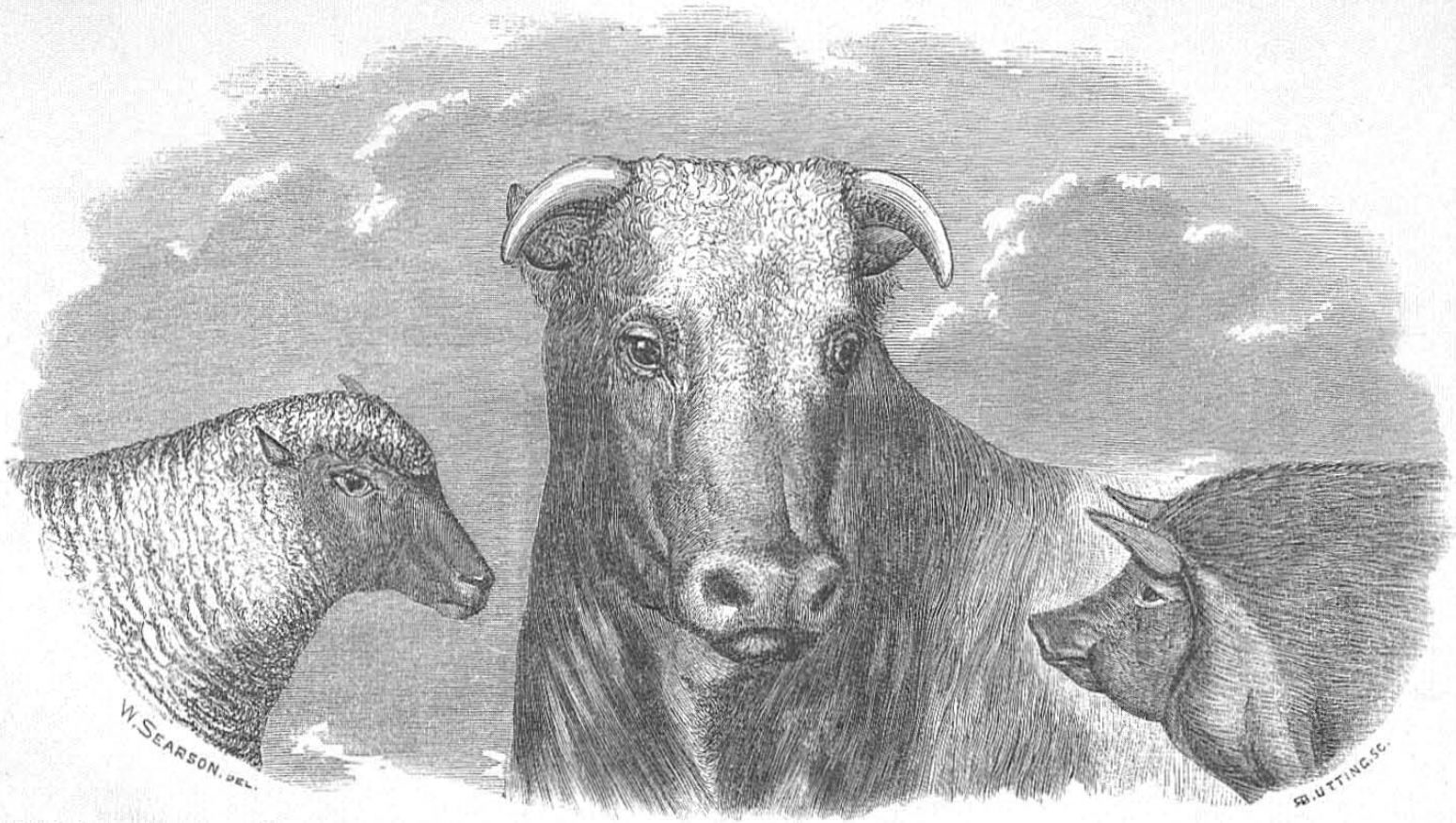
SIMONDS
ON THE AGE
OF THE
OX. SHEEP. AND PIG.

Frontispiece.



James Law

THE AGE

OF THE

OX, SHEEP, AND PIG;

BEING

THE SUBSTANCE OF TWO LECTURES DELIVERED BEFORE

THE ROYAL AGRICULTURAL SOCIETY OF ENGLAND

ON THE STRUCTURE AND DEVELOPMENT OF THE
TEETH OF THESE ANIMALS.

By JAMES BEART SIMONDS,

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ILLUSTRATED WITH NUMEROUS ENGRAVINGS.

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PREFACE.

As the following pages contain merely the substance of two Lectures delivered by the Author before the Royal Agricultural Society on the 17th and 24th May in the present year, it might perhaps be thought that no prefatory observations were called for. He, however, owes it to his readers to explain as briefly as possible the circumstances that have led to their being given publicity to.

In his official capacity as Veterinary Inspector to the Society, he was requested by the Council to offer some remarks on the structure and development of the Teeth, and the changes that take place in those organs by which the different ages of the Ox, Sheep, and Pig are indicated. The subject was not new to him, and long-continued and repeated observations had convinced him that the opinions advanced by veterinary writers, both of this country and France, were often incorrect. This, added to the importance of the question in the present day to agriculturists, made him doubly solicitous that the views he was thus about to promulgate should be founded on *data* both sufficiently numerous and correct.

Exceptions will doubtless now and then be met with to the rules he ventured to lay down, arising from peculiar conditional circumstances under which the animals may have been placed; but these, he believes, will be found to be only few, and as such they will serve to make the laws general ones.

Above 2000 animals had been examined by him, whose ages were correctly known.

At the monthly Meeting of the Council of the Society following the delivery of these Lectures,

Mr. Fisher Hobbs moved:—

"That, on account of the immediate practical importance of the two Lectures recently delivered before the Society by Prof. Simonds, on the age of animals as shown by their teeth, these Lectures be at once prepared for publication in the second part of the Journal for this year: but as that number will not be due till the 1st of January next, that Prof. Simonds be allowed to print off from the type and woodcuts as many copies as he may require for the purpose of publishing the Lectures in the form of pamphlet, at a cheap rate, in time for purchase by the public at the Lincoln Meeting."

This being unanimously carried, the author's duty became an immediate compliance with the request thus handsomely made, although, from the lectures being extemporary, the time allowed him for their preparation for the press was extremely short. On this account he ventures to appeal to the kind consideration of his readers for any inaccuracies that may exist in the publication.

Nor must he, in conclusion, neglect to express his obligations to Mr. Searson and Mr. Utting for the superior manner in which the illustrations have been executed by them, and the earnestness with which they laboured so as to complete their work within the given time. To Mr. Topping his best thanks are also due for the promptness with which he prepared the really beautiful microscopic objects from which several of the illustrations have been taken. Some of these will be found to be new, and being so, the Author has been compelled to differ from the statements made by anatomists as to the manner in which certain parts of the teeth are formed. In this, however, as well as in other particulars wherein his views may not accord with those of hitherto received authorities, he trusts it will be found that he has not erred in the conclusions he has arrived at.

Royal Veterinary College, July 1st, 1854.

CONTENTS.

PAGE

Preliminary Observations — Digestive organs of the Infusoria — Digestion in the Entozoa — Dental apparatus of the Crustacea —Gizzard of Birds — Teeth of Fishes — Teeth, parts belonging to the mucous membranes - - - - - 1—10

Teeth divided into incisors, tushes, and molars — Application of incisor teeth to the collection of the food — The dental pad of Ruminants — The sense of taste — Connexion between taste and smell — The Stenonian ducts — The Sense of smell in the Pig - - - - - - - - - - 11—16

The tushes not met with in Ruminants — Exceptions, the Camel and Musk Deer — Causes influencing the size of the tushes — Form of the tushes - - - - - - - - 16—19

Molar teeth; their number and varieties — Use of the molars — Division of a tooth — How held in the jaw — Constituents of a tooth — Enamel — Dentine and crusta - - - 19—24

Structure of the enamel — Structure of the dentine — Structure of the crusta — Changes occurring in the dentine of old teeth - 25—35

Formation of the teeth, the papillar, follicular, sacular, and eruptive stages — Provision for the development of the permanent teeth — Formation of the dentine — Formation of the enamel — Formation of the crusta - - - - - - - 35—46

Simple and compound teeth — Development of compound teeth - 47—51

DENTITION OF THE OX.

Causes of the fall of the temporary teeth — Persistency of the temporary incisors — Circumstances promoting the shedding of the teeth — Dentition of the Ox as described by writers — Teeth at birth; incisors and molars — Peculiar form of the third temporary molar—State of the incisors and molars at one month—Six months — One year — Fifteen months — Eighteen months — One year and three quarters — Two years — Two and a quarter — Two and a half — Three years — Three and a half — Four and five years — Table of early and late dentition — Anomalies in the cutting of the teeth - - - - - - 52—80

DENTITION OF THE SHEEP.

PAGE

State of the teeth at birth — Cutting of the temporary incisors and molars — Mr. Youatt's account of the dentition of the Sheep — Incisors and molars at three, nine, twelve, fifteen, eighteen, and twenty-one months ;—two, two and a half, three and a half, and four years — Broken-mouthed sheep — Tables of early and late dentition - - - - - - - 81—97

DENTITION OF THE PIG.

The importance of the subject — Writers on the dentition of this animal — Prevailing opinions — Description of the incisors — Teeth at birth — Temporary incisors, tushes and molars at one month, three, six, and nine months — Premolars mistaken for the permanent tushes—Cutting of the permanent tushes— Causes influencing the development of the tushes — State of the teeth at one year, a year and a quarter, and a year and a half — Condition of the mouth when the tushes are fully developed — Cases of teething —Table of dentition — Concluding remarks 98—118

LIST OF ILLUSTRATIONS.

Figs.		Page
	FRONTISPIECE — The Head of the Ox, Sheep, and Pig.	
1	Incisor Tooth of the Ox -	21
2	Vertical Section of an Incisor of the Horse - - - -	23
3	Enamel cap from the Molar of a Pig - - - - -	24
4	Enamel Prisms - - -	25
5	Section of Dentine and Enamel, showing Tubes passing from one to the other - -	27
6	Dentinal Tubes - - -	28
7	Transverse and oblique Sections of the Dentinal Tubes	28
8	Section of Dentine showing its Lacunæ - - - -	30
9	Vertical section of the Enamel Cup, showing the crusta within it - - - -	32
10	Transverse section of an Incisor of the Horse, showing the conversion of the dentine into crusta - - - -	34
11	Magnified view of altered dentine and crusta - - -	35
12	Diagram of the development of the Teeth - - -	36
13	Vertical section of a Molar of a young Calf - - -	40
14	Vertical section of a similar tooth further developed -	40
15	Structure of the enamel pulp	44
16	Molar of the Calf in the act of cutting - - - - -	45
17	The third temporary Molar of the Calf - - - -	47
18	Transverse section of a Molar —Calf - - - - -	48
19	Vertical section of a Molar —Sheep - - - -	49
20	Transverse section of a Molar —Sheep - - - -	50

DENTITION OF THE OX.

21	Front of the lower jaw of the Ox with persistent temporary teeth - - - - -	54
22	Lower jaw of a Calf a month old - - - - - -	60
23	Section of the lower jaw at six months - - - -	63
24	Incisor teeth at one year -	64
25	Section of the jaw at fifteen months - - - -	66
26	Incisors at eighteen months -	67
27	Incisors at one year and ten months - - - - -	68
28	Dissected lower jaw at two years, showing the temporary and permanent sets of teeth	70
29	Incisors at two years and four months - - - - -	72
30	Section of the lower jaw at two years and a half - - -	74
31	Section of the lower jaw at three years - - - -	75
32	Incisors at three years - -	76
33	Incisors at three years and a quarter - - - - -	77
34	Incisors at five years - -	79

DENTITION OF THE SHEEP.

Figs.		Page
35	Skull of a lamb three months old	84
36	Section of the lower jaw at nine months	85
37	Incisors at one year (temporary)	86
38	Incisors at one year	88
39	Dissected lower jaw at fifteen months, showing the temporary and permanent teeth—incisors and molars	89
40	Section of the lower jaw at eighteen months	91
41	Incisors at a year and three quarters	92
42	Section of the lower jaw at two years	94
43	Incisors at two years and a half	95
44	Incisors at three years and a quarter	97

DENTITION OF THE PIG.

45	Upper and lower incisors as removed from their sockets	101
46	Skull of the pig at birth	102
47	Skull at a month old	102
48	Front of the lower jaw at three months	103
49	Lower jaw, showing the incisors and molars at six months	105
50	Front of the lower jaw at nine months	107
51	Dissected jaw at ten months, showing the temporary and permanent teeth — incisors and molars	109
52	Front of the lower jaw at one year	110
53	Lower jaw,—incisors, tushes, and molars at fifteen months	111
54	Front of the lower jaw at eighteen months	112
55	Incisors, tushes and molars, at eighteen months	114
56	Lateral view of the anterior part of the upper and lower jaw of a Boar	115

THE

DEVELOPMENT OF THE TEETH.

In directing the reader's attention to "the formation and structure of the teeth, and the means which they afford in the progress of their development of ascertaining the age of the Ox, Sheep, and Pig," I may first observe that the teeth belong to the system of organs termed the digestive.

This system is an essential part of the organism of every animal, no matter how low may be the position assigned to it in the scale of animated nature. It is through the digestive organs that materials altogether extern to an animal, but containing the elements necessary for its support, are made to contribute to the maintenance of its life. Hence we have an explanation of the fact, that a digestive system, more or less complex, exists where we can detect no trace of the organs of either respiration, circulation, or even sensation. Endowed with that mysterious principle, life, the impress of the great Creator, the monad and the man alike require sustenance for its continuance. Mere animal life is a common property bestowed equally on all creatures, and therefore dependent on the same laws for its existence.

The invisible world of wonders revealed by the microscope discloses hundreds of creatures, of various forms, in a few drops of water, going hither and thither in search of their food. Some of these Infusoria, as they are called, from the numerous globular cells within them supposed to perform the office of digestion, have been named Polygastrica (many stomachs). Others, of the class, have not only stomachs for the digestion, but organs similar to the gizzard of the bird for the reduction, of their food, while many of them are furnished with a distinct dental apparatus for the like purpose. We may select as examples of the latter the Rotifera, those creatures, the peculiar movements of whose cilia in the collection of their food have obtained for them the common name of the wheel animalcules.

We may ascend the scale to a far greater height, and still find creatures without respiratory or circulatory organs. Take as an illustration the ENTOZOA—those parasitic creatures that live within the bodies of other animals. Select from among these the liver-fluke, the well-known entozoon which abounds in the gall-ducts of sheep affected with the rot, and here we have, as a type of the class, a creature whose systems of digestion and generation are perfect, without any traces of those of respiration and circulation. Self-support seems in the entozoa to be only secondary; the great end of their existence appears to be the extension of their species. They live for this. Their own sustenance, and the perfection of their ova, are alike derived from the elements taken in through their digestive organs. Hence the entire creature seems to be but a generative and a digestive system mingled together, and confined within a certain boundary by an external skin, which gives form and outline to its body. To come to animals still higher in the scale, did the occasion require, it could be shown how system after system of organs is superadded to those alluded to, until at last we arrive at the VERTEBRATA, where all are perfected.

Teeth, or the organs for the bruising and comminution of the food, will be found to occupy different situations among *vertebrate* animals. One rule, however, obtains throughout, namely, that in these creatures they are always placed anterior to the true digestive organ, the stomach. In the INVERTEBRATA, on the contrary, we have many examples of teeth being situated within the stomach. The most familiar of these are the crab and the lobster. The "lady of the lobster" is the true dental apparatus of this creature. The food, on being swallowed, is carried at once to the stomach to be subjected simultaneously to the action of these gastric teeth and of the digestive fluid. Here it is bruised, ground, and finely divided, that it may at the same time be the more easily digested.

In birds we have a provision, somewhat analogous to these gastric teeth of the CRUSTACEA, in the development of a peculiar organ, termed the gizzard. In birds there are no teeth properly so considered, although the beaks of many serve a similar office. The carnivorous birds, which tear their food, and the granivorous, as the parrot, which bruise the seeds of plants, offer us some of the best illustrations of this fact. In the grain feeding birds the gizzard reaches its highest development. In some of these the bills are serrated, and in the mixed feeders

often laminated, but still in neither can it be said that true teeth are present.

The gizzard of the bird is beautifully adapted to the office it has to perform. It is a hollow cavity, the walls of which are composed of two powerful but short muscles, with smaller ones superadded. These muscles are remarkably thick in proportion to their length, and with their tendons are so arranged as to give a grinding or partial rotatory motion to the whole organ. The inner surface of the gizzard is lined with a very dense cuticular membrane, which is thrown into ridges, the better to act mechanically upon the food.

In addition to this arrangement the bird is led instinctively to swallow numerous small pebbles to further assist in the reduction of its aliment. If deprived of these earthy matters, as is well known, the health of the creature will soon suffer, because it cannot extract the same amount of nutriment from its food. It would appear that there is even a greater exercise of the instinctive faculty in the selection of these earthy materials than we might at first suppose. Dr. Crisp, who has dissected numerous birds at the Zoological Gardens, informs me that he has very frequently found one pebble much larger than the others, forming a kind of fulcrum for the smaller to move upon, and thus greatly increasing the mechanical or grinding power of the gizzard.

The food which is swallowed by the bird first enters the crop, where it is retained a short time to be softened by the secretions of this organ. From this receptacle it goes to the gizzard, passing through the *proventriculus*, a short canal which connects the two cavities together, and where the true digestive fluid, *gastric* juice, is produced. Within the gizzard the food is ground down and mixed at the same time with the gastric juice which enters the organ from the *proventriculus* above. After being sufficiently digested and comminuted, it passes onwards into the intestinal canal.

Such, in a few words, is an explanation of the digestive process as we find it in the bird. The gizzard has sometimes been compared to a mill, and the crop to the hopper from which it receives the supply.

It is evident from the preceding remarks that the teeth belong to the membrane lining the digestive canal rather than to the skeleton or bony parts of the frame. To further elucidate this

part of my subject, however, I will add a few observations, of a very general nature, on the teeth of fishes. In this tribe we find for the most part that the teeth are located either upon the membrane of the mouth or at the commencement of the gullet. They are produced by the membrane, and are not, as in mammals, implanted by roots or fangs into distinct sockets in the jaws. When attached to the bones beneath the membrane, which they are sometimes found to be, they are so by distinct ossification of their expanded bases. Occasionally these teeth are few in number, but often they are so numerous as to thickly stud the greater part of the surface of the mouth. As in the mammalian class, the teeth of fishes present many varieties of form, each being suited to the kind of food on which these creatures live. In most fishes the teeth are shed and renewed several times during life. In this respect fishes differ greatly from mammals, as in them there are but two sets, the temporary and the permanent. If torn away, fresh teeth soon arise from the membrane of the mouth of the fish.

Their formation may be thus briefly described:

Projections or *papillæ* spring from the membrane, they become very vascular, increase in size, secrete a layer of osseous matter upon their free surfaces, and are thus converted into true teeth.

This plan is only slightly modified in the formation of the teeth of mammals. These are likewise produced from papillæ which arise from the mucous membrane, and have at first no connexion with the bones. The several stages of their development will hereafter be entered upon. It is sufficient therefore merely to allude to the fact in this place, in order to show the close identity of the two processes.

Many other illustrations in various animals, showing that the teeth belong to the mucous membrane as an internal skin, and not to the skeleton, or bony parts of the frame, might be given. Such, however, are not now required. It must, nevertheless, be stated in explanation that the membrane which lines the digestive and the other canals of the body is but a modified form of the external skin. Vascular and sensitive papillæ are developed on both, and these are protected in either situation by a dense and insensible epidermoid or cuticular covering. The sides of the mouth of the ox and sheep afford striking examples of papillæ growing from a mucous membrane. Long conical shaped papillæ thickly beset these parts, and also the tongue of the ox; having here a covering so

dense as to approach the character of soft horn. On the tongues of the feline tribe the papillæ have true horny sheaths. In the mouths of fishes they have bony, or modified bony coverings, becoming thereby, as before explained, the teeth of these creatures. These gradations are few and easily understood.

Thus we see that teeth, whether situated in the stomach, as in the crustacea; in the gullet, as in fishes; or in bony sockets, as in the jaws of the higher order of animals, are essentially the same in belonging to the membranous parts of the body. The practical bearing of these prefatory observations will be rendered evident when the succession of the first and second sets of the teeth of the ox, &c., is explained.

I now pass on to make some general remarks upon the three kinds of teeth of the Mammalian class, namely—incisors, tushes, and molars.

The names given by anatomists to the teeth are determined more by their situation and function than by their size or form. These names are therefore equally applicable to the first or deciduous, as to the second or permanent set. Several of the illustrations given in these pages will show these different kinds of teeth and likewise their relative positions. We may select fig. 56, page 115, as an example.

The teeth designated incisors are always placed in the front part of the mouth. Their situation here admirably adapts them for seizing the food. In the domestic herbivora, as our most familiar examples of the great family of the graminivora, we see that each animal, more or less, employs the incisors to lay hold of the herbage and to separate it from the roots by a clipping motion of the jaws.

The lips and tongue, as well as the incisor teeth, are used for this purpose, and consequently to a greater or less extent they are organs of prehension.

The horse, when grazing, grasps the herbage with the lips, and thus conducts it between the incisors, which he now employs for the purpose of both holding and detaching it from the roots—the latter action being assisted by a peculiar twitch of the head. The sheep gathers his food in a similar manner. This animal is enabled however to bring his cutting-teeth much nearer to the roots of the plants in consequence of a partial cleavage of the upper lip. Hence the adage, that the "sheep will fatten where the ox will starve." The upper lip of

the sheep, from its peculiar formation, is likewise endowed with considerable mobility, although to a far less extent than that of the horse. It is thin compared with many other animals, and protected from injury to some extent by a covering of hair, existing everywhere except at the place of its cleavage. Like the ox, also, a large amount of fluid is poured from its glandular follicles which thickly beset the hairless parts; and thus, by the moisture with which it is bedewed, it is further guarded from injury.

The ox chiefly uses his tongue in the collection of his food. In him the upper lip is thick and hairless, and has a very limited action. Most ruminants possess a great freedom of movement of the tongue: this is well seen while the ox is grazing on luxuriant herbage. The organ, being protruded from the mouth, is so directed as to encircle a small bundle of grass, which it conducts between the incisor teeth and the dental pad. Here it is cut asunder by the action of the incisor teeth, assisted, as in other animals, with a twitching movement of the head. These several actions of the lips, tongue, and teeth, in taking hold of the food and conveying it into the mouth, are variously modified, being, as we have seen, even more marked in some of our domesticated animals than in others.

The incisor teeth, although always placed in the front of the mouth, are differently arranged in different animals. In the horse and also in the pig these teeth are twelve in number—six being placed in the upper and six in the lower jaw, so that in the act of biting, their faces or wearing surfaces oppose each other. In the ox and sheep, on the contrary, the incisors, which are eight in each of these animals, are all placed in the lower jaw. They are opposed by a dense yet somewhat elastic cushion attached to the upper jaw, which has been named the dental pad (see D. P., fig. 35, page 84). The power of resisting the pressure of the incisors is given to the pad from its being chiefly composed of white fibrous tissue: mingled, however, with this is some yellow or elastic tissue, which gives to it that small amount of yielding, to the force employed, which it possesses. Upon the surface of these structures a capillary network of blood-vessels is laid for the purpose of forming that dense cuticular membrane which is observed to cover the pad in common with the whole of the inner surface of the mouth. This membrane, while it protects the sensible parts within, by resisting, like the cuticle of the true skin, the effects of attrition from without, gives increased firmness to the dental pad.

The existence of this elastic cushion in the place of the upper

teeth is rendered the more necessary in ruminating animals from the peculiar form of their incisors. In common language these teeth may be said to be chisel-shaped in the ox and sheep, especially when first protruding from the gum (see fig. 1, page 21). Besides having broad crowns which are flattened from before to behind, tapering to a sharp cutting edge above (fig. 1, A), the incisors of these animals have also rounded and comparatively small fangs for their size (fig. 1, C). Their fangs are likewise rather loosely implanted in their respective sockets, so that a degree of mobility exists between each tooth and its socket. These peculiarities consequently require a modification of the structures which oppose the incisors in their action. If, as in the horse, they were met with an equal number of teeth firmly attached to the jaw by their fangs, then it is evident that they would be exposed to displacement and early removal from their sockets. In grasping the herbage and detaching it from its roots, the ox can employ just that amount of compression which is needed, and this with perfect safety to the teeth, as both they and the pad yield slightly to the force imparted.

