelatinous cells disappear, and the outer ends of the enamel rods come in contact with the cells of the external enamel epithelium. By some observers the external epithelium is supposed to disappear without undergoing any special differentiation, but by others it is believed to undergo conversion into Nasmyth's membrane.

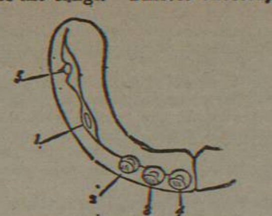
In this manner the crown of a tooth is formed, and it is lodged in a membranous sac formed by the differentiation into a fibro-vascular membrane of the surrounding connective tissue. Whilst within its sac, the crown of the tooth possesses the characteristic form of the group of teeth to which it belongs. After the calcification of the enamel rods is completed, it can undergo no further change either in shape or in increase of size.

Whilst the crown of the tooth is being formed, ossification of the jaws has been going on, and the tooth, with its membranous sac, has become lodged in an alveolus or socket in the jaw, which alveolus is closed in by the gum.

In order that the crown of the tooth may come into use as a masticatory organ, it has to be elevated to the level of the gum, which is absorbed by the pressure, and the crown then erupts into the cavity of the mouth. The process of eruption is due to the development of the fang, which, as it grows in length, elevates the crown of the tooth and forces it outward. The dentine of the fang is developed from the odontoblast cells of the pulp in a manner similar to that already described for the development of the dentine of the crown. The cement or crusta petrosa is developed from the connective tissue lining the alveolus, which forms the alveolo-dental periosteum. It is therefore an ossification in membrane.

As the temporary or milk teeth precede the permanent teeth, their papillæ are naturally the first to form. The series of milk-papillæ are not, however, simultaneously produced. From the observations of Goodsir, it has been shown that the milk-papilla of the anterior molar in the upper jaw appears about the seventh week; then the canine papilla, the two incisor papillæ, and the posterior molar papilla are sucessively formed, the last making its appearance about the end of the tenth week. The dental papillæ in the upper jaw immediately precede the papillæ of the corresponding teeth in the lower jaw.

The eruption of the milk teeth into the mouth does not begin to take place until the latter half of the first year of extra-uterine life, and is not completed until betweeen the second and third year. Though variations occur in the date of eruption of each tooth in different children, it may be stated that the incisors usually appear from the seventh to the ninth month, the anterior molars from the twelfth to the sixteenth month, the canines during the seventeenth or eighteenth month, the posterior milk molars from two to two and a half years. The milk teeth begin to be shed about the sixth year by the dropping out of the incisors. The last to be shed are the canines, which do not fall out till the tenth or eleventh year. The shedding of the milk teeth is preceded by the absorption of the fangs. This is effected, as was satisfactorily shown by J.



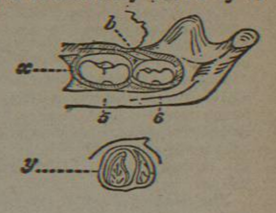


FIG. 22.—One-half the lower jaw of a fœtus about the 11th or 12th week, showing the dental papillæ in the order of their appearance. 1, the first milk molar; 2 the canine; 3 and 4, the two incisors; 5, the second milk molar.—From Goodsir.

FIG. 23.—Posterior part of the lower jaw of a child at birth. 5, the crown and sac of the posterior milk molar; 6, the crown and sac of the first permanent molar; *b*, the cavity in connection with which the papilla of the second permanent molar ultimately forms. *y*, shows a temporary and permanent incisor from the same fœtus.—From Goodsir.

Tomes, by the agency of a group of cells situated at the bottom of the sockets. As these cells occasion absorption of the tooth tissue, similar to that occurring in the bone tissue from the action of the large multi-nucleated osteo-klast cells, they may appropriately be called *odonto-klasts*.

The development of the *permanent teeth* will now be considered. In the description of the arrangement of the teeth it has been pointed out that the number of teeth in the permanent set exceeds that of the temporary set. The permanent incisors and canines come into the place of the temporary incisors and canines, and the permanent bicuspids succeed the temporary molars, but the permanent molars have no milk predecessors, and are superadded at the back of the dental series.

The development of the *successional permanent teeth*, which are the ten anterior teeth in each jaw, will first be examined. Prior to the period when the lips of the primitive dental groove meet, to produce the saccular stage of dentition of the several temporary teeth, an indentation, or furrow, takes place in the connective tissue adjoining the string of epithelial cells which form the neck of the enamel organ. This furrow constitutes what Goodsir termed the *cavity of reserve*, and it is filled up by epithelial cells continuous with the epithelium of the neck of the enamol organ. As a cavity of reserve is formed immediately behind (*i.e.*, on the lingual side of) each milk tooth, they are ten in number in each jaw, and, except that for the anterior molar, are formed successively from before backwards.