Other peculiarities of these incisors, and the changes which they undergo at different periods of an animal's life, will be explained hereafter when the subject of dentition is considered. It may be here added, however, that the incisors are the same in number, whether we regard the temporary, or milk set as it is sometimes called, or the permanent which succeed them.

Connected with the collection of the food we also see further evidence of design in the arrangement of the parts which are more or less employed in the act. Various plants are known not only to differ with reference to the quantity of their nutrient matters, but to possess properties which are prejudicial to animal life. Such plants as these are, as a rule, instinctively avoided. In the springing up, however, of these noxious plants with a luxuriant herbage, an animal cannot always avoid receiving them with the morsel. Essentially it is the office of the sense of taste to cause the ejection of such matters from the mouth, that they may not enter the system and exert their baneful influences.

Substances, however, vary considerably in the impressions they produce on the sense of taste, some being nearly insipid, although prejudicial to the animal economy. The sense of taste is intimately connected with that of touch and no less so with that of smell. Dr. Carpenter, writing of the sense of smell, observes,

that "a considerable part of the impression produced by many substances taken into the mouth, is received through the sense of smell rather than through that of taste. Of this any one may easily satisfy himself, by closing the nostrils and breathing through the mouth only, whilst holding in his mouth, or even rubbing between his tongue and his palate, some aromatic substance; its taste is then scarcely recognised, although it is immediately perceived when the nasal passages are re-opened, and its effluvia are drawn into them. There are many substances, however, which have no aromatic or volatile character, and whose taste, though not in the least dependent upon the action of the nose, is nevertheless of a powerful character. Some of these produce, by irritating the mucous membrane, a sense of *pungency*, allied to that which the same substances (mustard, for instance) will produce when applied to the skin for a sufficient length of time, especially if the epidermis have been removed. Such sensations, therefore, are evidently of the same *kind* with those of touch, differing from them only in the *degree* of sensibility of the organ through which they are received. But there are others which produce sensations entirely different from any that can be received through the skin, and which are properly distinguished, therefore, as *gustative*; such are common salt, which may be considered as a type of the saline taste; sugar, the type of the saccharine; quinine, of the bitter; tannin, of the astringent; and citric acid, of the sour. All such substances, therefore, are said to possess *sapid* properties, exciting distinctive tastes, quite irrespectively of any aromatic or odoriferous properties which they may also possess, as well as of their stimulating action on the skin."*

It is evident that while plants are being compressed between the teeth and the dental pad of a ruminant, their odoriferous as well as their other properties, affecting either touch or taste, would be most likely to be recognised. If insipid, the poisonous plant might be swallowed. Such plants, however, are not wanting *both in smell and taste.* To provide therefore for their odoriferous particles reaching the seat of smell, is one of the offices, at least, of certain ducts which we find forming a communication between the mouth and the nostrils of the ox, and sheep as well as in some other animals. These ducts, which are two in number, have been called the Stenonian, after Steno their discoverer. They pass from the mouth into the nostrils, one on

* Carpenter's Manual of Physiology, second edition, p. 581.

either side of the median line of the palate, having between their oral openings a peculiar shaped elevation of the mucous membrane. The form and also the size of this body are found to vary in our domesticated animals. In the ox it is lozenge-shaped, but in the sheep it has a triangular form the base of which may be said to rest upon the dental pad, and its apex to extend backwards towards the soft palate.

Thus we see that the Stenonian ducts open very contiguous to the bearing of the incisor teeth upon the dental pad, thereby effectually securing the passage of such odours into the nostrils as belong to the several plants on which the animal may be feeding. I am not aware that any anatomist has described similar openings as existing in the pig; there are, however, communications equally as direct between the mouth and nostrils in the pig as in the ox and sheep. The ducts of Steno are connected with *cul de sacs*, called sometimes Jacobson's organs; but these it is not now necessary for me to describe.

How much of the care in the selection of his food by the pig may depend upon the existence of this connexion between the organs of taste and smell cannot be ascertained. The pig is doubtless a filthy feeder, but that he is less so than is generally supposed will be apparent from the following quotation from Youatt's Work on the Pig:—"Roots and fruits are the natural food of the hog, in a wild as well as in a domesticated state; and it is evident that, however omnivorous this animal may occasionally appear, its palate is by no means insensible to the difference of eatables, for whenever it finds variety it will be found to select the best with as much cleverness as other quadrupeds." "In the peach-tree orchards of North America," says Pennant, "where hogs have plenty of delicious food, they have been observed to neglect the fruit that has lain a few hours upon the ground, and patiently wait a considerable time a fresh windfall."

"According to Linnæus, the hog is more nice in the selection of his vegetable diet than any of our other domesticated animals. They are gifted with an exquisite sense of smell as well as touch, residing in the snout, and this enables them to discover roots, acorns, earth-nuts, or other delicacies suitable to their palates, which may be buried in the ground. In some parts of Italy swine are employed in hunting for truffles that grow some inches below the surface of the soil, and form those pickles and sauces so highly esteemed by epicures. A pig is driven into a field and

there suffered to pursue his own course. Wherever he stops and begins to root with his nose, truffles will invariably be found."*

With these remarks on the uses of the incisors in the collection of the food, I pass to the tushes.

The teeth called the tushes occupy a position immediately behind the incisors and in front of the molars. More or less space exists between the incisors and the tushes, as also between them and the molars. This interruption to the regular order of the series may be taken as a characteristic of the inferior animals. In man the row is continuous, besides which the canine teeth are so reduced in size as not to stand above the level of the others. In the order Quadrumana, which approach nearer in the general development of their organs to man than any other creatures, these canine teeth are largely developed and rise considerably above the incisors and molars. This is even the case with the adult Chimpanzee, an animal standing at the head of the Quadrumana.

The tushes are always large in the flesh-feeding animals, and are evidently here used for lacerating and tearing the prey. Upon the whole, however, these teeth serve but little in either the collection or reduction of the food, and consequently we must regard them chiefly as weapons of offence and defence. As in some creatures they are developed to a greater extent than in others, so, as we should expect, seeing the infinity of both the number and variety of the mammalian order of animals, many are entirely destitute of these teeth. This is the case with the ox and sheep, and with ruminating animals as a family or tribe. There are however some notable exceptions to this rule. One of these we find in the camel, an animal whose usefulness to man has won for him the title of "the Ship of the Desert."

In this creature, the skull of which is now before me, we find in front of the lower jaw eight teeth standing tolerably close to each other. Six of these have wide, spreading crowns and contracted fangs, which give to them a character not very unlike that of the incisors of the ox and other ruminants. Two, however, the most posterior placed of the series, and which are removed a short distance from the others, agree in shape with the tushes of the horse. According to the definition of modern anatomists these teeth are true tushes. This arrangement giees the camel but six instead of eight incisors in the lower jaw, the typical number of the order Ruminantia. If we look to the anterior part of the upper

* The Pig, p. 24.

jaw of this animal, which is toothless for the most part in ruminants, we also find two well developed tushes. Besides these there are two other teeth, whose situation claims for them the appellation of incisors, being in front of the tushes, in fact occupying the very position of the corner incisor teeth of other animals. Placed in the long spaces between the molars and the tushes we find in addition a tooth on either side, which is the analogue of the *supernumerary* molar of the ox and sheep.

The camel thus offers a remarkable difference in its dentition from other domesticated animals.

In proof of the correctness of the names given to these separate teeth, I may remark, in the language of Professor Owen, that "those teeth which are implanted in the premaxillary bones (see fig. 46, F. I., upper jaw, page 102), and in the corresponding part of the lower jaw, are called incisors, whatever be their shape or size. The tooth in the maxillary bone, which is situated at or near to the suture with the premaxillary, is the canine (F. I., upper jaw, fig. 46); as is also that tooth in the lower jaw which, in opposing it, passes in front of its crown when the mouth is closed."*

Besides the camels, the llamas and musk deer have also canine teeth in the upper jaw. In the Memina musk deer and others of the same class the tushes are so long as to protrude from the mouth, curving downwards and backwards with an elegant sweep. In one variety, an animal called by Cuvier the Kanchil, proverbial both for its swiftness and cunningness, it is said, "that when closely pursued by dogs the creature will sometimes make a bound upwards, hook itself on a branch of a tree by means of its crooked tusks, and there remain suspended till the dogs have passed beneath."†

To return to the animals of whose dentition I have principally to speak:—In the pig we find the tushes, when fully grown, to be of large size. These teeth, however, vary considerably in their development in different animals of the *same* species, and perhaps quite as much so, as they are found to vary in animals of *different* species.

Among the modifying causes of the magnitude of the tush as we find them in the pig, I may mention breed. The larger and coarser the breed, and the fewer the attempts that have been made to improve it, the greater will be the size of the tush.

* Clyclopædia of Anatomy and Physiology, vol. iv., p. 903.
† Animal Kingdom, vol. iv., p. 65.

Although these things will come more especially before us when the dentition of the pig is entered upon, it may be here added, that few causes have more influence over the dimension of this tooth than sex. Compare the tush of a sow with that of a boar when it has reached its full extent in both animals, and it will be seen that in the sow the tooth is but a miniature portrait of the other.* As would be supposed from this, it is in entire animals that we meet with the largest tushes. Castration limits the size of these teeth, and prevents their being developed to the same extent they otherwise would be. This operation brings the tooth of the male pig to a size more corresponding with that of the perfect female.

The further influence of sex upon this tooth is shown by the fact that the males alone in some classes possess it. We may take the horse as an example. Persons, who profess to a great deal of horse knowledge, will often tell you that they can distinguish the sex of this animal by going to the head in the dark. This judgment is drawn from the existence or otherwise of the tush. They are not, however, absolutely correct in saying that the mare is without this tooth; as a rule she wants it, but there are numerous exceptions. When present the tooth is always small in the mare. It is in the horse also that we meet with another exception with regard to the tushes as applying to animals in general, namely, that they are not preceded by deciduous teeth. These teeth appear above the gums, usually between the fourth and fifth years of the horse's age, and should they fall by accident or otherwise, they are not renewed.

The part of the tush which protrudes above the gum is more or less cone-shaped in all animals. Sometimes it terminates in a tolerably sharp point, at others its apex is rounded; this is more particularly the case with the upper tush of the pig. The embedded portion frequently is but a counterpart of the protruding as to form, and consequently when the tooth is fully developed, its largest part is that which is embraced by the gum.

In the pig and his congeners, the greater portion of the tush which is implanted in the jaw is but a continuation of the base of the cone.† The deeper or further the tooth extends, until its

* Fig. 56, page 115, gives a representation of the tushes of a boar of full size.

† It is necessary to state that these remarks apply especially to the tushes of the lower jaw.

final length is *nearly* acquired, the larger does it become. When its dimensions, however, have been fully reached, we have then a slight diminution of the end of the fang, approaching again the conical form. The height of the protruding part will often give but a very imperfect idea of the entire length of the tush. In a specimen now before me, from a pig of ten months of age, the tooth measures more than three inches and a half long, while the portion which had penetrated the gum is less than half an inch in length. This explains how it is that the tush in time so far exceeds the other teeth in the height it attains. It is also to be remembered that, long after the period of the animal's life which has been named, the tush continues to grow, from its persistent dentinal pulp. To provide for this increasing length, the tooth is curved so as to form the segment of a circle, having its embedded part lying below the fangs of the anterior molar teeth, and occupying thereby far less space in the jaw than otherwise it would do.

I pass to a general description of the molar teeth.

The molars, or, as they are commonly called, the grinders, are placed at the back part of the mouth. In the ox and sheep, the permanent molars, when completed, are twenty-four in number, as in most animals. They are arranged in sets of six on either side of the upper and lower jaws, as seen in fig. 35, page 84.* The *temporary* molars, on the contrary, are only twelve; they occupy a like situation, and give place in due time to an equal number of permanent, twelve others being added to complete the set.

Occasionally, in all animals, supernumerary molars are present. These are always placed, one on either side, in *front* of their respective rows, and are very small in size compared with the other teeth. So frequently do these additional teeth exist in both jaws of the pig, that we are in the habit of speaking of this animal as having twenty-eight molars.

The molar teeth of the ox, sheep, and pig increase in bulk from before backwards, while, on the contrary, in the horse they diminish in the same direction. This is especially seen in the molars of the lower jaw. The last permanent molar in the *lower* jaw of both the ox and sheep differs from the others in having three lobes or principal parts united together in the place of two.

* This figure is referred to simply to show the relative position of the molar teeth. It represents the skull of a three months old lamb, and as such, but four molars are seen above and below.

These peculiarities will be fully described hereafter. In the upper jaw this difference is not observed, the tooth varying not essentially in its form from those that stand before it. In the pig, the last molar teeth in *both* jaws are similarly formed, being trilobular, and far exceeding in size any of the others.

The office of the molar teeth is that of reducing the food to a pulpy mass by grinding it between their faces. It is this process which is called mastication. The aliment, being received into the mouth, is conducted, by the movements of the tongue, upon the molar teeth, and while being ground down, it is mixed with the saliva and other fluids found in the mouth: in other words, it is both masticated and insalivated, each of these processes being of the first importance to healthy digestion and consequently to the well-being of the animal. It is, however, only in the vegetable feeders, the herbivora, that we see the perfection of the grinding movement. In the omnivora the action is very limited, while in the carnivora it does not exist at all, the molar teeth being in this class used simply for crushing.

The different effects of the molars upon the food in different animals mainly depend upon the manner in which the lower jaw is united to the upper. The joint forming the union is modified in the herbivora so as to allow of a lateral movement of this jaw. It is a less perfect and less restricted hinge joint than in the flesh feeding class.

Among vegetable feeders the movements are also varied. We see this in comparing the ox with the horse. In the ox, the mouth being slightly opened, the lower jaw is first moved to one side, next elevated so as to approximate the faces of the upper and lower row of molars, and then carried in the opposite direction, bruising the food between them. Should this action, which depends on the will of the animal, be so commenced as to carry the jaw from right to left, it will be thus continued, or *vice versâ*. In the horse, on the contrary, the jaws are not separated from each other to the extent they are in the ox, and the food is ground down by an alternate movement of the lower jaw from side to side.

To secure an irregular surface upon the face of the molars, which is necessary for the complete grinding of the food of herbivorous animals, we find that the three constituents of a tooth, *enamel*, *dentine*, and *crusta*, are so arranged as to enter into the interior of the organ and to be all exposed to wear at the same time. These constituents differ, as hereafter will be shown,

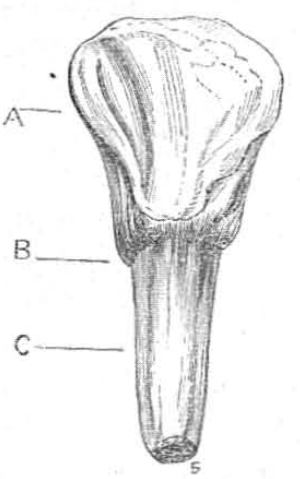
in the amount of their relative hardness, and therefore in their power to resist attrition. Hence we see that a simple, but nevertheless an effectual, provision is made by which the roughened surface becomes persistent. Such teeth are called compound, to distinguish them from those designated simple teeth, which have their external surfaces only covered with enamel. In the carnivorous animal, as the dog, and in the omnivorous, as the pig, we find simple teeth; but in herbivorous, as the ox, compound teeth, in so far as the molars are concerned.

The most familiar example we can give of a simple tooth is an *incisor* of the ox or sheep. The molar teeth of the pig might, perhaps, from their size and irregular wearing surfaces, be thought to be compound; they are, however, of the same description as the incisors and tushes of this animal. I refrain from adding to these remarks respecting the two classes of teeth in this place, as the peculiarities of each, in so far as they have a practical bearing on the subject of dentition, will be hereafter explained.

To proceed. Not only are the teeth classed as incisors, tushes, and molars, but each tooth of itself is divided into different parts. The annexed engraving, *fig.* 1, gives a view of a perfectly-formed *permanent* incisor of an ox, removed from the jaw just as it was about to be cut. The "chisel form" of the tooth, as a whole, is very apparent.

The several parts into which a tooth is divided are its *crown*, *neck*, and *fang*. These are well seen in the example before us. The crown is the broad or expanded portion above, marked A. It is that part which is exposed to wear. Sometimes it is called the body of the tooth, from its constituting, in many animals, the main bulk of the organ. It will be observed that the crown gets thicker and narrower as we approach the neck—a circumstance which explains the alteration in the shape and size of a worn incisor of the ox, when compared with one recently cut. The neck is the contracted part marked B. It is

Fig. 1.*



* Fig. 1. A perfectly developed permanent incisor of an ox. A, the crown; B, neck; C, fang. Natural size.

the point of junction between the crown and the fang. In no teeth that I am familiar with is the neck so well marked as in the incisors of the ox.

Usually, when a tooth is fully up, the gum is said to embrace its neck, and thus to assist in keeping it in its place. In the progress of a tooth rising from its socket, the gum, however, will encircle different portions of it. Thus, in the case before us, when the tooth is first cut, the gum embraces the crown; when further advanced, it surrounds the neck; still further, and we find it around the upper part of the fang.

The lower portion of a tooth, as has just been explained, is called its fang; marked c in the figure. It is that part which is implanted in the socket (*alveolus*), and by which the tooth is mainly held in its situation. The fangs of teeth vary considerably. Sometimes they are single, at others double, and not unfrequently treble. We see these varied forms chiefly in the molar teeth. The incisors and the tushes have single fangs as a rule; occasionally we find, however, that the fangs of a tush are bifid, as in the upper one of the pig.

The firmness of the union between a tooth and its socket is much influenced by the form and as well as the number of its fangs. The incisors of the ox are so loosely imbedded, that, as has been before stated, a degree of motion can always be detected between the tooth and its socket, and the same thing is observed in the sheep. This looseness increases with increasing age from the circumstance that the tooth is less deeply imbedded than before, and also that the lower part of the fang is rounder than the upper. This is not the case with the pig, the fangs of the incisors being both square in form, and deeply inserted in the jaws. The implantation of a tooth in its socket, being similar to that of a nail in a piece of wood, has been called a union by *gomphosis* (from γόμφος, a nail).

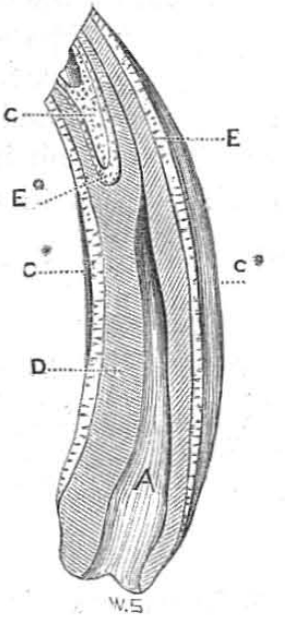
It should be observed that the terms used in dividing a tooth into its crown, neck, and fang, are to a considerable extent arbitrary, as well as the statement of the crown being above or without the socket and the fang within it. Three-fourths of the body of a molar tooth of the horse, ox, and sheep are often imbedded in the socket. Some of these molar teeth are all but fangless, although perhaps they may be from one to two inches long, even in an animal as small as the sheep. This great length is in fact produced by their body, and such teeth cannot strictly speaking

be said to have any neck, certainly none where they are embraced by the gum. The incisors of the horse and the pig, more particularly those belonging to the lower jaw, are similar examples of teeth wanting necks. (See figs. 2 and 45.) This observation will likewise apply to the tushes.

Three kinds of structure unite to form the solid part of a tooth, whether it belongs to the division called simple or to that termed compound. These structures, which partake more or less of the character of bone, are designated *enamel*, *dentine*, and *crusta* or *cement*. They vary considerably in hardness and consequently in their power to resist attrition, a circumstance which has been previously alluded to. *Enamel* is by far the hardest of the three, and therefore we find it existing as a kind of cap to a simple tooth, but entering more or less deeply into the body and flanking the sides of a compound one. (See figs. 3, 13, 14, and 19, pages 24, 40 and 49.) *Dentine* holds the second place in the order of hardness, and *crusta* the last. The cause of these differences of density and the advantages springing therefrom will appear by-and-by.

In fig. 2, which represents a vertical section of an incisor of the horse, we have exhibited the relative amount as well as the situation of each of these constituents. The enamel is marked E; the dentine, D; and the crusta, C. This tooth is, truly speaking, a compound one, in as much as the enamel, besides forming the lateral boundary to the dentine, descends in a cup-like form into the upper part of this structure. The crusta is found filling this enamel cup, and when discoloured by the secretions of the mouth and the juices of the plants on which the animal feeds, it constitutes "the mark" by which the age of the horse is partly ascertained. Professor Owen, in his description of the incisor of the horse, says that "a *layer* of cement is reflected into the deep central depression of the crown, and that a coloured mass of *tartar* and *particles of food*, which fill up the cavity, form

Fig. 2.*



* Fig. 2. Vertical section of an incisor tooth of the horse. A, pulp cavity; D, dentine; E, enamel; C*, enamel cup; C, crusta filling the cup; E*, crusta covering the enamel. Natural size.

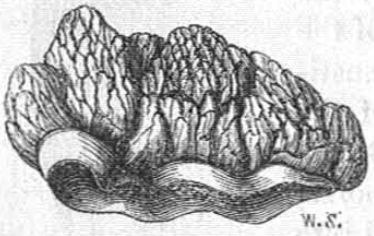
'the mark' of the horsedealer."* It is, however, blackened crusta, and not tartar, which produces the mark, as has been just explained.

A similar thing is observed in the *molars* of the ox and sheep; these teeth being almost always blackened on their sides above the gum, where a layer of crusta exists.

The central portion of a tooth (A, fig. 2) is hollowed out to receive the pulp from which the organ chiefly derives its nourishment. The size of this cavity depends upon the age of the tooth. It is always large in a young tooth, becoming gradually smaller as age advances. The pulp cavity is bounded by the dentine, D, which makes up the chief part of the organ. Before, however, directing further attention to this cavity, I shall describe the special characters of the hard parts of a tooth. First, of the enamel:

On inspecting an incisor tooth of an ox, as an example, we observe that a white incrustation, having in the young subject more or less of a pearly appearance, covers the crown of the tooth. This is the enamel. If the tooth should have been recently put up this substance forms also its cutting edge. It is thicker on the front surface of the crown than on the back, an arrangement which tends to keep up a sharp edge to the tooth. It extends also downwards to the neck, where it suddenly ceases. It is harder and more compact than the dentine, and has as much, according to the statements of our most celebrated chemists, as 96 or 98 parts of earthy matter in every 100. The enamel not only covers the exposed surface of a tooth, but in some teeth it enters deeply into their interior. It matters not what may be the shape or size of a tooth, or how numerous its projections, the whole of these are originally covered with a layer of enamel. In many teeth these projections, technically called *cusps*, are very numerous. They are seen most to advantage in teeth which have been recently cut. Fig. 3 gives a view of a cap of enamel as removed from the sixth molar of a pig on the eve of its appearing through the gum. Its irregular surface admirably adapts it for the comminution of the food.

Fig. 3.†



* Cyclopædia of Anatomy and Physiology, vol. iv. p. 867. The italics in the extract are our own.

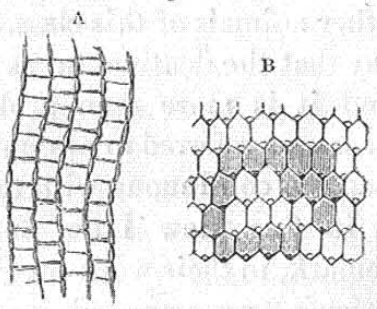
† Fig. 3. Enamel cap of the sixth molar of a pig removed from the jaw just prior to the tooth being cut. Natural size.

When viewed microscopically with a magnifying power of 400 to 500 linear, enamel is found to consist of an assemblage of rods or bars lying side by side, and piled also in layers the one above the other proportionate to the thickness of the specimen under examination.

These rods have been named the enamel prisms or fibres. They are evidently the structures upon which the hardness of the substance depends. In different parts of a tooth the fibres are somewhat differently arranged, but they are always placed endways upon the surface of the dentine on which they rest. On the apex of the crown the prisms proceed directly upwards, but they incline a little on its sides, becoming more and more oblique as they approach the neck of the tooth. Between each bar, and running parallel with its course, a minute canal can be detected in very recently-formed enamel, seemingly produced by the membranous walls of elongated cells which have coalesced to form the prism. The shape of each prism has been differently described by anatomists, but the commonly-received opinion appears to be that they are hexagonal in form. The figures which are added to assist this description show this form, but after repeated investigations, I have by no means satisfied myself of its positive correctness. They seem to me to be rectangular in shape, and slightly flattened.

Fig. 4, A, shows the prisms as a single layer; and it will be observed that, besides the minute canals between them, each prism is crossed by lines which are in some places double, representing connecting cross passages. In our best works on structural anatomy, these lines are also said to be produced by the walls of united cells. I think, however, that this point requires further investigation. I have often examined enamel which has been very recently deposited on a *forming* tooth, and have then failed to see any crossings on the separated bars,

Fig. 4.*



* Fig. 4. Structure of enamel after Retzius, somewhat modified. A, vertical section showing the enamel prisms with their interposed canals. B, transverse section showing the *supposed* hexagonal form of the prisms with the openings of the canals. Magnified 500 diameters.

although these are to be observed in the structure when viewed in section after the ordinary manner.

To the description of these bars being placed endways on the dentine, it should be added that their course outwards is not perfectly straight, but slightly waving, as shown in fig. 4 A. I am inclined to think that the separate layers of enamel at times decussate, and that this explains the well-known circumstance, that brown spots of irregular outline are observed in this structure when examined with a low magnifying power. The hexagonal appearance (fig. 4, B.) which is only seen here and there in thin sections of enamel, I have also thought might depend on an oblique cutting of a superimposed layer of the prisms, or perhaps upon the decussation of these layers.

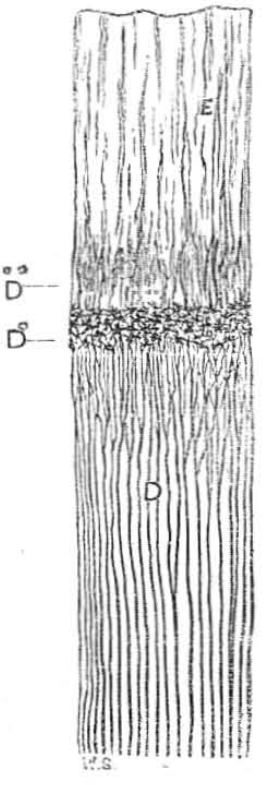
It may naturally be asked what is the use of the minute canals existing between the prisms? A solution of this query is probably found in looking to the situation of the enamel in compound teeth. In them, as has been stated, this structure dips inwards forming cups of greater or less depth in different teeth, and which are always filled with crusta (see figs. 2, 9 and 19, pages 23, 32 and 49). On the slightest reflection we perceive that the *crusta here placed* can only receive the fluid necessary for its support, through the layer of enamel which is interposed between it and the dentinal tubes (fig. 9), and there seems to be no reason to doubt that the tubes, from the boundary of the dentine, may extend to the canals between the prisms, and thus supply the materials of nutrition to the crusta within the cup. Mr. Tomes many years since drew attention to the fact that dentinal tubes passed in great numbers into the enamel in the kangaroo, and other animals of this class. From my own examinations I can also say that the dentinal tubes penetrate the enamel in the herbivora; and it is more than probable that in *consolidated* enamel the passages referred to are united with these dentinal tubes, and thus become continuous with them.

In this view I am supported by Todd and Bowman, who remark, in their work on Physiological Anatomy, that the enamel prisms "are arranged in the most suitable manner for percolation by the fluids derived from the dentinal tubuli. These tubuli indeed may be seen to communicate directly with the interstitial passages of the enamel."*

* Physiological Anatomy, part iii. p. 172.

In the annexed engraving, fig. 5, is given a representation of the dentine and enamel in which it is evident that tubes are permeating the latter, and that they are connected with those in the dentine. The illustration was taken from the tooth of a horse, and the part here shown is magnified 200 diameters. In the fig. the dentinal tubes, marked D, are seen to be passing to the dentinal *lacunæ*, D* (small hollow spaces), which have other tubes, D**, arising from them and running into E, the enamel.

Fig. 5.*



To proceed to the structure of the dentine. This substance makes up the great bulk of both the body and fangs of a tooth. It is that which gives form and size to the organ, and upon which its hardness mainly depends. In the interior of the dentine we meet with a cavity of large size compared with the dimensions of the tooth, and more particularly of one recently formed. From containing a red and pulpy mass, composed chiefly of blood-vessels and nerves, interposed with cells and filamentous tissue, designated the tooth pulp, this cavity has been called the pulp cavity. It is from the pulp that the tooth receives sensation as well as its greatest supply of fluids, which are derived from the blood, for its nourishment. Entering the cavity from below and being bounded on all sides with dentine, the pulp is secured from injury. Thus rude pressure can be borne by a tooth without the pulp being damaged: a simple but effectual provision to maintain the vitality of the organ. (See A, figs. 2, 13, and 14, pages 23 and 40.)

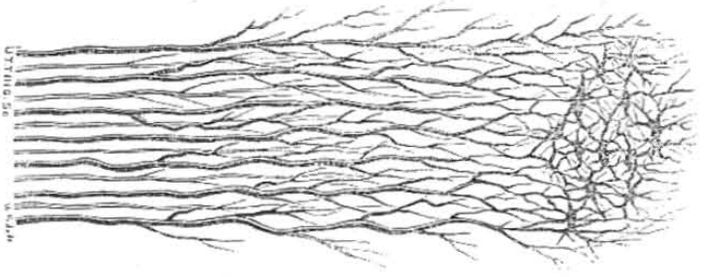
Dentine approaches very near to the enamel in its density; and its chemical analysis shows that there is but little difference between these structures. According to the analyses of Berzelius and Bibra, the dentine of human teeth consists of 28 parts of animal, and 72 of earthy matter, the latter being somewhat less in quantity in every 100 parts than in enamel.† When examined micro-

* Fig. 5. Section of enamel and dentine, magnified 200 diameters. D, dentinal tubes; D*, dentinal lacunæ; D**, tubes extending from the lacunæ into E, the enamel.

† Quain and Sharpey's Anatomy, vol. ii. p. 974.

scopically dentine is seen to be composed of an intertubular substance, and of numerous tubes which radiate from the pulp cavity towards the periphery of the structure. In fig. 6 we have a view

Fig. 6.*



of these tubes magnified 400 diameters, and which, like many other of the illustrations contained in these pages, has been taken from the tooth of a sheep.

In fig. 7, A represents the tubes, similarly magnified, as imbedded in the intertubular substance, and cut transversely; and, B, when they are cut obliquely.

Examined with transmitted light, these tubes always appear of a dark colour, a circumstance which has been variously accounted for. Some suppose that it depends merely on their walls being more opaque than the surrounding intertubular substance.

Fig. 7 A.†

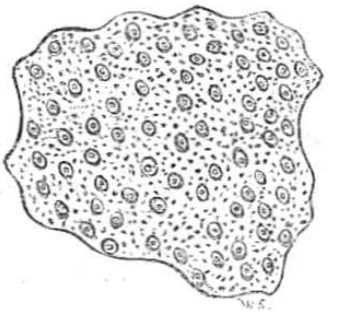


Fig. 7 B.‡

In this particular these dentinal tubes agree with hair, which has usually a dark central line running from the root to the point, and marking the seat of its inner tubular or cellular portion. It should be observed, however, that all the hairs even of the same animal are not cellular. Some are without this structure, and as such they are *naturally* transparent; while others possessing it

* Fig. 6. Dentinal tubes ending in lacunæ, sheep, magnified 400 diameters.

† Fig. 7 A. Transverse section of dentine magnified 400 diameters, showing the tubes and the intertubular structure. After Todd and Bowman, slightly modified.

‡ B. Oblique section of dentinal tubes magnified 400 diameters. After Hassall.

are on the contrary opaque. These latter named hairs can however be rendered transparent by immersion in fluids which will penetrate the walls of the cells composing their tubular portion.

The true tubular character of dentine is likewise shown by immersion in different fluids, which can be seen passing along the tubes displacing the air they may contain, and removing their opacity.

The dentinal tubes, at their openings from the pulp cavity, are larger in size than elsewhere; and according to Retzius, their average diameter near to the cavity is $\frac{1}{4500}$ of an inch. The distance between each of them, at the same place, is about twice that of their diameter.

The direction of the tubes varies considerably in different parts of the tooth. Those which come immediately from the superior part of the cavity take a vertical course; those which arise a little removed from the apex pass obliquely upwards, terminating on the borders of the structure with a gentle curve outwards and downwards; those springing from the sides and lower parts have a direction almost horizontal; while in some teeth the tubes proceeding from the most inferior part of the pulp cavity are seen to pass immediately downwards.

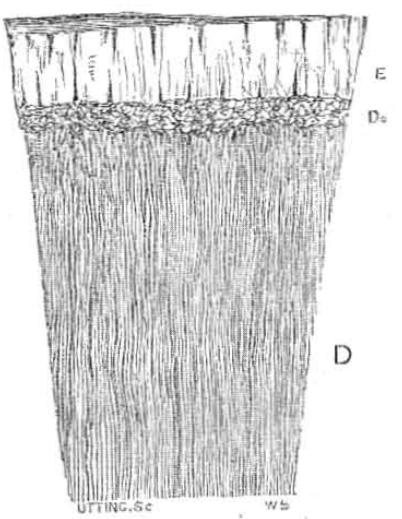
Towards the terminal portion of the fang the dentinal tubes, in some animals, of which the sheep is an example, are often collected into little bundles, having between them a comparatively large space, which is occupied with the intertubular structure. The tubes thus compacted together run towards the periphery of the dentine, before reaching which, however, they suddenly disperse, pursue their course at regular distances from each other, and end in the ordinary manner. As this is only seen in some teeth, it is probable that it may depend on an interruption to the regular formation of the dentine from either local or constitutional causes.

In their course the dentinal tubes always describe two or three bends or curves; besides which each tube is more or less wavy of itself. The former of these bendings have been called the *primary*, and the latter the *secondary curvatures*, by Professor Owen and other writers on the structure of the teeth. Besides this, it has to be remarked, that each tube splits into several branches. Usually, its first division is into two. These by further separation become exceedingly numerous, their size diminishing with each division, till at length many of them terminate in immeasurably fine and inosculating branches. In some animals, however, as seen in the

annexed figure of a section of dentine and enamel from the sheep, the tubes for the most part end in minute cavities (*lacunæ*). From these cavities *tubuli,* as previously stated, pass into the enamel or the crusta, whichever of these structures may happen to be the covering to that particular part of the dentine. The whole of this arrangement is beautifully adapted to carry nutrition to every part of the tooth. In the illustration (fig. 8) the dentinal tubes are marked D ; the lacunæ, D * ; and the enamel, E.

The *intertubular* substance is tolerably transparent, and according to Mr. Tomes is finely granular. Both it and the walls of the tubes contain the earthy matter of the dentine.

Fig. 8.*



I proceed to speak of the crusta, the third constituent of a tooth. This substance approaches nearer to ordinary bone in the arrangement of its component parts than does either the dentine or enamel. It also resembles bone both in its chemical composition and in its density, and hence it is frequently designated the bone of the tooth. The proportionate quantity of crusta to the other constituents depends upon the kind rather than upon the size of the tooth. For example, in a simple tooth very little is present, but on the contrary in a compound one, a good deal of crusta exists. This difference arises from the circumstance that the crusta, in a simple tooth, is met with chiefly on its fang, while in the other variety it not only covers the fang but dips deeply with the enamel into the interior of the organ.

* Fig. 8. Section of dentine and enamel, from an incisor of a sheep, magnified 100 diameters, showing the tubes ending in lucunæ. D, dentinal tubes ; D*, lacunæ ; E, the enamel.

Existing on the fangs of the tooth, and being covered here by a membrane which also lines the socket in which it is placed, the crusta helps to retain the tooth in its situation. When examined microscopically the arrangement of the component parts of the crusta is observed to differ considerably from that of the dentine or enamel. It is more or less thickly filled with bone cells (*lacunæ*) from which radiate minute canals, called therefore the *canaliculi*. (See fig. 11, page 35.) Besides these canaliculi the crusta has, and in our domesticated animals in particular, numerous passages opening on its external border where it is in contact with the lining membrane of the socket, after the manner of the opening of the dentinal tubes into the pulp cavity.

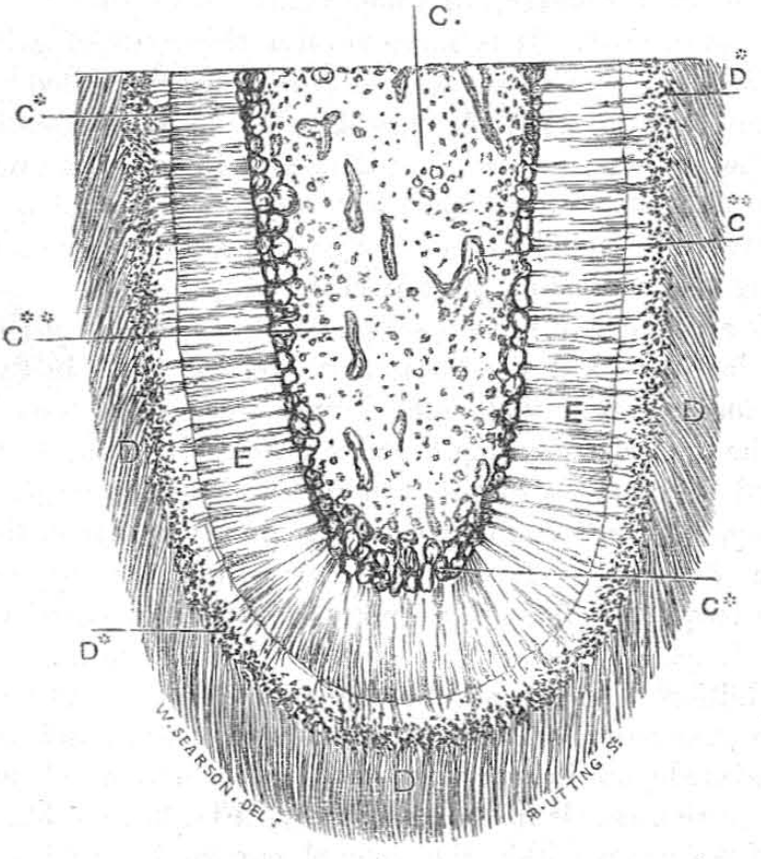
This arrangement is well seen in sections *even of young* teeth, particularly those of the horse and pig, and it distinctly proves that a tooth, even at that time, derives some of its nourishment from the parts surrounding it in its socket. In young teeth these external tubes are situated principally about the upper part of the fang, as it is here that the crusta, from the greater thickness of the dentine, is furthest removed from the pulp cavity, and consequently from the more common source of nourishment. These things will have again to be referred to.

In addition to the lacunæ, their canaliculi, and the external order of tubes, the crusta has also numerous passages within it of larger size, and analogous in every respect to those which have been called the Haversian canals in ordinary bone. Fig. 9, page 32, gives a view of the crusta within the enamel cup of the incisor of the horse, in which such canals abound. The illustration also shows the terminations of the dentinal tubes around the cup. The letter C applies to the crusta as a whole; C** to the Haversian canals; and C* to a series of cells which are in direct contact with the enamel; D to the dentine; D* to the dentinal lacunæ; and E, to the enamel, which it will be noticed is thickly traversed with tubes passing from the dentinal lacunæ to the cells in the crusta. It is a somewhat singular circumstance that the crusta filling these enamel cups, invariably has more numerous Haversian canals and fewer canaliculi than that covering the fangs. Compare fig. 9 with fig. 11.

The principal object in these explanations of the microscopic characters of the constituents of a tooth being to show the manner in which it derives its nutrition, I venture to detain the reader by some further remarks on the crusta. It needs hardly to be stated

that upon the due supply of nutritive materials to the teeth, so will their integrity be preserved, and they thus be kept fitted for their important office.

Fig. 9.*



If teeth die in their sockets, they would greatly impair the health of the animal, from his incapability of properly masticating the food, as also from the suffering he would endure. The diseases of the teeth of animals and the causes leading to them has certainly not as yet received all the attention which the importance of the subject merits. Many cases might be cited to show this, but on the present occasion I must refrain from adding to these observations, although they may have a very practical bearing.

To return to the crusta. On the fangs of teeth recently cut, but little of this substance is met with, when compared

* Fig. 9. Vertical section of the enamel cup of the incisor of the horse, filled with crusta and bounded by the dentinal tubes ending in lacunæ, from which tubuli are seen to pass through the enamel to the crusta. C, crusta; C**, Haversian canals in the crusta; C*, cells lying in apposition with the enamel; D, dentine; D*, dentinal lacunæ; E, the enamel. Magnified 100 diameters.

with that existing on old teeth. As age advances, however, the crusta increases. Hereafter it will be shown how this and the other structures are originally produced. It may, nevertheless, be now asked how the increased quantity upon an old tooth is accounted for? Is the crusta always added to from the original source of its production, or can it be otherwise augmented? I answer that it frequently receives an addition altogether independent of its original source. As this is a novel view of the subject, in order to show its correctness, I must direct the reader's attention to two illustrations, figs. 10 and 11, taken from specimens in my possession.

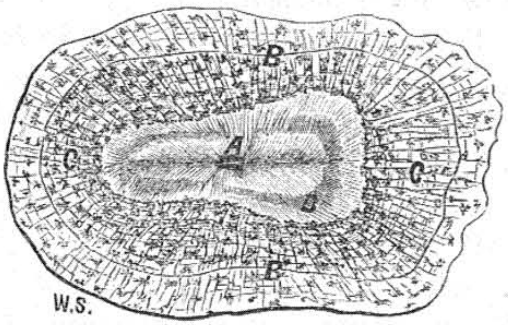
I premise the explanation of this matter by stating that anatomists are generally agreed that after a given time the pulp ceases to produce any more dentine, and becomes converted by *ossification* into a substance which Professor Owen has designated *osteo-dentine.* This substance therefore would now fill the pulp cavity of the tooth. However true this statement may be of man or of many species of animals, it does not appear to be positively correct when applied to our domesticated Herbivora.

In the horse, as an example, obliteration of the cavity is gradually effected by *the pulp continuing to form dentine.* This, as its normal action, goes on and is not supplanted by an *ab*normal or diseased one, as it would be were the pulp to become ossified. As the producing organ of the dentine, the pulp simply gives way to its own product, which ultimately is thus made to occupy its place in the cavity. In proportion as the pulp diminishes so is the supply of nutriment to the tooth lessened, and at length entirely cut off from the interior. To provide for the vitality of the tooth under these circumstances, the crusta increases in quantity on the fang *at the expense of the perfectly formed dentine* which is lying in immediate contact with its inner surface. Through the medium of the canals in the crusta, which open on its borders, the tooth now draws its nourishment from the blood-vessels of the socket, and thus it continues, long after the obliteration of its pulp cavity, to serve all its purposes as a part of the living organism.

Fig. 10, page 34, represents a transverse section of the fang of an incisor tooth of an old horse magnified two diameters. Its pulp cavity, A, is barely visible, the encroachment inwards of the dentine, D, having nearly closed it. On its outer boundary, the dentine, which had originally extended to about as far as the line marked,

B, has become changed to crusta, C. Sections of teeth of this kind, even when viewed without any magnifying power have a

Fig. 10.*



peculiar white appearance of the more recently formed dentine in their centre, which exceeds in opacity the other parts. From this circumstance it might be thought that the structure here existing was not the same as the surrounding dentine. The microscope however at once dismisses the doubt. When viewed with an inch object-glass only, this whiteness is seen to depend on closely compacted dentinal tubes, and nowhere can be detected that arrangement of the structures which has led to the opinion of the canal being filled with *osteo-dentine*.

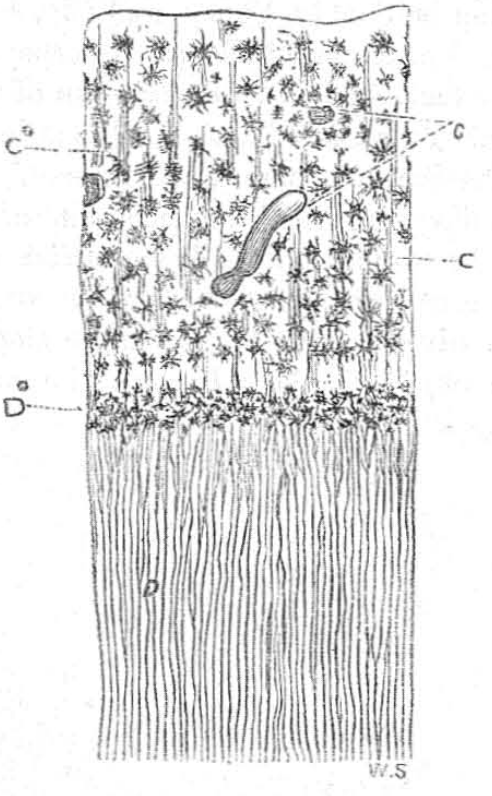
The precise way in which the dentine at its periphery changes into crusta has yet to be ascertained. It seems that the dentinal lacunæ undergo dilation and thus become identical with the hollow spaces or cells in the crusta. All the dentinal tubes however do not end in lacunæ, but many of them, as has been explained, terminate in very fine branches, and it is worthy of note that in this crusta bundles of such dentinal tubes are preserved, as if they had passed in unchanged. In further confirmation of the opinion that the transition is thus effected, in part at least, is the circumstance that the cells in the crusta lying near to the border of the dentine are circularly arranged row above row. Another feature has likewise to be named, which is that a true Haversian system, independent of scattered Haversian canals, exists in such crusta.

These several things are depicted in the following engraving, fig. 11, which gives a magnified view of a small portion of the tooth from which fig. 10 was taken. In it, D represents the dentinal tubes, D* the dentinal lacunæ, C the crusta with bundles of

* Fig. 10. A transverse section of an incisor of an old horse, magnified two diameters, showing the conversion of the dentine into crusta. A, pulp cavity; D, dentine; C, crusta: B, a line drawn for the purpose of denoting the original extent of the dentine.

tubes interspersed in its structure, and c* the Haversian system, which is so perfect in places as to lead to the crusta being

Fig. 11.*



readily mistaken by a casual examination for true bone. The simplicity as well as the beauty of this provision of nature for a maintenance of the vitality of old teeth is so self-apparent that no necessity exists for further observations on the point.

From the explanation of the structure of a tooth, I proceed to speak of the manner the teeth are formed, confining, for obvious reasons, my remarks to those animals which are the chief subjects of these pages. The development of teeth has of late years been studied with much advantage, and we are now enabled to describe the successive stages of the process with far greater confidence than formerly. In a work of this kind it is not required that I should enter very minutely into this subject, but merely give a general outline of it, so that the reader may the better understand how a

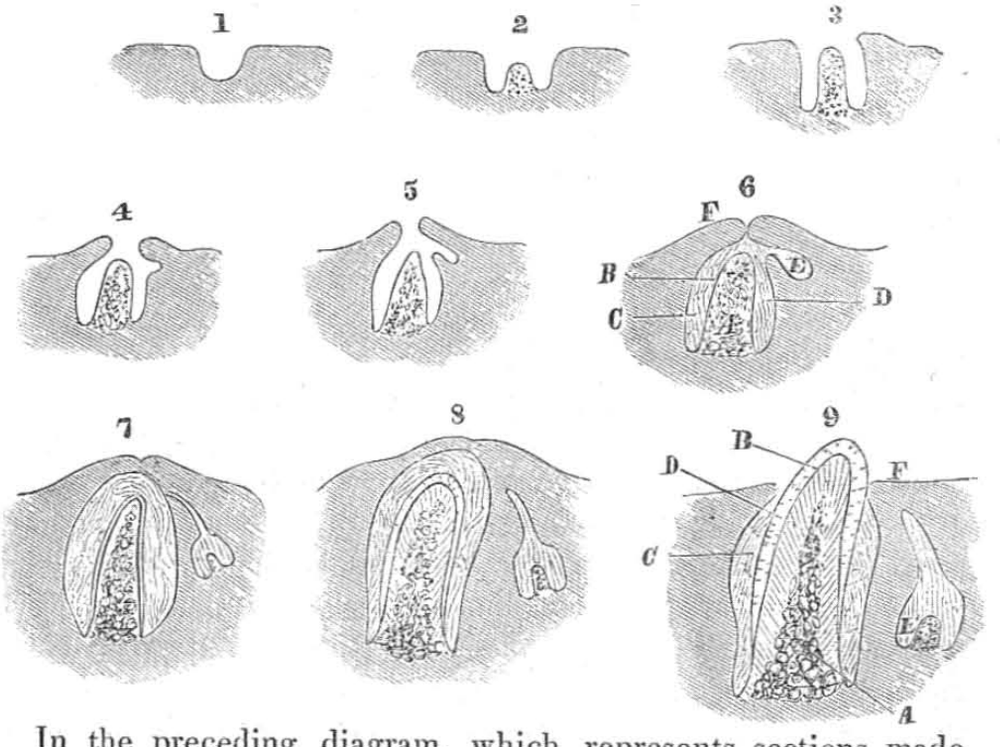
* Fig. 11. Conversion of the dentine into crusta. D, dentinal tubes; D*, dentinal lacunæ; C, crusta with its tubes and cells; C*, Haversian system in crusta. Magnified 200 diameters.

second set of teeth, the permanent, spring up to supply the place of the temporary, after they have served their purpose.