The cavities of reserve are concerned in the production of the permanent successional teeth, and each temporary tooth is replaced by the permanent tooth formed in connection with the cavity of reserve situated immediately behind it (fig 21). The cavities of reserve become elongated, and widened, and pass above the temporary teeth in the upper jaw, and below those in the lower jaw. At the bottom of each a dental papilla forms, the apex of which indentates and becomes covered by the epithelium contained in the cavity, which forms a cap for the papilla, and constitutes the enamel organ for the permanent tooth. The cavity becomes completely closed by the growth of the surrounding connective tissue, and the embryo permanent tooth becomes sacculated. The process of calcification then goes on, in both the enamel organ and dental papilla, in a manner similar to that already described in the temporary teeth. The permanent teeth then become lodged in sockets in the jaw distinct from those of the temporary teeth. The sac of each permanent tooth remains connected with the fibrous tissue of the gum by a slender fibrous band, or *gubernaculum*, which passes through a hole in the jaw immediately behind the corresponding milk tooth. Before the successional permanent tooth erupts, not only should the temporary tooth be shed, but the bony partition between their respective sockets must be absorbed.

The *superadded permanent teeth*, or permanent molars, three in number on each side, lie behind the successional teeth. Their mode of origin is similar to that of the temporary teeth. The primitive groove, occupied by an involution of the epithelial covering of the gum, is prolonged backwards. Three dental papillæ successively appear at the bottom of this groove, and the epithelium covering each papilla forms its enamel organ. Legros and Magitot, however, state that the second permanent molar arises in connection with a diverticulum (cavity of reserve) proceeding from the epithelial string of the enamel organ of the first permanent molar, and that the wisdom tooth is formed in connection with a similar diverticulum from the second permanent molar. The embryo tooth becomes sacculated, and goes through the process of calcification similar to what has been described in the other teeth

The germ of the first permanent molar appears about the sixteenth week of embryo life; that of the second permanent molar not until about the seventh month after birth; whilst that of the wisdom tooth is not formed until about the sixth year The crown of the

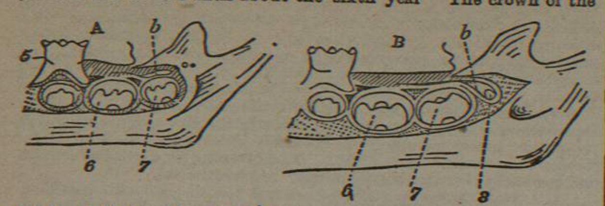


FIG. 24.—A, the lower jaw of a child between four and five years old. 5, the last milk molar, with the successional bicuspid tooth in the cavity of reserve immediately below it; 6 and 7, the first and second permanent molars in their sacs; *b*, the cavity in connection with which the wisdom tooth is formed. B, the lower jaw of a child about six years old; 6 and 7, the first and second permanent molars; 8, the papilla of the wisdom tooth developed in connection with its cavity *b*.—From Goodsir

first molar is the first of the permanent teeth to erupt into the mouth, which it usually does in the sixth year. The incisors appear when the child is seven or eight; the bicuspids when it is nine or ten; the canines about twelve; the second molars about thirteen; and the wisdom teeth from seventeen to twenty five.

In his dentition man is diphyodont as regards his incisor, canine, and premolar teeth, but monophyodont in the molar series.

From the description of the development of the teeth, it will have been seen that a tooth is made up of three hard tissues—enamel, dentine, and cement—and of the soft vascular and nervous pulp. These tissues are not developed from one layer only of the blastoderm. The enamel is of epiblast origin, whilst the dentine, cement, and pulp are derived from the mesoblast. A tooth in its fundamental development, as was long ago pointed out by Goodsir, must be referred to the same class of organs as the hairs and feathers. The enamel of the tooth, like the hair, is produced by a differentiation of the involuted epithelium of the epiblast, whilst the dentine and pulp resemble the papilla of the hair, in proceeding from the mesoblast. The tooth-sac, like the hair-follicle, is also of mesoblast origin. Whether the cement, as Robin and Magitot have described, be developed by means of a special *cement organ*, in the interior of the tooth-sac, or be formed, as has been stated in this description, by the alveolo-dental periosteum, it is on either view derived from the mesoblast. As to the origin of Nasmyth's membrane, there is a difference of opinion; some regard it as a special cornification of the external cells of the enamel organ, in which case it would be from the epiblast; whilst others consider it to be continuous with though structurally different from, the cement—homologous, therefore, with the layer of cement, which in the horse, ruminants, and some other mammals covers the surface of the crowns of the teeth.

The tissues of a tooth have not all the same importance in the structure of a tooth. The dentine is apparently always present, but the enamel, or the enamel and cement, may be absent in the teeth of some animals. For example, the tusks of the elephant and narwhal, and the teeth of the Edentata, are without enamel, and in the Rodentia enamel is present on only the anterior surface of the incisors. But though the enamel is not developed, or forms only an imperfect covering for the crowns of these teeth, yet an enamel organ is formed in the embryo jaws. In 1872 W. Turner described a structure homologous with the enamel organ in relation with each of the dental papillæ in the lower jaw of a fœtal narwhal; but this organ did not exhibit a differentiation into the three epithelial layers, such as occurs in those teeth in which enamel is developed. Since then C. S. Tomes has seen an enamel organ in the embryo armadillo, and has also pointed out that, in teeth generally, enamel organs exist, quite irrespective of whether enamel subsequently does or does not form.