Besides the order of eruption of the teeth in two sets, which, as the practical part of my subject, will be considered under the head of Dentition in the Ox, Sheep, and Pig, I may observe, in the language of Professors Quain and Sharpey, that "the development of the teeth includes a description of their origin and growth as distinct organs, and also the formation of their component tissues, the dentine, enamel, and cement." *

The annexed diagram, which has been altered from Professor Goodsir's, will be found materially to assist the description. First, it must be observed that the process of formation, as a whole, has been divided into four separate stages, which have been called the *papillary*, the *follicular*, the *saccular*, and the *eruptive*.

Fig. 12.†



In the preceding diagram, which represents sections made across the jaw in the several stages of the process, the first of them is shown by the numerals 2 and 3; the second by 4 and 5; the third by 6, 7, and 8; and the fourth by 9.

* Elements of Anatomy, vol. ii., p. 981.

† Diagram representing the successive stages of the development of the teeth; altered from Goodsir.

It is during the early existence of fœtal life that the formation of the teeth commences, in common with the other parts of the body. Provision is also made at this time for the permanent teeth which are to succeed the temporary. According to the observations of Professor Goodsir, it is as early as the sixth week that the process begins in the human fœtus. At that time a groove appears along the border of the future jaws which has been called the *primitive dental groove.* This groove is lined by the membrane of the mouth—a circumstance to be kept in mind for the better understanding of the subject; and also that this membrane, as an "internal skin," is composed of two layers in chief, which are analagous to the *dermis* and *epidermis* of the external or true skin. Fig. 12—1 shows the groove as it appears when the jaw is cut across.

At the bottom of "the dental groove," projections, *papillæ*, spring up, corresponding in number with the temporary set of teeth. For example, in the ox there would be eight of these representing the eight temporary incisors, and twelve representing the number of the temporary molars, three of the latter being placed on either side of the upper and lower jaws. I may here say that, for the sake of perspicuity, my account will be confined to the teeth of the lower jaw—incisors and molars.

These papillæ gradually increase in size, and acquire the shape of the future teeth. While this is going on, partitions are formed across the groove between the papillæ, by which they become separated from each other. These partitions subsequently form part of the bony sockets, as existing between the teeth when they are fully developed. The rising and growth of the papillæ constitute the first or *papillary* stage (2, 3, fig. 12).

By the formation of the partitions each papilla is placed in a separate cavity of a square shape, called a follicle; and thus we see that the *follicular* stage now exists (4, 5, fig. 12). Concurrently with the formation of the follicle, small growths also take place from the membrane just as it dips into the cavity. These, as lids to the follicle, by their further enlargement cover in the papilla, and by their subsequent union place it in a closed sac or bag. This is the *saccular* stage (6, 7, and 8, fig. 12).

The formation of the different component parts of the tooth now goes on with greater rapidity, and after a certain state of completeness, the young tooth grows upwards, and penetrates both its sac and the gum which by this time also covers it, constituting

thereby the *eruptive* stage, commonly known as the cutting of the tooth. (9, fig. 12.)

Returning to the diagram: fig. 4 shows a slight folding inwards of the membrane of the primitive dental groove near to the lid on the right side; this is made more apparent in fig. 5. In fig. 6 it is marked E, and also in fig. 9, where we observe that the folded membrane considerably altered in form, as also increased in size, having a projection from its bottom part—the papilla destined for the production of the permanent tooth, is detached from the follicle. The intermediate figs., 7 and 8, show the progressive advance and separation of this fold of membrane from that which lines the original groove. As one of these folds belongs to each follicle, so they are equal in number with the temporary teeth; and thus each temporary tooth, while being formed, lays the foundation for its permanent successor. These have been called by Professor Goodsir "*cavities of reserve*, as they furnish delicate mucous membranes for the future formation of the permanent teeth."*

With regard to the formation of the permanent molar teeth, which are *three* standing behind the temporary in each row: the *first* of these is developed from a papilla which rises in the lengthened primitive groove, behind the last temporary molar; and from *cavities of reserve*, with a slight modification of the plan, the two last are subsequently formed.

We have thus an explanation of the fact that the *additional* permanent teeth of mammals are, like the temporary and their successors, productions from the membrane of the mouth, as had previously been seen to be the case with the teeth of fishes, &c. The implantation of the teeth in bony sockets in animals is only to give them a greater hold of the jaw, the better to serve their important offices.

To pass from this general description of the formation of the teeth to the structures of which they consist. First, of the dentine, the substance making up the bulk of a tooth.

It is agreed on by all observers that this structure is a product of the parts entering into the *composition of the papilla* which rises in the dental groove, but they differ materially in their explanation of the process of its formation. When fully developed, the papilla is chiefly composed of numerous microscopic cells,

* Todd and Bowman's Physiological Anatomy, part iii., p. 179.

held together by a network of very delicate fibres, and receiving its blood from vessels which enter at its base.

The precise manner in which the dentinal tubes and the intertubular structure is formed out of these elements of the papilla is still a question for future investigators. It may be that Schwan's view of the tubes being produced by the elongation of the cells and their union endways, and of the intertubular structure becoming solidified by a deposition of earthy materials, is correct. To describe the minutiæ of the process, however, as given by other authorities equal with Schwan, but who differ from his views, would be scarcely suited to a work of this kind were I to attempt their explanation, and which for the above reason I shall refrain from doing.

It is sufficient to state that recent observations have fully proved that the dentine is first produced upon the apex of the papilla, and that from this point it extends downwards upon its sides, and thus encloses it as with a cap. This may be the better understood by supposing one's finger to be covered with a thumbstall, and looking to the finger as the papilla and the thumbstall as the dentine. The papilla, thus capped by dentine, is now called the tooth pulp, under which name it has been previously referred to in these pages.

This layer of dentine is at first very thin, but by fresh depositions being added to it from the pulp within, its thickness becomes daily increased. The effect of this is a gradual decrease both in the size of the pulp and of the cavity in which it is placed. The ultimate consequences of this diminution, with regard to the nutrition of the tooth as derived from the pulp through the medium of the dentinal tubes, has been already shown.

The continuous lessening of the cavity is nicely seen in a transverse section of the fang of an incisor of the ox. To the unassisted eye a preparation of this description shows concentric lines, one within the other, marking fresh deposits of the dentine. The varying sizes of these rings, and the sudden curvatures of the dentinal tubes in these places, would seem to indicate an irregularity in the rate of the formation of the structure.

In a tooth with more than one fang, as for example the molar of a pig, when the sides of the pulp are covered with dentine, a horizontal projection of this substance shoots across the *base* of the pulp. By this means one fang becomes separated from the other, and the same process of conversion goes on in each lower division of the pulp until the final length of the fangs is accom-

plished. This circumstance explains how it is that in a molar tooth, in particular, a section, made in a vertical direction through its middle, exposes a cavity of a similar shape to the tooth itself.

The irregularities on the face of a tooth forming its points or cusps are simply caused by the papilla assuming that form, before any dentine is produced upon its surface. This brings me to the question of the formation of compound teeth, as in them we find *deep* depressions in the dentine into which the enamel dips. These depressions are effected by a kind of cleavage of the upper part of the papilla or tooth pulp to a depth corresponding with that of the hollow. Thus, supposing a tooth to have two principal cusps with an enamel cup between them, the substance of the papilla recedes from the centre and forms two apices. Each of these becomes first capped with a layer of dentine, as seen in the subjoined engraving, fig. 13, and next covered with a

Fig. 13.*

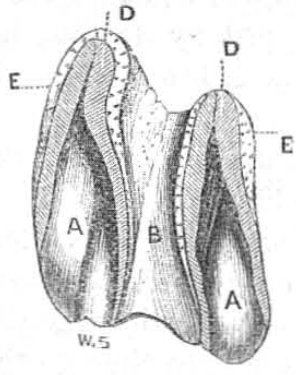
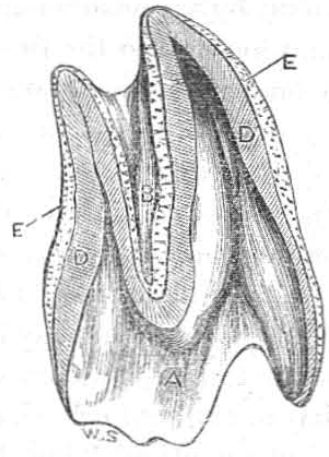


Fig. 14.†



layer of enamel. The "enamel membrane," hereafter to be more particularly described, is present in these hollows, because in the separation of the substance of the papilla to produce the form of the future tooth, this membrane, as its original covering, is not *cleft*, but merely *adapted* to the altered shape of the pulpy mass.

The process of development goes on, and after a time the two caps of dentine unite at the bottom of the hollow, and thus form a cup, in which enamel is afterwards produced by its membrane, lining the cavity throughout. Compare figs. 13 and 14.

* Fig. 13. Vertical section of a molar tooth of a young calf while being developed, showing the formation of the enamel cup. A, the pulp cavity; B, the enamel cup still open at the bottom; D, the dentine; E, the enamel.

† Fig. 14 also represents a vertical section of a similar tooth, and shows that the enamel cup is now closed at the bottom by a further production of dentine. A, the pulp cavity; B, the enamel cup; D, the dentine; and E, the enamel.

The preceding illustrations are taken from the molar teeth of a calf during their development. They are both vertical sections made across the teeth, at their opposite ends. The same letters apply to each figure; A, the pulp cavity; B, the enamel cup, which is still unclosed at the bottom in fig. 13, but closed in fig. 14 by a coalescence of the forming plates of dentine; D, the dentine, and E, the enamel. The depth to which these cups extend, and also the peculiar arrangement of the enamel in these compound teeth, are correctly depicted in fig. 19, page 49, which represents a vertical section of the posterior half of a molar tooth of a sheep.

A question of some importance arises at this stage of our inquiry on the proper solution of which depends the correctness of all which has further to be explained with regard to the formation and arrangement of the other structures of the teeth,—enamel and crusta. It is whether the dentine, described as being formed originally on the apex of the papilla, is in reality produced *beneath* the membrane which covers the papilla? or otherwise, whether this membrane is or is not the *nucleus* of the formation? Under the supposition that the membrane gives rise to the first production of the dentine, and is itself *obliterated* by the process, it has been called the *performative* membrane of the dental papilla.

Without presuming to decide this vexed question, I must say that, after repeated investigations, I agree in opinion with those who state that the membrane does not become obliterated, but that the dentine is formed altogether *beneath* it. *The membrane remains upon the cap of dentine*, but in consequence of the altered circumstances under which it is now placed, and especially with regard to the nature of the structure immediately beneath it, and having also an important part to play in the production of the other constituents of the tooth, its original character is greatly changed.

To the circumstance of this membrane, as an ordinary inflection of the mucous membrane of the mouth, being covered with an *epithelium*, which is analogous to the epidermis of the skin, special attention has been already called. A reference to figs. 4, 5, and 6 in the diagram, page 36, will show that when the young tooth becomes sacculated, the sac itself is merely lined with a continuation of the same membrane which is reflected upon the papilla. Under these circumstances the epithelium of the *lining* of the sac, and likewise that of the *covering* of the papilla, is changed into a pulpy mass, which has been called the *outer* or *enamel pulp*, from the belief that the enamel was directly produced from it. These

several things are rendered very clear in fig. 6 of the diagram, where A represents the papilla; B, the membrane which covers it, or rather that part of the membrane which answers to the true skin deprived of its epidermis; C, the altered epithelium of the membranous lining of the sac and the covering of the papilla, called now the outer pulp; and D, the "true skin" or vascular portion of the membrane of the sac. E is the germ of the permanent tooth, and F the gum. These several symbols also apply to the same parts in fig. 9 of the diagram, which represents the young tooth as cutting through its sac and the gum.

Having now shown that the membrane remains as a covering to the papilla, its office has next to be inquired into. This is, I believe, to form the enamel, for it appears to me that the so-called performative membrane of the dentine is identical with the *adamantine* membrane of the enamel; that, in fact, there are not two membranes, but only one.

The general received opinion seems to be that the *outer* pulp produces the enamel; and the *inner* surface of the sac, that is, the tooth capsule, the crusta which lies both upon the fangs of the tooth and also upon the surface of the enamel, where it covers the dentine. This opinion is negatived, however, by the fact that the *capsule is not reflected into the enamel cups of compound teeth*, although these are always filled with crusta, and therefore it is evident that this crusta has some other source, and this I am inclined to believe is the outer pulp. If this pulp produces the crusta in one part, it necessarily would do so in another. If within the enamel cups then on the outer surface of the enamel, and also on the fangs of the teeth. Further confirmation of this opinion will be presently given.

Although the formation of the crusta succeeds that of the enamel, the two are so intimately bound together that it is with difficulty their developments can be separately described, and especially in a popular account, where one has to abstain as much as possible from an undue employment of scientific terms.

First, of the enamel membrane, as I propose to call the *original covering* of the papilla in its now altered condition. If a permanent molar tooth of a lamb, sufficiently developed as to have a thin layer of enamel on its body, be removed from the jaw with its capsule entire and dissected under water, a membrane, which is interposed between the outer pulp and the forming enamel, can be readily floated from the surface of the latter. This, the enamel

membrane, firmly adheres to the tooth at that part from which the fangs arise—in short, as far down as the enamel extends. The *forming fangs are coated with the outer pulp*, which nowhere else, from the interposition of the membrane, can come in contact with the dentine. See fig. 9 of the diagram. The pulp existing here, as the formative organ of the crusta, depends on the circumstance that the capsule is continued, independent of the enamel membrane, to *the end of the developing fang*, by adhering firmly to the lowermost part of the papilla.

Todd and Bowman, in describing the development of a *simple* tooth, state that which is perfectly correct, namely, "that the reflection of the original mucous membrane of the follicle on to the papilla takes place at a line corresponding nearly to the neck of the future tooth, and that the original papilla answers to the crown or body of the tooth, and not to the root. The latter is a subsequent formation, and is laid down gradually after a certain amount of ossification has already taken place in the crown, and after the enamel has been calcified." *

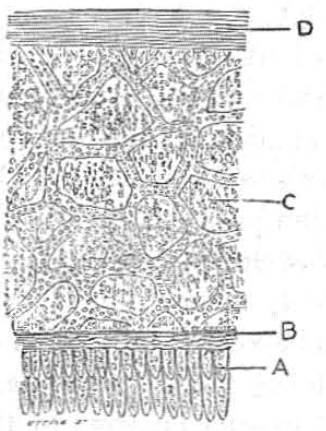
The enamel membrane also, on the upper part of the young compound tooth, is reflected, after the manner of an inverted finger of a glove, into the enamel cup (B, figs. 13 and 14, page 40), because it is not divided, as before explained, in the cleavage of the papilla, to produce this variety of tooth. The inverted portion of the membrane has between its folds some of the outer pulp, and thus the crusta is ultimately produced within the cup.

Examined under a low magnifying power the surface of this membrane, which is in contact with the newly deposited enamel, and which has undergone a change equal with its outer or original epithelial surface, seems to be merely linear in its arrangement; but when magnified 200 diameters, columns or elongated prismatic cells of forming enamel are readily detected upon it. In the annexed engraving, page 44, these prismatic cells (A, fig. 15) are represented *in situ* as they would be seen in a vertical section of the pulp. B, shows the enamel membrane by which they are produced; C, the outer pulp with its vascular net-work of vessels ramifying amidst cells in a reticulated membrane; and D, the capsule. The close resemblance of this figure to one given by Todd and Bowman in their Physiological Anatomy, cannot escape the notice of the scientific reader. It is said by

* Physiological Anatomy, part iii., p. 177.

them that "the structure of this thick pulpy mass is very beautiful and peculiar. It consists of a mesh of short fibres, meeting in numberless points, and at each point of junction a transparent clear nucleus is visible. It is elastic, spongy, loaded with fluid albumen, but destitute of vessels, and it seems perfectly distinct from that columnar structure which appears to be afterwards converted into enamel."† What this "mesh of short fibres, meeting in numberless points," the "stellated bodies" of other observers, so accurately described by Todd and Bowman, may be, I do not presume to decide. Probably they are cells in a transition state from the ordinary epithelium of the mucous membrane to the cells of true crusta.

Fig. 15.*



With reference, however, to the pulpy mass being "destitute of vessels," much of the correctness of this depends on the stage of development when the examination is made. Todd and Bowman could not detect any vessels ramifying in the pulp of a human *fœtus* five months old, but they saw, even at that early date, *loops* of vessels descending from the membrane of the capsule upon the outer surface of this pulpy mass. In my description, and also in the accompanying figure, I have drawn attention to numerous vessels permeating the mass, but then it must be stated that my examinations were made on the *permanent* molar teeth of calves whose ages ranged from two to six months. It is the vascularity of the outer pulp, and which appears to be perfected in the latter stages only of the developing process, that alters the general character of the mass, and leads to its ultimate conversion into crusta.

This view of the formation of the three structures will explain another well-known circumstance, namely, that the *crown* of a simple tooth, and likewise the *cusps* of a compound one, have upon them a mere *film* of crusta. By the time these parts are sufficiently covered with enamel the tooth is so far developed as to rise towards the under-surface of the gum. The resistance to its

* Fig. 15. Vertical section of the capsule, pulp and enamel membrane. A, enamel prisms in the process of formation; B, the enamel membrane; C, the outer pulp; D, the capsule.

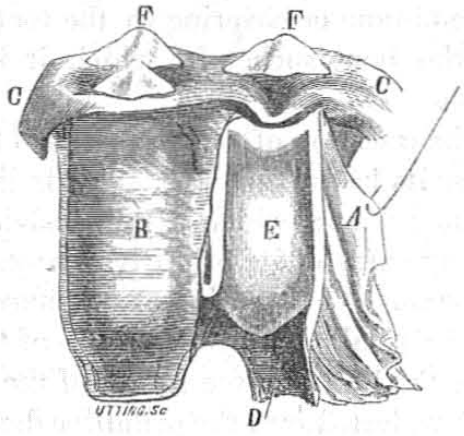
† Physiological Anatomy, part iii., p. 175 *et seq.*

advance through this structure forces the outer pulp downwards towards the middle part of the body and also the fang. Under these circumstances the upper part of the capsule, through which the tooth is passing, adheres to the enamel membrane on the inner side, and to the gum on the outer. (See fig. 9 in the diagram, page 36.) The source of the supply of crusta, always the last formed of the three structures, is thus somewhat exhausted and hence a mere film of it, if any, is found on this part of the tooth. At first sight, this explanation may seem to be negatived by the fact that the enamel cups are filled with crusta, but a little reflection will at once remove the doubt.

To render this more clear, I insert a figure representing a molar tooth in the act of cutting.

Here it will be seen that although the enamel *cusps*, F, F, have penetrated the gum C, C, that the latter is still pressing on the upper part of the enamel *cups*. This pressure retains the still existing portion of the outer pulp, which with the enamel membrane had been reflected into the cups, in its place. The supply of blood to it is kept up by the vessels which pass inwards from both the capsule and the gum, securely lodged in the grooves upon the edge of the cusps and likewise in the hollows between them. Thus, while the tooth is cutting, the process of filling the enamel cup with crusta goes on.

Fig 16.*



The somewhat altered circumstances under which this crusta is formed may possibly account for the difference observed in the

* Fig. 16 represents a molar tooth of a calf in the act of cutting the gum—dissected to show the retention of the matrix of the crusta (the pulp) in the enamel cup. A, a portion of the capsule of the tooth reflected backwards; B, the remaining part of the capsule covering one half of the tooth; E, an enamel cup; F F, the cusps penetrating the gum; C C the gum pressing upon and covering the openings of the enamel cups.

arrangement of its several parts when compared with the crusta on the fang. Attention was called to this fact when the microscopic characters of the dentine, enamel, and crusta were described.

The other references to fig. 16 are, A, the capsule, reflected back from one-half of the tooth, which has also been cut away to show E, an enamel cup; B, the entire half of the tooth covered by the other portion of the capsule, which is seen to join the gum above, and to extend downwards to the *end* of the forming fang; and D, the dentinal pulp cavity.

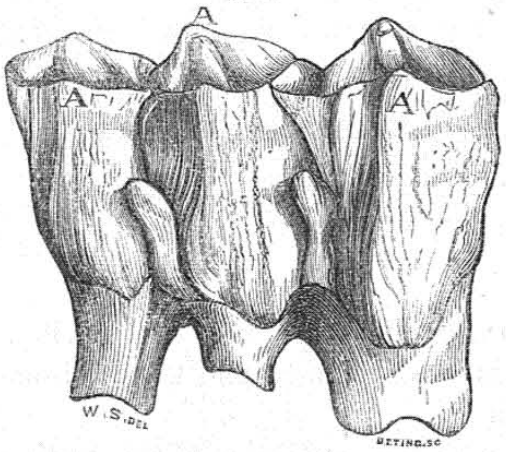
After a tooth is fully cut, and the crusta upon its imbedded portion also perfected, then the capsule becomes a bond of union between the tooth and its socket. In this position it is to be viewed both as the *periodental* covering to the tooth and the *periosteal* lining of the socket. Much more might be added in further explanation of these phenomena, but it is unnecessary in a work of this kind.

In concluding this portion of my subject, I will therefore merely observe—1st, That it appears to me that the dentine is formed beneath the original membranous covering of the papilla; 2ndly, That this membrane is the true producing organ of the enamel, and identical with both the *performative* and the *adamantine* membranes, these being, not two, but one; 3rdly, That the pulpy mass lying external to the enamel membrane is the matrix of the crusta; and 4thly, That the capsule becomes the *periodental* membrane or covering to the tooth, and the *periosteal* lining of the bony socket in which it is placed—these being also but one.

This view of the question of the formation of a tooth has at least simplicity for its basis; for, after all, it is little more than a layer of mucous membrane, which is reflected inwards, changed partly in the arrangement of its primitive elements, and then reflected outwards again. That portion of the mucous membrane of the mouth which originally flanked the sides of the dental groove remains behind as the lining to the socket of the tooth, while the portion which was reflected over the primitive dental papilla again comes to the surface as a covering of enamel—the two having now between them a third substance, the crusta, and which has been formed by the changes that each *in part* has undergone. These views of the development of the dental tissues will be made the more apparent if the series of objects in the diagram (fig. 12) are attentively examined.

In the preceding pages reference has more than once been made to compound teeth, and to the advantages which result from the several constituents of a molar tooth being so arranged as for all of them to meet on its wearing surface. From this it might be supposed that the dentine, enamel, and crusta, were all brought into wear immediately upon such a tooth being cut. Such, however, is not the case. In fig. 17, which gives a representation of the third temporary molar of a calf, taken from out of its socket a few days after it was cut, it will be seen that the cusps A, A, A, are very

Fig. 17.*



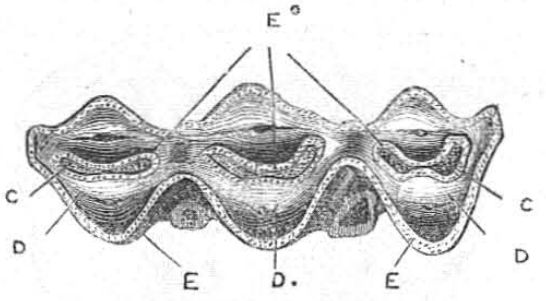
pointed, and that no other structure, except that which covers the body of the tooth and these projections, is as yet apparent. The cusps of molar teeth, as well as the edge of the incisors, are cased with enamel, as was shown when speaking of the formation of this structure. The hardness of the enamel combined with the irregularity of the shape of the cusps is sufficient for all the purposes needed at the first by the young tooth, as a grinding organ. Continuous use, however, soon wears away these projections, and after a time the caps of enamel are completely cut through.

It will also be remembered that the enamel passes from the outer surface of the body of a tooth, as a covering to the dentine into deep hollows, which are originally produced by a separation of the papilla, and that it lines them throughout. The wisdom of nature's arrangement in thus blending the several structures together now becomes more evident. By the wearing away of the enamel caps the outer reflection of this structure is separated from the inner, and thus, instead of there being fewer points of resistance to attri-

* Fig. 17. The third temporary molar of the calf showing its general form, and likewise that its cusps, A, A, A, are covered with enamel when first brought into use.

tion, there is a positive multiplication of them. Between the separated layers of enamel, the dentine is exposed, and as the enamel cups are filled with crusta, so we see that all three structures are now in wear together. The tooth will therefore present on its surface the appearances depicted in fig. 18, and which may be supposed to represent the preceding tooth (fig. 17) after its upper part had been removed by continuous use. The irregularity also of the wearing surface by the blending together of the

Fig. 18.*



structures is very nicely shown in the engraving, where E represents the outer layer of enamel, and E*, the inner; C, the crusta; and D, the dentine.

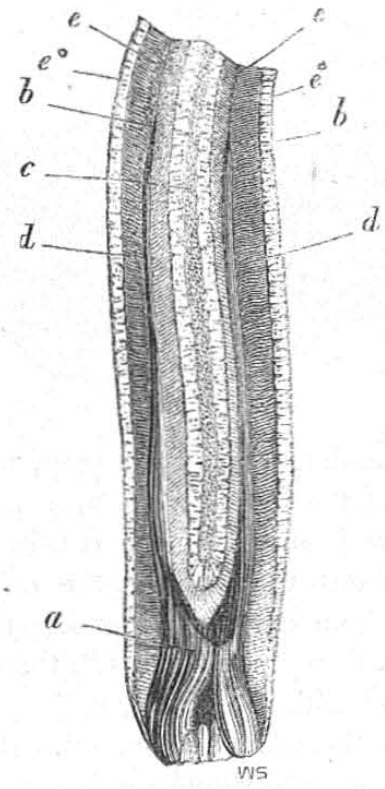
When speaking of the production of the dentine it was observed that its situation upon the tooth pulp might be compared to one's finger as covered by a thumbstall. A similar figure may be employed to elucidate the arrangements of the structures in a molar tooth of an Herbivorous animal. Thus, suppose two fingers when held up to represent a cleft tooth pulp. Cover these first with two leather caps, say of a yellow colour (this is the dentine), place over them two other caps of a white colour (this is the enamel), put over these two more caps of a brown colour (this is the crusta). Now unite the brown caps by approximating the fingers; and supposing these several coverings to be all joined together, and thick enough to have a horizontal section carried through them, we shall find in reckoning from outside to outside, first brown (crusta), then white (enamel), next yellow (dentine), then white again, next brown, and afterwards white, yellow, white and brown. Like most similes, objections can easily be taken to this, but still it is sufficient to show the commingling

* Fig. 18. Face of the third temporary molar of a calf, natural size, showing that the exposure of the dentine and isolation of the central from the outer enamel is caused by the wearing away of the original enamel cusps. E, outer layer of enamel; E*, inner ditto forming the cup; C, crusta; D, dentine.

of the several structures; and as they all differ in density, we see how a roughened surface is maintained upon the exposed part of a compound tooth.

As these molar teeth wear away so do they rise in their sockets, and consequently they always stand at about the same height in the mouth. This persistency of wear necessitates such an arrangement of the dentine, enamel, and crusta, that the tooth of the old animal, when worn nearly to its fangs, may be as effective an instrument for grinding the food as it had been when the animal was young. Provision is made for this, by elongating the bodies of these molars at the expense of their fangs. The body of the last molar of the ox is not less than two inches long, and that of the same tooth of the sheep an inch and a half long; while the bodies of several of the permanent molars of the horse

Fig. 19.*



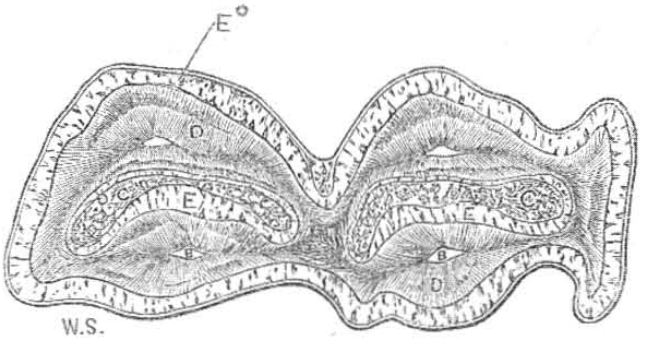
* Fig. 19. A vertical section of the posterior half of the *fifth* molar of a sheep in its short diameter, showing the great depth of the enamel cup and that it is filled with crusta. *a*, the inferior part of the pulp cavity; *b*, its superior portion which is being closed; *c*, the crusta in the enamel cup; *d*, the dentine; *e**, the outer layer of enamel; *e*, the inner layer of the same substance, forming the cup.

are often from three to three inches and a half long, although little more than a quarter of an inch of these teeth may appear above the gum. These things, however, have been previously alluded to.

The great length of the body of all the molars of the horse renders these teeth nearly fangless, and the same is the case with the fifth molar in particular of the sheep, as seen in the preceding engraving, fig. 19. This figure, which has been drawn a size larger than natural to make the several parts of the tooth more apparent, shows the depth to which the enamel cup descends, and also the extent of the outer layers of the same substance. The pulp cavity, which can be traced to nearly the top of the tooth, is marked *a*, at its bottom part, and *b*, where it is about to close above; the crusta has the letter *c*, and the dentine, *d*; the enamel cup is distinguished by *e**, and the outer layer of this substance by *e*.

In fig. 20 we have a view of a transverse section of the upper

Fig. 20.*



part of a permanent molar, also of a sheep, magnified two diameters. It shows that the pulp cavity, B, is nearly closed in the part where the section is made by the dentine, D, the radiating lines in which map out the size of the original cavity from which they spring. The external layer of enamel, as in many other of these illustrations, is marked E*, the crusta, C; and the inner enamel, as filled with the crusta, E.

From these explanations of the arrangement of the structures in compound teeth, I pass to the changes that the teeth undergo after they are brought into daily use.

* Fig. 20. Transverse section of the upper part of a permanent molar of a sheep magnified with a lens only to show the arrangement of its several constituents. B, the pulp cavity slightly open; C, the crusta; D, dentine; E, enamel.

It has been already shown that in all animals, with which we are familiar, there are two sets of teeth; the deciduous or temporary, and the permanent. The *temporary* set in the ox and sheep consists of twenty teeth; eight of these being incisors and twelve molars; fourteen of this number, that is, the eight incisors and six molars, are placed in the lower jaw, the remaining six occupying the upper jaw. The number of *temporary* teeth in the pig is twenty-eight, namely, twelve incisors, four tushes, and twelve molars; a moiety of each being located in either jaw. It may be also necessary to repeat that it is while the temporary teeth are being formed that nature provides for the development of the permanent, which are to replace them, as well as for those molars which, in due time, are put up and add to their number.

The order in which the two sets succeed each other, together with the cutting of the additional permanent molar teeth, constitutes dentition. To these phenomena, as they occur in the ox, sheep, and pig, I have now to direct the reader's attention, as a means by which we can determine the age of these animals. Their value for such a purpose will become apparent as we proceed. This may be called the more practical part of my subject, and as such it will necessarily require a full investigation of its several details.

I shall direct attention, firstly, to the Dentition of the Ox.

DENTITION OF THE OX.

The causes of the fall of the temporary teeth, and the way in which it is effected, will at the outset require our notice. Three principal causes are in operation together to produce the fall of the temporary incisors; these are, wear, greater width of the animal's jaw from increasing years, and the pressure of the advancing teeth; to these some minor things might be added.

That the fall of the temporary teeth, as a general principle, depends more upon the rate of the development of the permanent beneath them than upon either their own wear or the spread of the animal's jaw, seems however to be evident. As the permanent teeth grow, so do they press upon the fangs of the temporary, and produce an absorption of these projections, with, of necessity, a daily diminishing firmness of their attachment to the jaw. It is hardly necessary to enter at any length into an explanation of the manner that the absorption of a tooth is effected. Pressure is its great promoter. The permanent tooth which is imbedded in the socket, by its pressure upon the pulp, interferes more or less with the nutrition of the temporary tooth, and thus predisposes its elementary matters to undergo a change. Besides this the temporary tooth having served its purpose, the balance of nutrition is turned against it. On the other hand, however, the developing process is steadily going on in the permanent tooth, and thus its power as an expeller becomes daily increased.

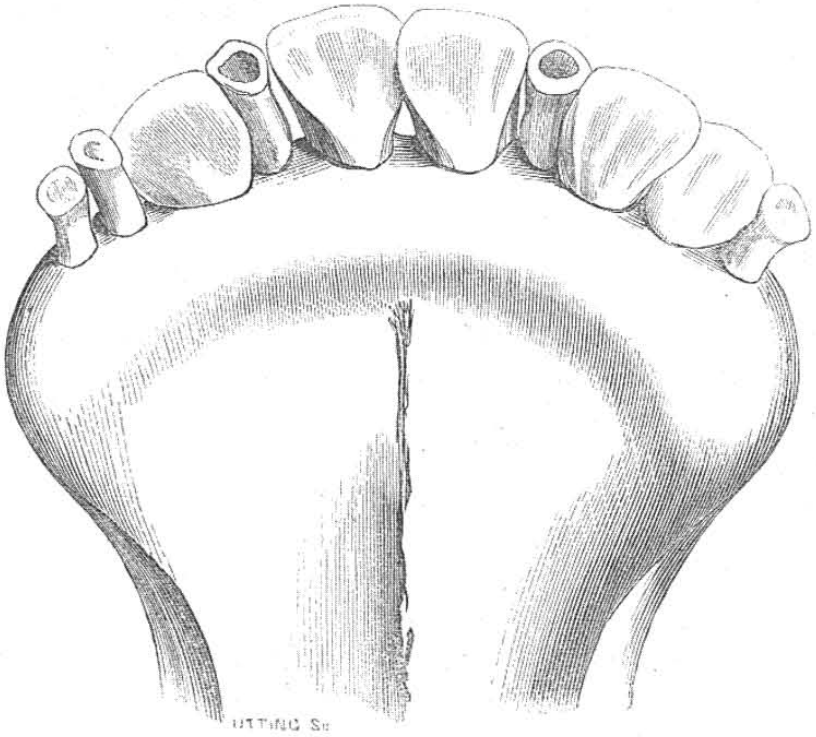
Absorption necessarily implies pre-existing solution, but how the solid parts of a tooth become fluid, or indeed those of any part of the body, is not well understood. With the theories of this change we have not to do. It appears that in proportion to the quantity of the animal matter in the several structures of a tooth, so is the rapidity of their absorption: thus crusta is observed to give way quicker than the dentine, and this quicker than the enamel. This difference in the rate of the absorption of the constituents is well seen on a close inspection of the crowns of the temporary teeth which have fallen from absorption. An advantage arises from this: the enamel which covers the tooth will be found to project from the edges, and thus

to hold its connexion with the gum when the whole of the middle part of the tooth has been hollowed out as if with a chisel. Premature removal is thus very often prevented.

The influence of absorption over the fall of the temporary teeth will necessarily be in proportion as the pressure to their fangs is *direct*. In the horse and pig the permanent incisors come up more within the original sockets of the temporary than in the ox or sheep, and this seems to be of itself almost sufficient to produce the removal of the temporary teeth of those animals. In the ox and sheep, on the contrary, from the disproportion which exists in the size of the two kinds of teeth, and also from the greater readiness with which the surrounding bone gives way to the pressure, it generally happens that the permanent incisors come up rather *without* than *within* the sockets which are occupied by the temporary. The temporary teeth are therefore very often pushed aside instead of being expelled. The liability to this displacement is increased by the loose connexion which at this time exists between these teeth and their sockets. These several circumstances now and then lead to a persistency of the temporary incisors, by their retaining a hold of the surrounding parts. An instance of this kind is exhibited in the following engraving, fig. 21, where we observe that the second pair of temporary incisors is still standing between the first and second pairs of the permanent. In addition to this, *one* of the third pair is also *in situ*, the corresponding temporary incisor of the opposite side having given way to the permanent tooth, producing thereby an inequality in the relative number of each set.

It is a circumstance worthy of a passing remark, that these temporary teeth are not unfrequently hollow, their pulp cavity being opened from above by the decaying process they are slowly undergoing. The adage that "Nature gives nothing in vain" is beautifully exemplified in the fact before us. These teeth have but a temporary purpose to serve, and therefore, although dentine is gradually added from the pulp to keep their wearing surfaces solid while attrition is daily going on, their cavity is not perfectly obliterated by a conversion of the pulp into dentine, as it is in the teeth of old animals. Had this been the case, the crusta, to a certain extent, would have taken the place of the dentine, in order that the tooth might still be nourished as a perfect organ. Out of its proper situation, however, the socket, and having served its purpose, the temporary tooth scarcely

Fig. 21.*



obtains from the surrounding vessels sufficient nutrient matter to maintain its vitality. Decay consequently results, and which not unfrequently leads also to a diseased state of the gums. These displaced teeth, likewise, from projecting forwards out of the line of the jaw, occasionally produce abrasion of the lips, which will now and then interfere with the capability of the animal to collect his food. These are among the things, therefore, to which we should direct our attention when we observe some slight impairment of the power of grazing.

To return to the causes of the shedding of the teeth. The removal of a temporary tooth, as an impediment to the advance of a fully-developed permanent one, doubtless favours the process. It should be observed, however, that these teeth are often, in one animal at least, intentionally removed, and as such their fall is premature. I allude to the well-known circumstance that persons are accustomed to draw the temporary "corner" teeth of the horse, to give this animal an apparent age beyond his real one. Whether such a procedure does in reality

* Fig. 21. In this figure the second pair and one of the third pair of the *temporary* incisors is represented as having become persistent from their being pushed aside by the permanent. Engraved from a specimen in the author's possession.

exert any considerable quickening process upon the permanent teeth is somewhat questionable. There are those in the Veterinary profession, eminent for the extent of their practical knowledge, who hold that the cutting of these teeth is not in the least facilitated by such an act. That the taking out of a temporary tooth, upon the near approach to the surface of a permanent one, may hasten the process, can be readily supposed; but the *premature* removal of such a tooth acting as a *promoter* to the development of the premanent is quite another thing.

The premature or accidental removal of the incisors of the ox and sheep, especially of the latter when pastured amid heath plants, is a circumstance of common occurrence. Whether the permanent incisors of these animals are put up earlier from such an accident becomes an important question in deciding upon age. Men of observation as extensive breeders of sheep differ materially on this point. On the whole, however, there seems but little ground for the opinion that the cutting of the permanent incisors is hastened by such removal.

In competing for prizes it is hardly to be supposed that any person would interfere with the teething of his animals, because such proceedings would but defeat the object had in view. Still, with such a precedent before us as the celebrated "Running-rein case," it is possible that the *accidental loss* of the temporary teeth might be assigned as the cause of the too early existence of the permanent. We often hear of the "bishoping" of old horses to deceive an unwary purchaser; but I know of means which would give to the teeth of the ox or sheep an appearance of youthfulness which in reality did not belong to them.

The *tushes* of pigs are sometimes cut off, and their stumps brought by a file to an unnatural sharpness, with a view to impose on persons who are not conversant with the ages of these animals. These things, however, notwithstanding the care with which they are often done, can be easily detected.

There are few questions which have a more direct influence upon the success of agricultural exhibitions than that of a prize being obtained by an animal of proper age. The information which we have hitherto possessed upon the subject of dentition has availed us but little in disputed cases. Practice here has not harmonised with theory. Several years since I became satisfied that nothing which had been written upon the dentition of either the ox or sheep in this country could be relied upon, and I

resolved, by an extensive examination of animals of all breeds and under all circumstances, to ascertain what the facts were which belonged to the process. My position in the Royal Veterinary College first required this, for, being ever desirous of imparting practical information, I felt the want of this knowledge when speaking to the class year after year on the subject of dentition. It is true that my examinations had extended over a considerable period of time and were numerous, but from the uncertainty which belonged to many of them, with respect to the exact ages of the animals, I was impressed with the belief that they were insufficient to found correct conclusions upon.

On the honour being conferred upon me by the Royal Agricultural Society of electing me as its "Veterinary Inspector," this subject assumed a more important aspect. Forthwith I determined to examine all the animals brought together at the annual exhibitions and make records of the facts relating to their dentition. This was done to some extent at the Windsor meeting, but at Lewes and Gloucester it was fully carried out. Note-book in hand I went from stall to stall and recorded the condition of the animal's teeth without reference at that time to its stated age. Subsequently the two things were compared and I have now before me the notes of upwards of 800 oxen of *certified* age, the condition of the teeth of each standing on the opposite page to that which gives the age, breed, and sex of the animal. The *data* thus obtained are embodied in a tabular form for more easy reference, and will be hereafter given.

Before proceeding to these details, however, it is right for the better elucidation of the subject, that I should first bring before my readers the observations of other persons upon the dentition of the ox. I select for this purpose the statements which are contained in the work on cattle, published by the Society for the Diffusion of Useful Knowledge. The writer of this, when speaking of the age of oxen as indicated by their teeth, says, that "The mouth of the newly-born calf presents an uncertain appearance, depending on the mother having exceeded or fallen short of the average period of utero-gestation. Sometimes there will be no vestige of teeth, but generally, either two central incisors will be protruding through the gums, or they will have arisen and attained considerable bulk.

"About the middle or close of the second week a tooth will be added on either side, making four incisors. At the expiration

of the third week, the animal will have six temporary incisors or front teeth.

"At a month, the full number of the incisors will have appeared. These are the temporary or milk teeth. The enamel will be seen covering the whole of the crown of the tooth, but not entering into its composition as in the horse, and it will be observed, that the edge is exceedingly sharp. The only indication of increasing age will be the wearing down of these sharp edges, and the appearance of the bony substance of the tooth beneath. The two corner teeth will be scarcely up before the central teeth will be a little worn. At two months, the edge of the four central teeth will be evidently worn; yet as the wearing is not across the top of the tooth, but a very little out of the line of its inner surface, the edge will remain nearly or quite as sharp as before. At three months the six central teeth, and at four months the whole set will be worn, and the central ones most of all; but after the second or third month, the edge of the tooth will begin to wear down, and there will be more of a flat surface with a broad line in the centre.

"About this time a new change will begin, but very slowly, to be seen. The central teeth will not only be worn down on their edges, but the whole of the tooth will appear diminished, a kind of absorption will have commenced. There will be a little but increasing space between them. The face of the tooth will likewise be altered, the inner edge will be worn down more than the outer, and the mark will change from the appearance of a broad line to a triangular shape. The commencement of this alteration of form and diminution of size may be traced to about the fourth month. The two central incisors at eight months are not above half the size of the next pair, and they are evidently lessened. At eleven months the process of diminution will have extended to the four central teeth. The vacuities between them will now be evident enough. At fifteen months six of the incisors will have this shrunken appearance. . . . At eighteen months old, the corner teeth will not be more than half their natural size; the centre ones will be yet more diminished, and the vacuities between them will be almost equal to the width of the teeth. . . . All this while, the second set of teeth, the permanent ones, have been growing in their sockets, and approaching towards the gums; but not, as is said to be generally the case with other animals, and with the human being in particular, pressing upon the roots of the milk teeth, and causing them to be absorbed,

until at length, losing all hold in the socket, they fall out. The process of absorption commences here in the whole milk tooth, and as much in the crown or body of it, as at its root.

"The process of general diminution seems now for awhile retarded; it is confined to the central teeth, and they gradually waste away until they are no larger in the body than crow-quills. About the expiration of the second year, or a little before, the milk teeth are pushed out or give way, and the two central teeth appear. The process of absorption will be suspended with regard to the two outside pairs of milk teeth, but will be rapid with regard to the second pair, and a little before the commencement of the third year they will disappear. Thus the three-year old beast will have four permanent incisors, and four milk teeth.

"Now the remaining milk teeth will diminish very fast, but they show no disposition to give way, and at four years old there will be six permanent incisors, and often apparently no milk teeth; but if the mouth is examined, the tooth that should have disappeared, and the tooth that is to remain until the next year, are huddled together and concealed behind the new permanent tooth.

"At the commencement of the fifth year the eight permanent incisors will be up, but the corner ones will be small; so that the beast cannot be said to be full mouthed—*i. e.*, all the incisors fully up—until it is six years old." The author finishes this account by alluding to the writings of others who have described dentition as being perfected at an earlier date, and adds, "we have no hesitation, however, in appealing to the experience of the breeders of cattle for the general accuracy of our account." *

It is evident from this that the author was satisfied with the correctness of his conclusions; and as his work is regarded as the standard one on the diseases, &c., of cattle, so we cannot be surprised that his views of dentition should have been generally received.

Much might be said to show that many of the rules laid down in the above description are rather the result of imagination than of practical investigation, notwithstanding the confidence with which the author appeals to the experience of the breeders of cattle. I refrain, however, entirely from this task, rather desiring to lay before the reader the facts as I have found them.

To commence with the birth of the calf. The condition of the teeth at birth is subject to great variation. It not unfrequently

* 'Cattle, their breeds, management, and diseases,' p. 318, et seq.

happens that as many as six of the temporary incisors have thrust their edges through the gums, while in other cases none as yet have made their appearance. These differences probably depend rather on the variations in the periods of utero-gestation than on any other circumstance. The offspring, it is true, inherits the qualities of its parents, and among them may be an aptitude to arrive early at maturity; but it is stretching the point to infer that such a power is the true cause of the cutting of the teeth while the fœtus is *in utero*. This ground might probably be defended by some; but when we see the great differences there are in the times of gestation, it appears to me that here is sufficient to account for all the variations we observe.

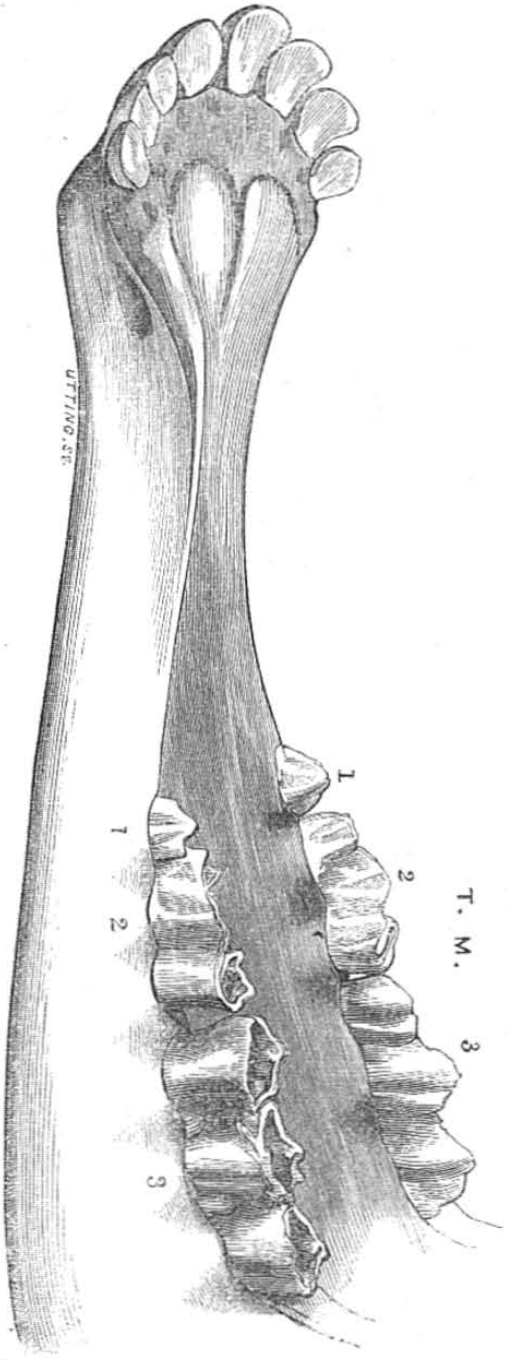
The prevalent notion among breeders, that a cow carries a bull-calf longer than a cow-calf, received singular confirmation by the experiments of the late Earl Spencer, who also showed that the male parent influences to some extent the duration of the period of pregnancy. If forty weeks is the average time of *utero-gestation*, and some cows exceed and others fall short of it by ten days each way, we can easily see that this very common occurrence will explain the teeth being cut or not when the calf is born. In this particular, therefore, my opinion accords with the author of the work on Cattle, when he says that "the mouth of the newly-born calf presents an uncertain appearance, depending on the mother having exceeded or fallen short of the average period of utero-gestation."