But further, the involution of the oral epithelium, and the coincident formation of a primitive groove, take place not only where the teeth subsequently arise, but along the whole curvature of the future jaws; whilst the production of dental papillæ is restricted to the spots where the teeth are formed. Hence it would seem that the inflection of the oral epithelium is not so essential to the development of a tooth as the formation of a papilla. The inflected epithelium marks only a preliminary stage, and it may or may not be transformed into tooth structure. But that which is essential to the formation of a tooth is the production of the papilla which appears at the bottom of the primitive groove. (W. T.)

DIGITALIS, or FOXGLOVE, a genus of biennial and perennial plants of the natural order *Scrophulariaceæ*. The common or purple foxglove, *D. purpurea*, is common in dry hilly pastures and rocky places and by road sides in various parts of Europe; it ranges in Great Britain from Cornwall and Kent to Orkney, but it does not occur in Shetland or in some of the eastern counties of England. It flourishes best in siliceous soils, and is not found in the Jura and Swiss Alps. The characters of the plant are as follows:—stem erect, roundish, downy, leafy below, and from 18 inches to 6 feet or more in height; leaves alternate, crenate, rugose, ovate or elliptic-oblong, and of a dull green, with the under surface downy and paler than the upper; radical leaves together with their petioles often a foot in length; root of numerous, slender, whitish fibres; flowers $1\frac{3}{4}$–$2\frac{1}{2}$ inches long, pendulous, on one side of the stem, purplish crimson, and hairy and marked with eye-like spots within; segments of calyx ovate, acute, cleft to the base; corolla obtuse, with the upper lobe entire or obscurely divided; stamens four and didynamous (see vol. iv. p. 138, fig. 226); anthers yellow and bilobed; capsule bivalved, ovate, and pointed; and seeds numerous, small, oblong, pitted, and of a pale brown. As Parkinson remarks of the plant, "It flowreth seldome before July, and the seed is ripe in August;" but it may occasionally be found in blossom as late as September. In one variety, common in gardens, the flowers are white; in another their purple is of a coppery or metallic hue; and not unfrequently in cultivated plants several of the uppermost blossoms may be united together so as to form a cup-shaped compound flower, through the centre of which the upper part of the stem passes. A figure of *D. purpurea* will be found in vol. iv. plate xi. Many species of foxglove with variously-coloured flowers have been introduced into Britain from the Continent. The plants may be propagated by off-sets from the roots, but are best raised from seed.

The foxglove (Ang.-Sax., *foxes-clife*, *foxes-glofa*) is known by a great variety of popular names in Britain. In the south of Scotland it is called bloody fingers; further north, dead-men's-bells; and on the eastern borders, ladies' thimbles, wild mercury, and Scotch mercury. Among its Welsh synonyms are *menyg-ellyllon* (elves' gloves), *menyg y llwynog* (fox's gloves), *bysedd cochion* (red fingers), and *bysedd y cwn* (dog's fingers). In France its designations are *gants de notre dame*, and *doigts de la Vièrge*. The German name *fingerhut* (thimble) suggested to Fuchs, in 1542, the employment of the Latin adjective *digitalis* as a designation for the plant.

The leaves, gathered from wild plants when about two-thirds of their flowers are expanded, deprived usually of the petiole and the thicker part of the midrib, and dried, constitute the drug *digitalis* or *digitalis folia* of the pharmacopœia. The prepared leaves have a faint odour and bitter taste; to preserve their properties they must be kept excluded from light in stoppered bottles. They are occasionally adulterated with the leaves of *Inula Conyza*, Ploughman's Spikenard, which may be distinguished by their greater roughness, their less divided margins, and their odour when rubbed; also with the leaves of *Symphytum officinale*, Comfrey, and of *Verbascum Thapsus*, Great Mullein, which unlike those of the foxglove have woolly upper and under surfaces. The powder, infusion, and tincture of digitalis are employed both externally and internally; and its active principle, *digitalin*, may further be used for subcutaneous injection. Digitalin, according to Nativelle, is a crystallizable, neutral, inodorous, bitter substance, of the formula $C_{25}H_{40}O_{15}$, insoluble in water and ether, but soluble in alcohol and chloroform. The earliest known descriptions of the foxglove are those given by Fuchs and Tragus about the middle of the 16th century, but its virtues were doubtless known to herbalists at a much remoter period. Gerarde, in his *Herbal* (1597), advocates the use of foxglove for a variety of complaints; and John Parkinson, in the *Theatrum Botanicum*, or *Theater of Plants* (1640), tells us that