The presence of four incisors at birth is, I believe, the rule; more or less being an exceptional number. At this time, also, the outline of the other teeth, as ready to cut the gum, is distinctly visible beneath the tissue. The third pair is usually through by the twelfth or fourteenth day; but the corner or fourth pair seldom penetrates the gum until about the end of the third or beginning of the fourth week. By the time the calf is about a month old, all the incisors will therefore be *in situ*.

Thus we find that the statements of the author of the above work do not agree with nature's proceedings. The account he has given is fanciful in the extreme, and it is rendered the more so by the illustrations which accompany his descriptions. We have figures of the mouth at birth, and at the second, third, and fourth week, but it is not until the last named date that we can trace even an *outline* of more than *two* teeth at birth, *four* at the second week, and *six* at the third, all of which are exhibited of *full size* at these respective periods.

The eight temporary incisors of the calf are in all respects, excepting size, the counterparts of the permanent by which they will be succeeded. The first or middle pair is the largest of the set, and the corner the smallest, a gradual decrease taking place

Fig. 22.*



* Fig. 22. Lower jaw of a calf one month old, natural size, showing that the eight incisors and the three temporary molars on each side of the jaw are *in situ*.

from the one to the other. These teeth by the end of the fourth week from the growth of the maxillary bone, are less crowded together than when first cut, although they are still observed to be partially overlapping each other.

Not only are the incisors all up by this time, but the temporary molars are also in their place. It may be again necessary to state, that they are twelve in number, three occupying each side of both jaws (upper and lower). The accompanying engraving (fig. 22) of the lower jaw of the calf at a month old, gives the general form as well as the position and size of the incisors and molars.

The temporary molars have many peculiarities, the chief of which must be named, as these teeth likewise furnish important evidence of age during the early period of the animal's life. At birth none of the molars have cut the gum, and it is not until the calf is a month old that they are well developed. Like the incisors, they follow no special order of eruption, but more frequently than otherwise the first in position is the last to be cut. The first and second of the temporary molars in either jaw do not differ essentially in form from the permanent, by which they are succeeded. If we compare, however, the teeth of the upper jaw with those belonging to the lower, it will be found that the two anterior ones in the latter are much smaller than the corresponding molars of the former, still these points are of less practical import than others which have to be named.

The *third* in position of the temporary molars in the lower jaw varies considerably from all the others, as also from its permanent successor. It differs likewise as greatly from the fourth in situation, the first permanent which is put up, and with which it can scarcely be confounded even in a casual examination, if the following particulars are borne in mind. It is the last of all the temporary molars which, as a rule, is renewed, and consequently throughout it furnishes much assistance in determining a question of age. A reference to figs. 22 and 23, pages 60 and 63, will show that it occupies a space in the jaw equal or even greater than both the other molars together which stand before it, in consequence of its increased width from front to back, which however would be more correctly called its long diameter. It is composed of three main parts or lobes of a semi-cylindrical form, having in the hollows between them, on the outer side, two smaller portions which also rise into asperities or

cusps. The latter, when the tooth is somewhat worn down, add both to the strength of its body as well as to the irregularity of its grinding surface.

Each of the three principal lobes likewise rises into cusps, an inner and an outer, of which the inner are always the highest. In fig. 17, page 47, a representation of this molar, as removed from the jaw, is inserted. The description there given shows how the roughness of the face of the tooth is added to by the wearing away of the cusps. This tooth being of triple form, might, for brevity's sake, be called a tri-cusped tooth; but this, critically speaking, is far from being correct, for originally, as we have seen, it has six principal with two minor projections or cusps.

These particulars suffice to distinguish the third temporary molar so well, that in examinations of the mouth it is quickly recognized. By merely bearing in mind that this tooth has three lobes, while both the fourth and the fifth molars have but *two*, and that when it falls it is renewed by a tooth similar in size and form to them, we recognize immediately both the number and the kind of molars which occupy the mouth. It may be added that the form of this tooth beautifully adapts it to its office, for in the act of mastication each of its projections intersect those of the corresponding molar of the upper jaw, and thus effectually grind down the food which is submitted to their action.

The putting up of the temporary incisors and molars at about a month, completes "first dentition," and as there are now a given number of teeth, so any addition to them will mark an important stage in the further process of teething. When this addition takes place, the temporary teeth, merely by their number, cannot avail in our inquiries, nor can they be said materially to do so up to that period by the slight wear they may have undergone. The general appearance of the young animal, for the first few months, suffices to form a fair estimate of its age.

As the temporary incisors agree in number with the permanent, but the temporary molars are but a moiety of the whole of these teeth, so the addition is necessarily made to the latter. Inquirers into the age of the ox have assigned very different dates for the appearance of the first *permanent* molars. Most of our authorities concur in saying that these teeth are cut when the animal is about a year old. These statements, however, are far from being correct, as these teeth are put up when the calf is *six months* old.

In fig. 23, we have represented a side view of one half of the

ERRATA.

Page 62, line 10 from the top, *for* "tri-cusped" *read* "tri-cuspid."

Page 80, line 23 from the top, *for* "improved" *read* "unimproved."

Fig. 23.

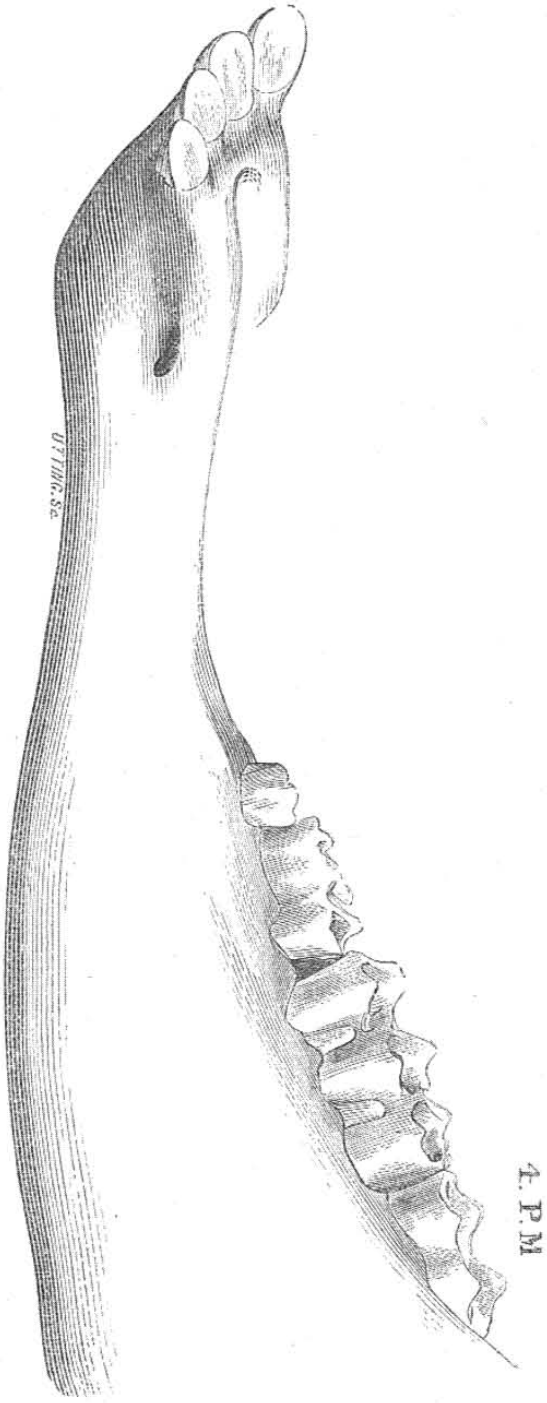


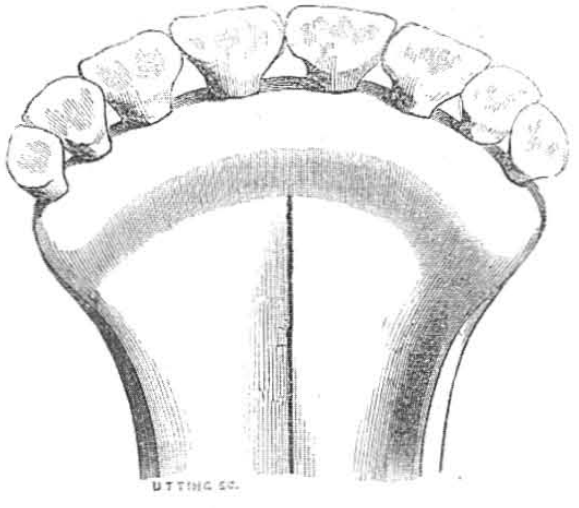
Fig. 23. Side view of one half of the lower jaw of a six-months-old calf, showing that the fourth molar tooth, 4 P. M., is cut. Reduced one fourth from the natural size.

lower jaw of a calf, reduced one fourth from its natural size; and it will be seen that the fourth molar, marked 4, P, M, is in its place. I have found, as a rule, that this molar in the lower jaw is usually a little more forward than its fellow in the upper, and that now and then it appears even before the sixth month. This tooth, it will be remembered, is of less length than the third molar, as measured from front to back, but it is wider from side to side, giving it thereby a more proportionate outline. In about three months the fourth molars attain an equal height with the others.

The next important stage in dentition is the cutting of the *fifth* molar in situation, the second permanent. This takes place at *fifteen* months; but as in the interim well marked changes have come on in the temporary incisors, so it is necessary to direct attention in the first instance to these.

From six to nine or ten months, the edges of the incisors, which at the former date were rather blunted, have been gradually giving way to attrition: this perhaps would be scarcely recognised in an ordinary examination. After the latter period, however, it becomes more and more apparent, and when the animal is a year old, the four centrally-placed teeth, in particular, will be worn rather flat on their crowns. These teeth also are now beginning to show spaces between their fangs. These changes are regulated partly by the

Fig. 24.*



* Fig. 24. Front part of the lower jaw of a year-old ox, showing the wear of the incisors and their separation somewhat from each other. Natural size.

system of management the young animal has received, and the kind of food on which it has been kept, and partly by the natural width of the lower jaw. If the food has been coarse and the jaw a wide one, the incisors will be more flat and the distance between them greater than otherwise it would have been.

In the preceding illustration, fig. 24, is represented the more usual state of the incisors at a year old. The engraving is of natural size, that the peculiarities may be the better recognised.

From one year we pass to fifteen months, when, as before stated, the fifth molar tooth is put up. This tooth does not essentially differ in its shape or dimensions from the fourth. Its cutting, however, at fifteen months, at a time that the incisors do not offer any satisfactory evidence of the *precise* age of the animal, is a point of some utility to an investigator of age. The regularity in the periods of the appearance of the permanent molars is pretty uniform. The fourth, as we have seen, is cut at six months; and the fifth at fifteen: the sixth follows at two years—an interval of nine months elapsing between each. This gradation is easily remembered. The following figure, 25, shows the fifth molar in the act of being cut. The engraving represents one-half of the lower jaw at fifteen months old, reduced one-third from its natural size; this tooth being marked 5 P. M., to distinguish it from the fourth molar, 4 P. M.

Like the fourth molar, this tooth also acquires its full height in the jaw about three months from the time of its cutting.

Attention must now be directed to the state of the incisor teeth at eighteen months. In fig. 24 it was shown that at a year old the four middle-placed incisors, in particular, gave indications of wear, by the loss of their sharp edges and increasing flatness of their crowns. By eighteen months this flatness has considerably increased; it is not now, however, confined to the teeth placed in the centre of the mouth, but has extended to all. The jaw of the animal has also grown wider, thus increasing the spaces between the teeth, so as to leave not merely their fangs apart, but likewise their crowns. To compensate, in part, for their diminished length, the teeth have likewise risen in their sockets; and as some of them are soon to be renewed by the permanent incisors, the process of absorption has commenced in their fangs. These various causes, more or less modified in different animals, give to the mouth an appearance which is quickly recognised.

To these indications of age have to be added a diminished

Fig. 25.

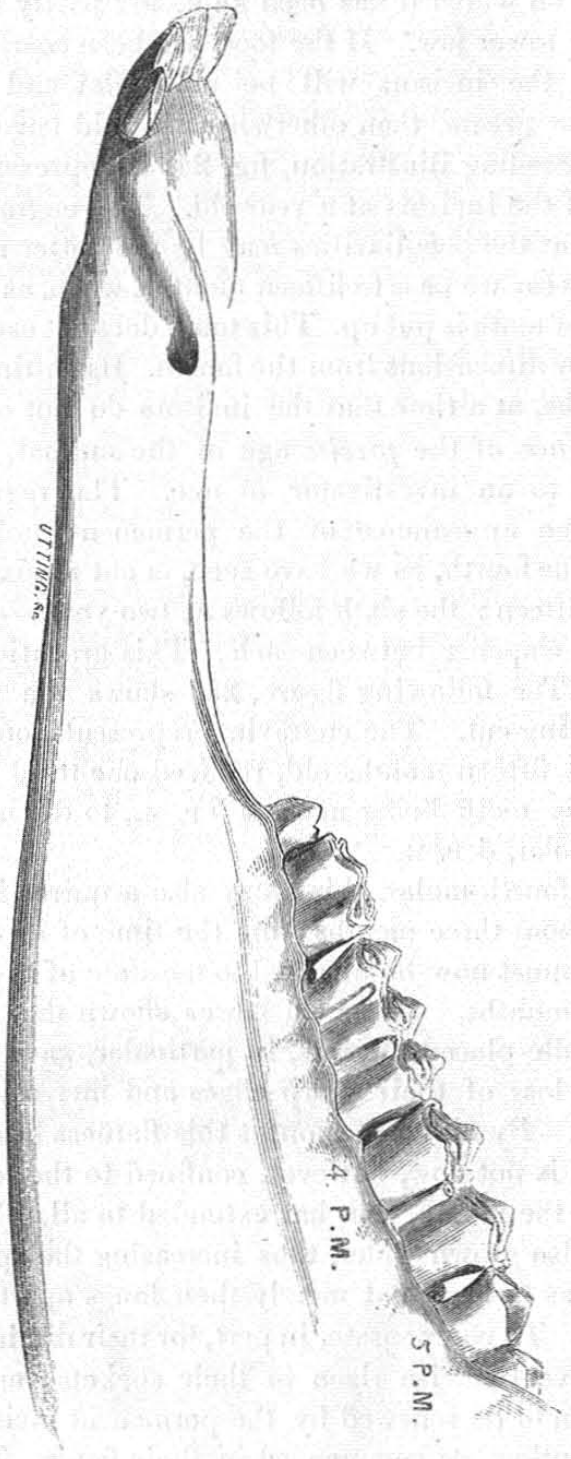
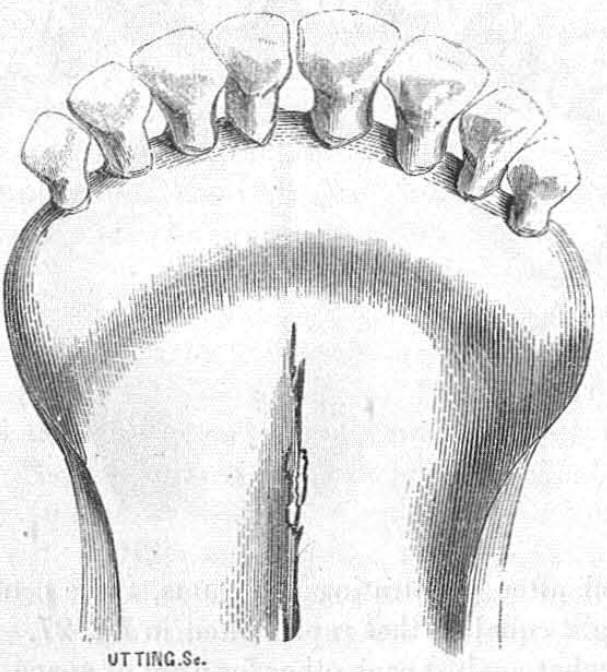


Fig. 25. One half of the lower jaw of an ox 15 months old, two-thirds the natural size, representing the fifth molar as being cut. The fourth in situation (first permanent) is marked 4 P. M.; the fifth, 5 P. M.

whiteness of the teeth, the part of their crowns which is exposed being that which is covered by a thin layer of enamel; the existence also of yellowish lines on their wearing surfaces, which indicate the outline of the once open pulp cavities; and the discoloured state of their fangs from the action of the food and secretions of the mouth upon the crusta.

Fig. 26 will convey many of these things to the mind of the reader. It represents the front part of the lower jaw at eighteen months.

Fig. 26.*



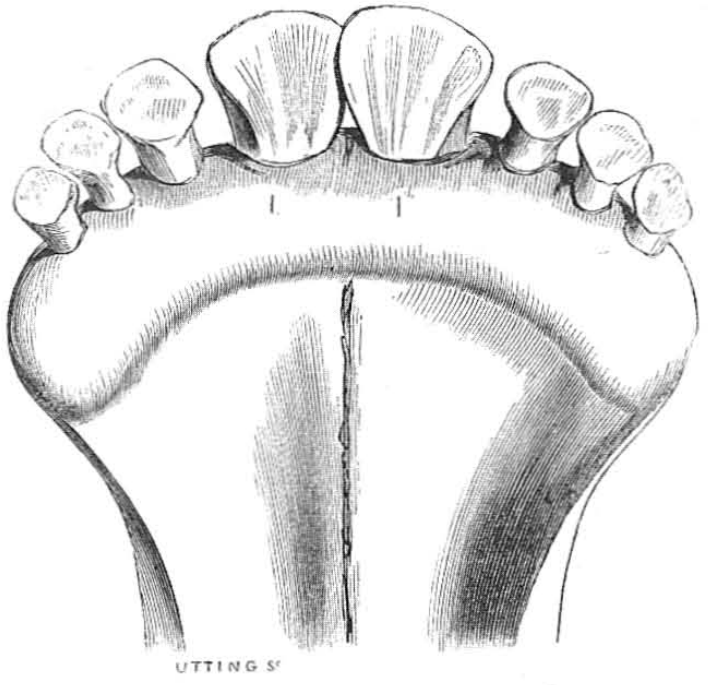
With increasing evidence of a speedy fall of the middle incisors, we arrive at one year and nine months. At this time the central incisors are often removed by the permanent. This change is generally observed in animals whose vigour of constitution and power of arriving at early maturity has been aided by a liberal diet. It is, therefore, that we see it principally among our competing breeds of Short-horns, Herefords and Devons. Such cases, however, are met with in other breeds, and even more frequently than is generally supposed.

In the preparation of the tables which accompany this description, this date has been taken as one of the standards of comparison by which the limits of the range of dentition may be ascertained.

* Fig. 26. The front part of the lower jaw at 18 months, exhibiting the diminished size of the bodies of the incisors, and the increased space between their fangs. Natural size.

Many oxen, however, do not put up the first pair of permanent incisors until they have passed their second year; a fact which at once shows that a single average table would have been next to useless in assisting our decisions in doubtful cases of age.

Fig. 27.*



Very soon after penetrating the gums, these central teeth acquire a height equal to that represented in fig. 27. At first they press somewhat against each other for want of space, but this soon yields to the altered position they take when their broad chisel-shaped crowns are clear of the jaw and their fangs properly located within their sockets. The thinness of the bony partitions between the sockets and the spongy nature of the bone, as a whole, often leads to the permanent incisors pressing the fangs of the temporary closer together, so that these teeth will have a more compact appearance than before the permanent were cut. These things are more clearly marked in oxen with a comparative narrow jaw, such as the Devons.

The general condition of the mouth at this time is shown in the preceding figure. It represents a front view of the lower

* Fig. 27. Front view of the lower jaw of an ox at one year and ten months old, showing that the central pair of permanent incisors, 1, 1, are well up. Natural size.

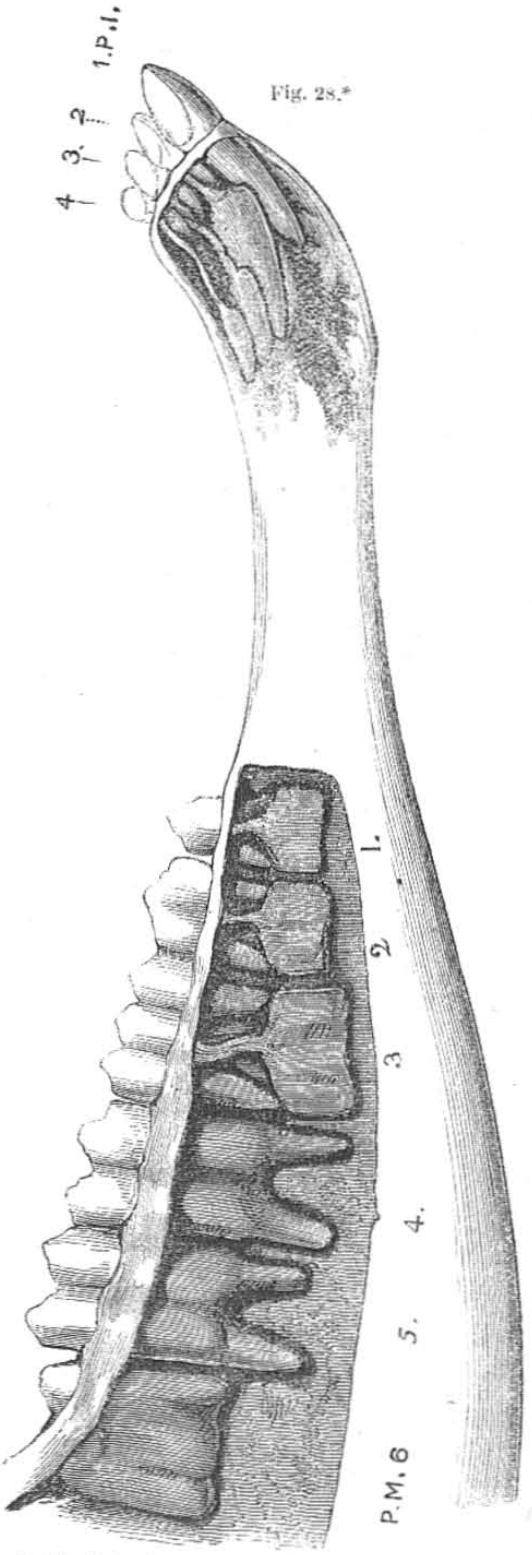
jaw of an Hereford ox at one year and ten months old. The permanent incisors, 1, 1, are as yet not fully up, so that the gum is embracing rather the lower part of their crowns than their necks. Although the observation will apply generally to all the permanent incisors, this will be a proper place to state that the conclusions which are arrived at with respect to age, must be always regulated by the amount of the *protrusion* of these teeth from the gum, as well as by their number.

At *two years* of age the last addition to the number of the molar teeth is made by the cutting of the sixth in situation. This tooth follows, as has been previously explained, the fifth molar, after an interval of nine months. It being in the mouth at two years, although not fully developed, is a circumstance to be kept in mind in our investigations of age.

The sixth permanent molar in the lower jaw has many of the special characters of the third *temporary* molar. Its long diameter exceeds that of the fourth or fifth, but its short diameter is only equal to theirs at its front part, decreasing gradually from before backwards. The tooth is therefore thicker at its front than at its hinder part. It is also tri-lobular, like the third temporary; but its lobes are scarcely so perfectly formed, or so distinct from each other. The hindermost one, not being of equal height with the others, is not unfrequently concealed by the gum long after the tooth is cut. Differing, however, as it does in so many particulars, the sixth molar cannot be confounded with the others, and therefore its existence in the mouth is quickly detected.

The general condition of all the teeth at about this time is depicted in the annexed engraving (fig. 28, page 70). We have here one-half of the lower jaw dissected in order to show the number and position of both the temporary and permanent sets of the incisors and molars. It will be noticed that the three temporary molars are still *in situ*, and that lying beneath their fangs are the corresponding permanent teeth 1, 2, 3, contained within their capsules. From the central part of each temporary tooth a portion of membrane contracted into the form of a small band extends to the capsule below, supporting it as by a pedicle. These elongated portions of membrane have been designated the *gubernacula*, the guides or directors of the teeth into the proper passage. Todd and Bowman, when describing the wisdom of design, which is observable in every stage of the process of development of the teeth, very truly observe that "it has been supposed that the

Fig. 28.*



* Fig. 28. One half of the lower jaw of an ox at about two years old, dissected to show the condition of both the temporary and permanent teeth. *Incisors:* 1, permanent, 2, 3, 4 temporary, having the permanent beneath them enclosed in their capsules. *Molars:* 1, 2, 3 permanent contained within their capsules beneath the fangs of the corresponding temporary; 4, 5, permanent molars full developed, 6, permanent molar cutting. Reduced one half from natural size.

elongated productions of the *cavities of reserve*, which have been carried down from the surface with the permanent tooth sacs, serve to re-direct them to their proper places as they rise through the gum. But it may be asked, what served previously to carry down the tooth pulps aright and to form these *gubernacula?* It is manifest we must ascend to a higher secondary law, to which to refer these wonderful phenomena of life."*

To return to our explanation of fig. 28. Behind the temporary molars the fourth and fifth permanent are seen, both in a perfect state of development. Immediately posterior to the fifth, the crown of the sixth is observed to be coming through the gum, its body and fangs being covered by the capsule, now called the *periodental* membrane. This tooth is fully up, namely, on a level with the others, by the time the animal is two years and a quarter old.

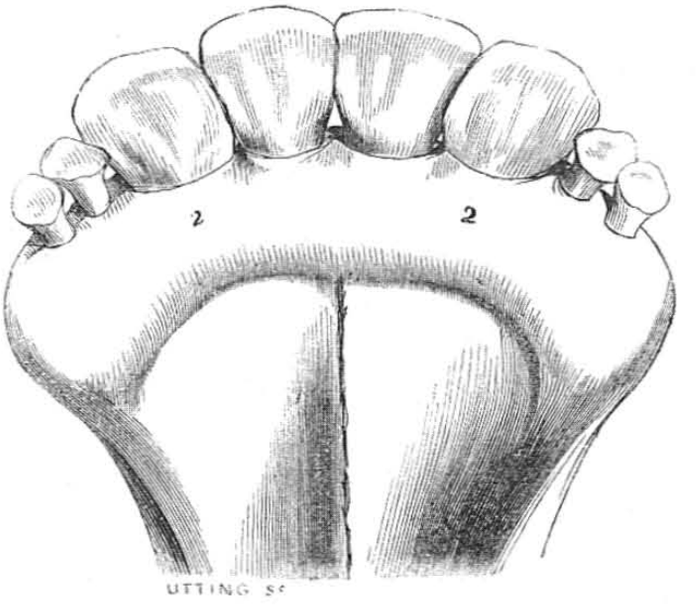
In this illustration also three of the incisor teeth are seen to be temporary, having their permanent successors imbedded in the jaw beneath them, within their respective capsules. One of these is in a state of great forwardness compared with the others, as it is soon to be cut. The tooth marked 1, is a permanent incisor, very recently put up. The great natural size of the jaw has required that the engraving should be reduced one-half, which prevents many of the peculiarities being depicted so clearly as otherwise they might have been.

Attention must again be directed to the front part of the mouth. In fig. 29, in the following page, we have a representation of the incisors at *two years and four months*, in a case of early dentition. The crowns of the second pair are as yet encircled by the gum at their lower part. In most cases these teeth will crowd upon the first pair, and overlap their outer edges. As time steals on, however, by further rising from their sockets they will stand more easy in the jaw.

The temporary incisors are now much diminished. These teeth, after the animal has completed the second year of his age, get rapidly smaller, and chiefly from the circumstance that the thin covering of enamel which they have about the neck is unable to stand against the daily attrition to which they are subjected. My note-book furnishes so many cases of the second pair of incisors being cut at two years and a quarter, especially in Short-

* Physiological Anatomy, part iii., p. 180.

Fig. 29.*



horn and Hereford bulls, that I have taken this date in the preparation of the table of *early* dentition, as the time of the cutting of these teeth. In our Devon cattle there are fewer instances of this, but both they and our other breeds furnish some cases of the same kind. I have only met with about half a dozen cases where the second pair of incisors was cut *before* two years and three months, and these were in animals certified to be *two years and two months* old.

More prizes are offered now than formerly for the best bulls and heifers *under* two years old, and it is therefore of great importance to ascertain what is the state of the mouth at two, and a little after it;—the limit in fact which belongs to the cutting of these teeth. At a recent Agricultural meeting a heifer was exhibited in this class, to which an objection was taken. The examination showed that there were *four* incisors *all well up*. Satisfactory proof of the correctness of the certificate was therefore called for, which having failed to be given, the animal was disqualified. According to the authority quoted in these pages, and the prevailing opinion of Agriculturists, this animal's mouth indicated *three years* of age, whereas she was probably but *two and a quarter*. An

* Fig. 29. Front part of the lower jaw at two years and four months, showing the second pair of permanent incisors, 2, 2. The temporary incisors are worn to their necks. Natural size.

animal three months over age might be sent to compete in the "young class," but it cannot be supposed that a three-years-old animal would be.

The existence of four permanent incisors, as a general rule, may be said to indicate two years and a half old, there being some oxen that do not cut the second pair until after this time. Such animals come under our second table of dentition, which gives the average periods of the changes, when breed and other *un*favourable causes are in operation. The case just cited, when contrasted with the latter named fact, will tend not only to confirm the propriety of classifying dentition under two heads, but to prove the absolute necessity of such being done.

At about *two years and a half* the two anterior molars are also shed, and their places occupied by the permanent. These teeth vary with reference to the order of their fall; occasionally the *first* in position is changed before the second, but generally the *second* gives place to its permanent successor before the first. This irregularity of renewal is even greater in the sheep than in the ox, as in that animal, as will be hereafter explained, the *third* temporary molar will sometimes be the first to yield to its permanent successor.

From two and a half to three years, the *third* molar of the ox falls, and the permanent occupies its place, thus completing the series of changes in these teeth.

Annexed we have two illustrations of the molar teeth. The first of these, fig. 30, page 74, shows that the third temporary molar is unchanged at two years and a half, when the first and second *permanent* are in their place. The second, fig. 31, page 75, shows that at three years the third *permanent* molar is also *in situ*.

The difference in the general form of the third permanent from that of the temporary is so well shown in the illustrations, that any special description of this tooth beyond that which has been already given, is rendered unnecessary.

From the preceding remarks respecting the molar teeth, we find that, during some of the most difficult periods of our correctly ascertaining the age of the ox by his incisors, the molars afford the assistance which is required, and that, if these teeth with the incisors are carefully studied, few errors will be made by an investigator. The importance of the subject may justify my repeating, that the fourth molar is cut at about six months, the fifth at fifteen, and the sixth at two years, and that each attains its level

Fig. 30.

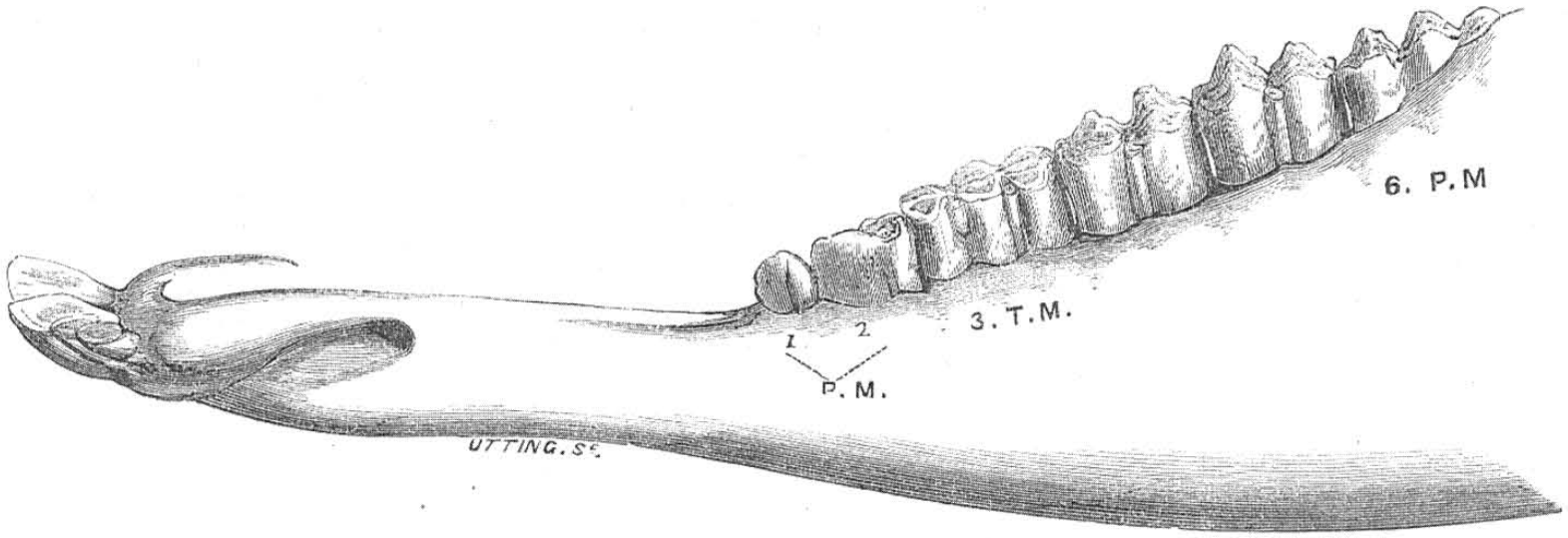


Fig. 30. Side view of the lower jaw at two years and a half, showing that the first two temporary molars are renewed by the permanent; the third temporary being still *in situ*. Reduced one half.

Fig. 31.

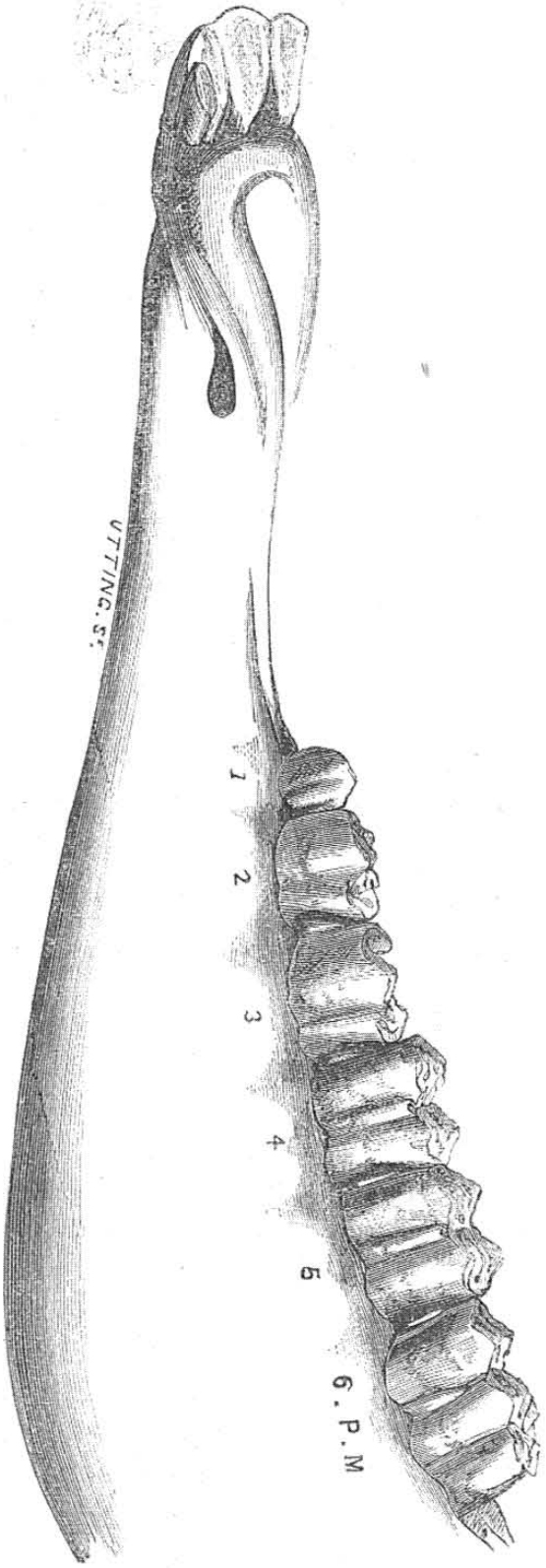
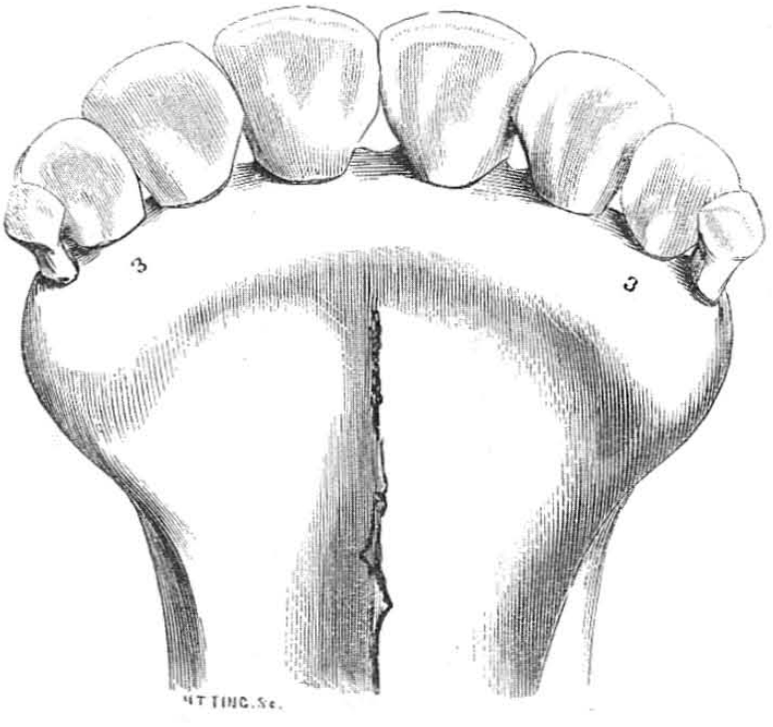


Fig. 31. Side view of the lower jaw at three years, showing that all the molars are permanent. Reduced one half.

in the jaw in three months after these respective dates: that at two years and a half the two anterior temporary molars give place to the permanent, as likewise does the third before the animal has attained the third year of his age.

To return again to the incisors. At *two years and three quarters*, the third pair of incisors are frequently cut, and as such this date is assigned to them in the early table. The variations in the putting up of these teeth being similar to the others, I have selected for my illustration the mouth of a *three-years-old*

Fig. 32.*



animal, fig. 32. In this engraving these teeth are marked 3, 3. They are smaller in size even when fully developed than the second pair, but larger, as will be seen by-and-by, than the fourth or corner permanent teeth. Besides there being six "broad teeth" in the mouth at three years, those first put up will now begin to show slight wear. Their enamel edge will be cut through, exposing the dentine and forming thereby a slight hollow immediately behind the reflection of enamel which covers the front surface of the tooth. The colour of this hollow contrasts with

* Fig. 32. Front part of the lower jaw at three years, showing the third pair of permanent incisors *in situ*. Natural size.

that of the enamel, being of a darker shade. Its depth and size mark the amount of wear.

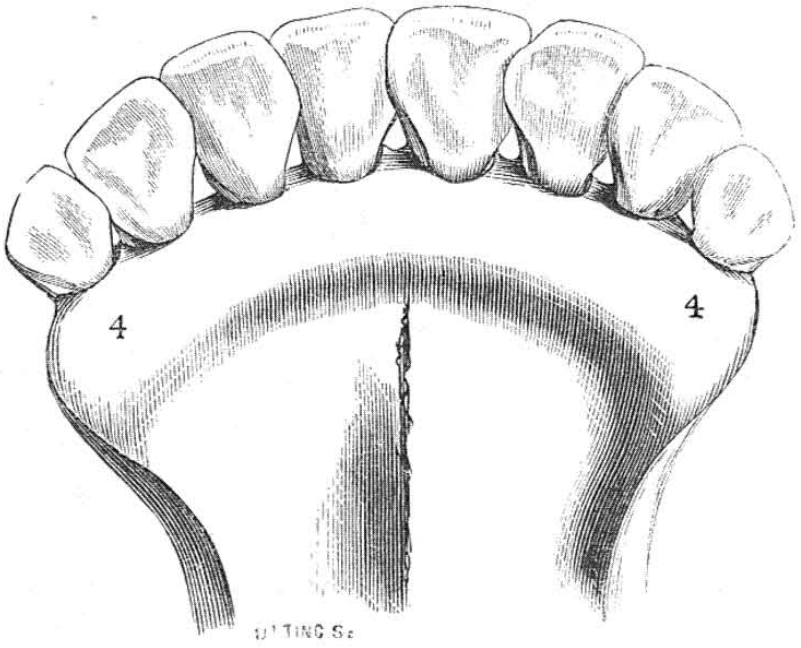
The two temporary teeth which are still standing are often so reduced in size, from absorption and attrition, as to be overlooked when the mouth is hurriedly examined.

From this date we pass to *three years and a quarter*, when, in animals of early maturity, the fourth pair of incisors will occupy the places of the temporary, and perfect the dentition of the ox. These teeth, as we might expect, will offer most variations as to the time of their cutting.

By far the larger number of oxen will not put them up till after three years and a quarter, and I have repeatedly examined animals whose ages ranged from three and three-quarters to four years and found these teeth in the act of cutting. On the other hand, I have occasionally seen them in Short-horn bulls, fairly through the gum at *three years and a month.* These things should guide the opinion of an examiner.

If an animal is certified to be three years old, or wanting that time by a week or two, and *all* the incisors are *permanent*, it most certainly is a proper case for investigation, so few are the exceptions to these teeth being cut before *three years and a quarter.*

Fig. 33.*



* Fig. 33. Front of the lower jaw at three years and a quarter, showing that the incisors are all permanent. Natural size.

Fig. 33, in the preceding page, gives an illustration of a "full mouth" at three years and a quarter; so called because the teeth are all permanent.

In these early cases of dentition the judgment often will be assisted by the examiner noting the amount of the overlapping of the incisors, and which is best seen on their upper surface. Thus the outer edges of the middle teeth are partially covered by the inner edges of the second, the second by the third, and the third by the fourth or corner incisors. This overlapping of the edges of these teeth arises from their broad and flat crowns being at their height of development when they penetrate the gums, and from the rapidity with which one pair has succeeded another, the jaw not having fully adapted itself to their larger size. These things are nicely shown in the illustration of the mouth of the three years and a quarter old ox.

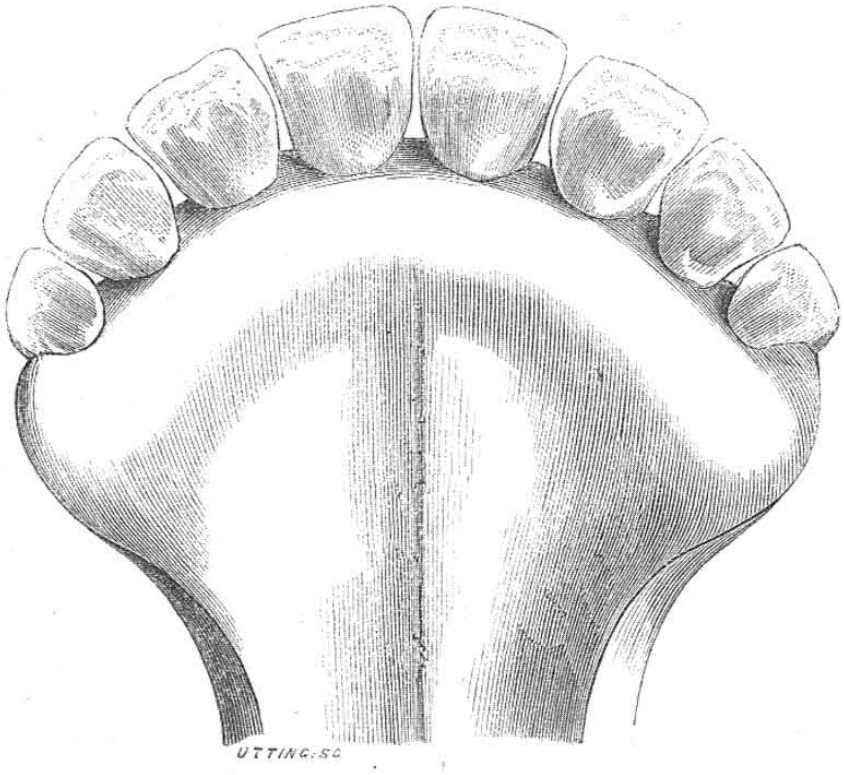
In judging of age, also, the fulness and redness of the gums combined with the extent of protrusion of the incisors *last cut* is to be considered. In about two months from the appearance of the edges of either the first, second, or third pair, these teeth will have acquired their full development, the second pair becoming nearly level with the first, or the third with the second, as the case may be. The corner incisors, however, although they more quickly acquire their full size after being put, rarely gain the proportionate level of the others.

When dentition is completed, any opinion which is given of age, must be drawn from the general appearance of the animal, rather than exclusively from the condition of the teeth. Nevertheless the changes they are gradually undergoing will assist in the inquiry. At four years old the edges will be worn off both the second and third pairs of incisors, which will now present a similar appearance to that described as denoting the attrition of the central pair at three years.

From four to five years the hollows on the wearing surface of all the incisors will increase, and by five years they will have lost the broad chisel form they had when young, and there will be no longer any overlapping of their edges. Fig. 34, in the succeeding page, gives a very good representation of the teeth at *five years* old, and is inserted to fix these things more firmly upon the memory.

Increasing age after five years is indicated by a diminished height, a flat or broad wearing surface, a less cone shape of the crowns of the incisors, discoloration of the enamel, and spaces between each tooth.

Fig. 34.*



I may now, in concluding this part of my subject, direct the reader's attention to the tables to which reference has been made in the course of this description, as in them the foregoing statements are embodied in a form the most easy for reference.

DENTITION OF THE OX.

TABLE OF EARLY AVERAGE. The Breed and other Causes favouring Development.			TABLE OF LATE AVERAGE. The Breed and other Causes retarding Development.		
Years.	Months.		Years.	Months.	
1	9	Two permanent Incisors.	2	3	Two permanent Incisors.
2	3	Four ,, ,,	2	9	Four ,, ,,
2	9	Six ,, ,,	3	3	Six ,, ,,
3	3	Eight ,, ,,	3	9	Eight ,, ,,

* Fig. 34. Incisors of a five-year-old ox, showing their flattened wearing surface and diminution of size from attrition. Natural size.

By the preceding tabular arrangement it will be seen that, as a rule, even under unfavourable circumstances, the dentition of the ox is completed before the *fourth year* of his age; a fact which contrasts greatly with the statements of all our authors, as also with the opinions that are generally entertained by breeders of cattle. The author of the work on the Management and Diseases of Cattle, which has been before alluded to, thus writes: —"At the commencement of the *fifth* year the eight permanent incisors will be up, but the corner ones will be small; so that the beast cannot be said to be '*full mouthed*'—*i. e.*, all the incisors up—until it is *six* years old."

On the present occasion I shall make no attempt to reconcile these conflicting statements with the conclusions to which I have arrived. It is necessary, however, to remark in this place that although the examples of both early and late dentition are selected from among our improved breeds of oxen, still the results of the examinations have been confirmed by the investigations of the ages of other breeds. In proof of this I may observe that the Sussex cattle which were exhibited in large numbers at the Lewes meeting of the Royal Agricultural Society were not found to offer more exceptions to the rules laid down than either the Short-horns, Herefords, or Devons. The same may be said of our other improved breeds. unimproved

To proceed. Among the anomalies which are met with in the teething of oxen, the cutting of one tooth of a given pair, four or five weeks before the other, is the most frequent. The tooth thus put up out of regular order is likely to lead to an error with reference to the animal's age. My own observations go to show that in most instances it is a *premature* cutting of the one, and not a delay in the coming up of the other tooth which produces the anomaly; and consequently that the animal is younger than he appears to be at first sight. I have noticed that this irregularity applies far more frequently to the third and fourth pairs than to either the first or second. An example of this abnormal number is given in fig. 21, page 54, where we also find a persistency of the temporary incisors, and which sometimes produces an impairment in the collection of the food. These things, however, having been already explained, I pass on to the subject of the dentition of the Sheep.

ERRATA.

Page 62, line 10 from the top, *for* "tri-cusped" *read* "tri-cuspid."

Page 80, line 23 from the top, *for* "improved" *read* "unimproved."

DENTITION OF THE SHEEP.

As with the ox, the description of the teething of this animal will commence at the period of its birth.

The lamb is usually born before any of the temporary teeth——incisors or molars—have penetrated the gums. In the calf some of the incisors are commonly cut at birth, as has been already explained; and, as we shall see hereafter, the young pig invariably has a given number of teeth when born. Generally, however, the first and second pairs of temporary incisors, the four teeth most centrally situated, are cut by the time the lamb is a week old. By the ninth or tenth day the third pair usually comes through, but the fourth or last pair is rarely put up until about the end of the fourth or beginning of the fifth week. With regard to the temporary molars, which are three in number on either side of the upper and lower jaws, these teeth are also uncut at birth. They are fairly through the gums, however, by the third week of the animal's age.

A marked difference exists with regard to the relative sizes of the different pairs of incisors. The central teeth are broader and longer than those of the second pair. The second pair also exceeds the size of the third, as the third pair does that of the fourth. In these particulars as in several others, the temporary incisors are the counterparts of the permanent, which succeed them. They are however very much smaller than the permanent.

The number of both the temporary and permanent sets of teeth of the sheep is the same as that of the ox. The temporary incisors are eight, and the temporary molars twelve. And when dentition is perfected by the changing of these teeth and the putting up of twelve more molars, the total number in both animals is thirty-two; namely, eight incisors, and twenty-four molars.

The temporary molars are likewise similar in form to the permanent, except being smaller. I may repeat, however, that this is not strictly correct when applied to the third molar of the lower jaw, which, like the corresponding temporary tooth of the

ox and pig, is composed of three principal parts or lobes blended together.

About the third week of the lamb's age, the incisors, and also the molars, are so well developed as to enable the young animal to crop the grass and to live comparatively independent of its dam. Hence the propriety of so arranging the sheepfold, as is now done by most farmers, that the lambs can pass in and out at will and cull the herbage before the ewes, by the shifting of the fold, are allowed to come upon the same ground.

Before proceeding further in the description of the dentition of the sheep, I may remark that but little has been written on this subject which is trustworthy.

The account given by authors of the teething of this animal does not differ in any essential particular from the following, which is quoted from the work entitled 'Sheep:'—"The mouth of the lamb newly dropped," says the author (Mr. Youatt), "is either without incisor teeth or it has two. The teeth rapidly succeed to each other, and before the animal is a month old he has the whole eight. They continue to grow with his growth until he is about fourteen or sixteen months old. . . . . Then with the same previous process of diminution which was described in Cattle, or carried to a still greater degree, the two central teeth are shed and attain their full growth when the sheep is two years old. . . Between two and three years old the two next incisors are shed, and when the sheep is actually three years old the four central teeth are fully grown. At four years old he has six teeth fully grown, and at five years old all the teeth are perfectly developed. This is one year before the horse or the ox can be said to be full-mouthed. The sheep is a much shorter lived animal than the horse, and does not often attain the usual age of the ox."*

These statements have generally been regarded as being correct. They are, however, very erroneous in many respects. For example, it is well known that sheep, even if they have not been well kept, or do not belong to the breeds celebrated for arriving at early maturity, have two "broad teeth" which are well developed long before the animal is two years old. Other inaccuracies in this account will become apparent as we proceed.

Nothing perhaps can better explain the necessity of a correct knowledge of this division of my subject than the preceding ex-

* Sheep, their breeds, management, and diseases, p. 5.

ample. The importance of protecting the rights of our Agricultural Societies, as well as those of the exhibitors, with reference to this animal as well as others, is so self-evident that it needs no comment.

To proceed. From one month till about three months no change of consequence takes place in either the incisors or the molars. At this time, or rather before than afterwards, the lamb cuts its *first permanent* molar teeth—the fourth in situation. These teeth, as in the calf, are usually more forward in the lower than in the upper jaw, and from possessing but two lobes they are scarcely so long from front to back in the lower jaw as the temporary molars which stand before them. By this addition of four molars the lamb has now sixteen of these teeth, which is about three months before the calf has a similar number.

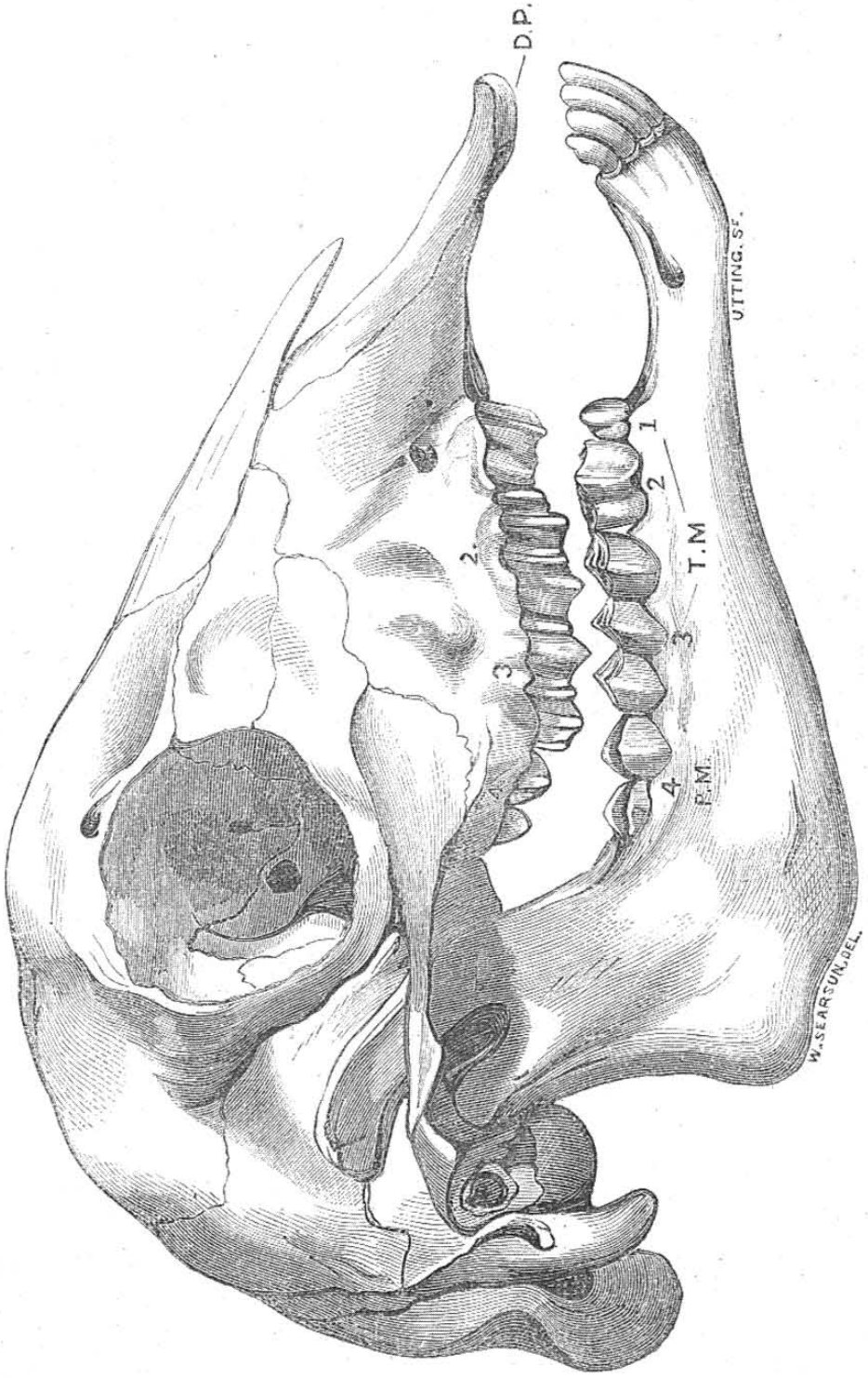
In the annexed illustration (fig. 35, page 84), which represents the skull of a lamb at three months of age, these molar teeth are marked 4 P. M., the temporary being distinguished by the symbols 1, 2, 3, T. M. Besides the temporary and permanent molars here shown, four of the *incisors* are also seen as occupying their place in the lower jaw. In this animal, and likewise in the ox, as will be remembered, the place of the incisors in the upper jaw is supplied by that peculiar structure called the dental pad: this is also represented in the engraving, and marked D. P.

The next important stage in the process of teething in the sheep is the cutting of the molars which are the *fifth* in position. This takes place when the animal has reached his *ninth* month, and it forms, consequently, a useful criterion to assist us in determining a question of age, both before and after this date. The molars are now twenty, which, added to the number of the incisors, gives a total of twenty-eight teeth.

At nine months the incisors offer but few facilities in ascertaining the animal's age. In most cases, they will have reached their acme of development; and in some few, where the sheep have been kept on heath land, they will begin to give evidence of slight wear. Much of the condition, therefore, of these teeth at this time, will depend on the food and management of the animals.

Although the fifth molar does not differ in any essential particular from the fourth, I have thought it right to insert an engraving representing the cutting of this tooth, that each stage in the progress of dentition may be recorded in the way best suited to impress the facts on the memory.

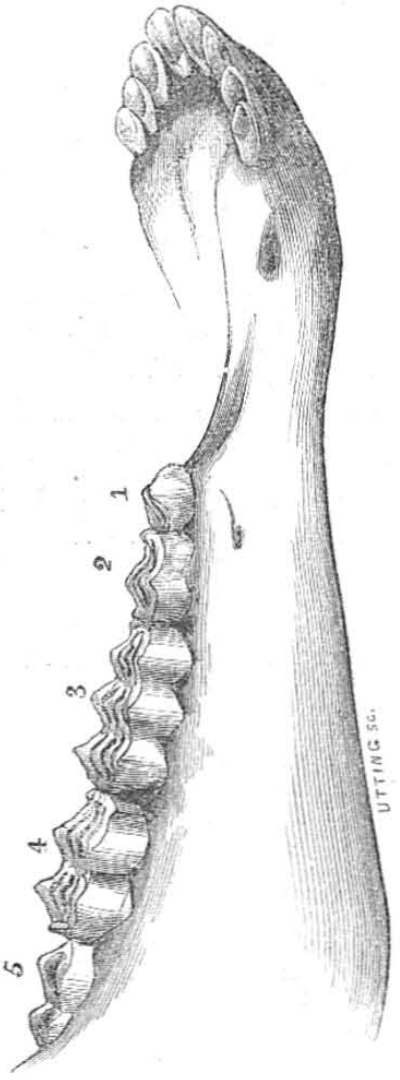
Fig. 35.*



* Fig. 35. The skull of a lamb three months old, natural size, showing the cutting of the first *permanent* molar teeth. These teeth being the fourth in position are marked 4 P.M. 1, 2, 3, the temporary molars; D. P. the dental pad which supplies the place of upper incisor teeth.

Both the fourth and fifth molar teeth consist of two main parts or lobes blended together, as seen in fig. 36. Each tooth, therefore, when first cut, has four cusps of enamel, of which the inner are always the highest in the *lower* teeth, and the outer in the *upper*. It is, however, to be remembered that the points of these cusps are soon worn away, and that consequently each of them is thus made to form two ridges of enamel, and thereby to give to the tooth eight elevations of this substance, of varying height, instead of four. It is somewhat necessary that

Fig. 36.*



* Fig. 36. Lower jaw of a lamb nine months old, showing the fifth molar cutting. 4 and 5 are permanent molars; 1, 2, 3, temporary.

these things should be repeated in this place, because the degree of wear of the teeth is one of the means by which the judgment is often assisted; and this is shown by the distance which intervenes between the external and the central ridges of enamel. The value of this fact will be seen the more when I state that the animal now passes nine months of his life without any addition being made to the *number* of his teeth, the *sixth* molar not coming up until he is *eighteen* months old. Conjoined with the condition of the incisors, the times of the cutting of the fifth and sixth molars will be found of much use in our practical investigations into the age of the sheep, and more especially between the dates abovenamed.

From about ten months, a close inspection shows that changes are being wrought in the incisor teeth. Some of them have pretty well served their purpose. The jaws of the animal have grown wider, and room is thereby made for the permanent teeth to come up. The *fangs* of the *central pair* are beginning to be absorbed from the pressure of the bodies of the permanent beneath them, and they have consequently a less firm hold of their sockets than before. The crowns of all the teeth are diminished from attrition, which gives them an appearance of standing wide apart, but far less so than in the ox when his temporary incisors are about to fall. The indications of advancing age gradually increase, so that by the time the animal is a year old the mouth will have the appearance seen in fig. 37.

I may repeat here that which was stated with reference to this condition of the temporary incisors of the ox, namely, that the gradual advance upwards of the incisors to maintain their original

Fig. 37.*

* Fig. 37. Front part of the lower jaw of a sheep at a year old, showing that the incisors are worn flat, and that spaces exist between each of their fangs, although their crowns are still in contact with each other. Natural size; seen from above.

height leads to the fangs being exposed, and is, therefore, among the causes of the width existing between these teeth. An attentive examination will often show, in sheep of this age, a space between each fang, while the faces of the teeth may be in close contact with each other.

At a year old, even greater changes than those just named will occur in some sheep, as they will now cut *the first pair of permanent* incisors. These are unquestionably cases of early teething, but they are far from being unfrequent.

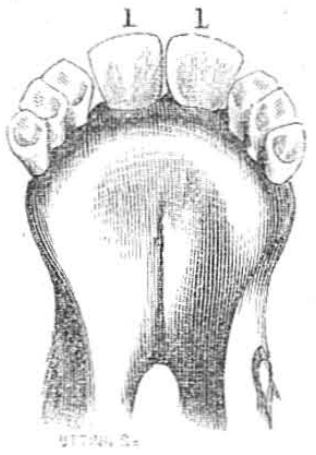
It is matter of great practical import for us to decide, if possible, whether any of the established breeds of sheep are likely to cut the first or central pair of teeth earlier than others, and what other causes besides breed may hasten the process.

With reference to the former part of this inquiry, it may be affirmed that Cotswold sheep, as a rule, have their first permanent teeth before either Southdowns, Shropshire, or Hampshiredowns. Leicesters tread so closely on the heels of the Cotswolds, that it is only by comparing numbers that any decision can be come to with regard to this question; but when this is done, Cotswolds are found to be the earliest in their dentition. How much of this may depend upon a naturally large frame, and a general increase of the size of this variety of breed over the others, and how much upon the efforts that have been successfully made to bring such animals to early maturity, are matters requiring an extended series of experiments of feeding, &c., to decide. It is, however, but with facts that we have now to deal.

An opinion prevails pretty generally among sheep-breeders that ram lambs cut their first pair of permanent teeth before ewe lambs. In our examinations this should be borne in mind, and allowance always made in cases where the point to be decided is a nice one, as it frequently happens to be at this particular period of the animal's life. It must be observed, however, that sex has not so great an influence as is commonly supposed. I find, in comparing Southdown ewe with ram hoggets which have been bred and reared on the same farm, that there is but a very slight difference in favour of the young rams.

On the following page is inserted an engraving of the front part of the jaw of a year-old sheep from a specimen of early teething. The central pair of incisors, marked 1, 1, give evidence, when compared with the height and size of the temporary teeth, of

Fig. 38.*



having been very recently put up. The frequency of the cutting of the first pair of permanent incisors at a year old, by sheep of *all* breeds, has led to my taking this as one of the standards of comparison in the table of *early* dentition which is attached hereto.

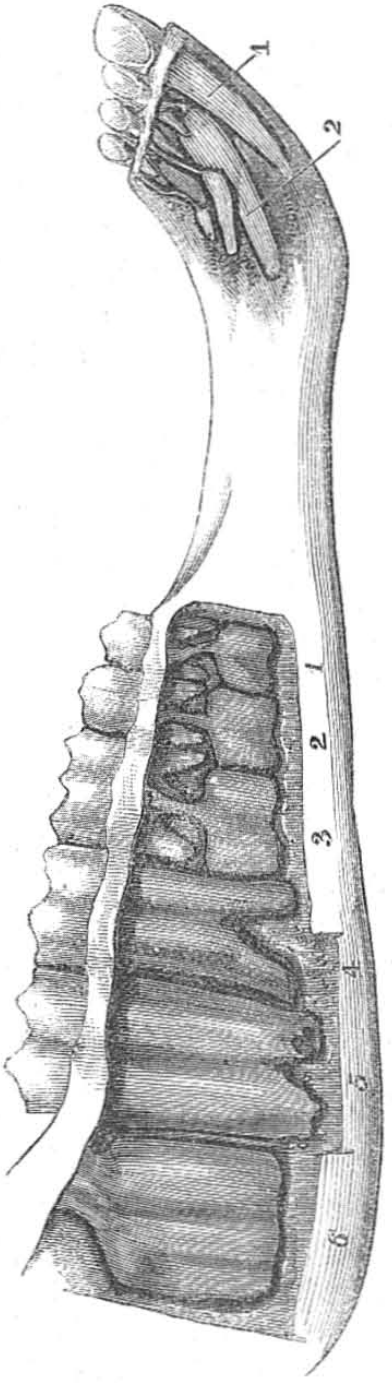
It will be found that the majority of sheep do not cut these teeth till they are about fifteen months old. The chief object of a tabular arrangement would, however, have been defeated, even if fourteen months had been fixed upon as the average time. The judge at a cattle-show might hesitate to award the prize, if he found a twelve or thirteen months' old sheep with two "broad teeth." The variations in the teething of sheep, as in the ox, have required that they should be reduced to two standards of comparison rather than one, and therefore in the first table the times of the earliest dentition are given as I have found them, in taking one breed with another.

At fifteen months, when, as just remarked, the greater number of sheep cut their first permanent incisors, it must be remembered that the animal has five molars on either side of the jaws, and that *two* of these are permanent. As this is an important period in the history of the dentition of the sheep, I add, as with the ox and pig, a view of one half of the lower jaw, dissected to show the true condition of both the incisors and the molars.

It will be noticed in this illustration that one of the first pair of permanent incisors (marked 1, fig. 39) is well up, and that one of the second pair, 2, is so far developed as to be soon cut. The other two incisors are as yet very small, and are situated, as

* Fig. 38. Front part of the lower jaw of a sheep, one year old, showing two permanent incisors, 1, 1. Natural size, seen from above.

Fig. 39.*



* Fig. 39. One half of the lower jaw of a sheep 15 months old, dissected to show the condition of both the incisors and molars at this date. 1, permanent incisor cut; 2, permanent incisor in its capsule; 1, 2, 3, temporary molars with the permanent beneath them in their capsules; 4 and 5, permanent molars up; 6, the last molar enclosed by its capsule. Natural size.

seen in the figure, a little above the second incisor. The three anterior permanent molars are lying in their capsules at the roots of the corresponding temporary teeth, each occupying about the same height in the jaw; a circumstance which explains the fact that the temporary molars, as in some other animals, are changed nearly all together. 4 and 5 are permanent teeth; the first of them was cut at three months, and the second at nine. At this time (fifteen months) they greatly exceed the others in size, but when the anterior molars are fully developed this difference will be less observable. 6 is the last molar, also contained in its capsule and in a state of great forwardness, as it will be cut in about three months from this date.

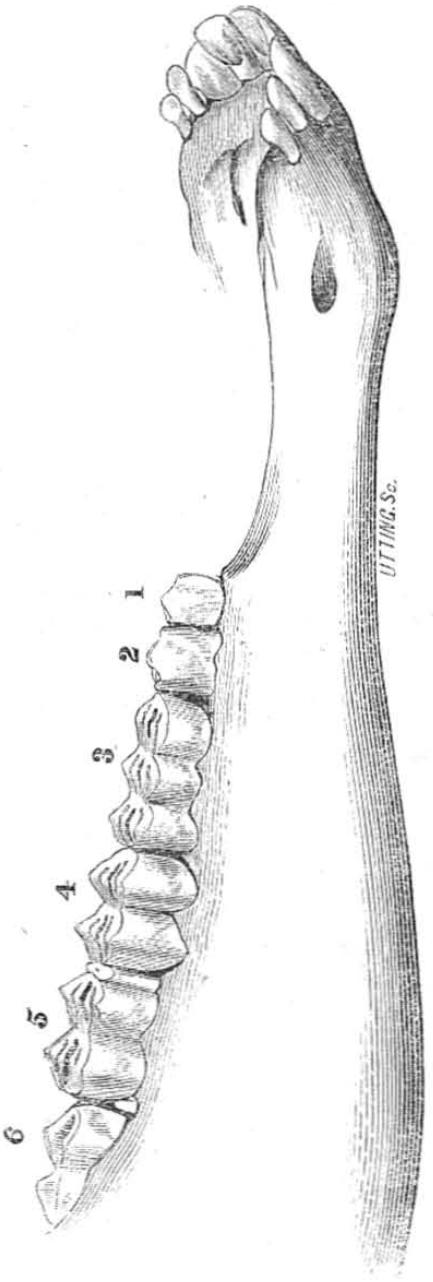
Allusion may here very properly be made to Mr. Youatt's account which has been before quoted. He says that the incisors of the sheep "grow with his growth until the animal is about fourteen or sixteen months old. Then, with the same previous process of diminution which was described in cattle, or carried to a still greater degree, the two central teeth are shed and attain their full growth when the sheep is two years old."

By way of contrast to this, it may be observed that many sheep at *eighteen months* old will have cut the second pair of permanent incisors. Before, however, I proceed to exemplify this, it is right to quote again from Mr. Youatt, as it seems that the writings of other persons obliged him to qualify the preceding statements, and therefore he adds that which is perfectly correct: "In examining a flock of sheep there will often be very considerable differences in the teeth of the hogs or the one *shears;* in some measure to be accounted for by a difference in the time of lambing, and likewise by the general health and vigour of the animal. There will also be a material difference in flocks, attributable to the good or bad keep they have had. Those fed on good land, or otherwise well kept, will take the start of others that have been half starved, and renew their teeth some months sooner than those." He continues, "There are, however, exceptions to this; Mr. Price* says that a Romney Marsh hog was exhibited at the show fair at Ashford weighing fifteen stones of 14 lbs. each, the largest ever shown there of that breed, and that he had not one of his permanent teeth. There are also irregularities in the times of renewing the teeth,

* Price on Sheep Grazing, p. 84.

not to be accounted for by either of these circumstances; in fact, not to be accounted for by any known circumstances relating to the breed or the keeping of the sheep." Mr. Youatt follows up these remarks by quoting some cases of irregular dentition; but to comment on these would draw me too much from my subject.

Fig. 40.*



* Fig. 40. One half of the lower jaw at 18 months, representing the cutting of the last molar tooth. Natural size.

The general tenor of the preceding observations is sufficient to show the impracticability of reducing all these variations in the teething of sheep to one standard rule.

To return. At eighteen months of their age most sheep will cut the *sixth* molar tooth, marking another important stage in the progress of dentition, and one which is of considerable importance when practically considered. Many animals, however, at this date are still without the second pair of permanent incisors. If, on the contrary, these teeth should be in the mouth and *nearly on a level* with the first pair, and the sixth molar not *cutting* but well up, such would be a proper case for investigation, if the animal were certified to be only eighteen months old.

The preceding illustration, fig. 40, represents the *cutting* of the sixth molar, and also the general state of the mouth at this time in a case of early dentition. It will be noticed that the second pair of permanent incisors is of small size, and that the anterior molar teeth are all temporary.

As is the case with regard to the cutting of the first pair of "broad teeth," so with the second, namely, that many sheep do not put them up until three months after others. A *year and three quarters* is to be taken as the average time when sheep will cut their second pair of permanent incisors. But instances are not wanting of sheep being nearly two years old, before these teeth are in the mouth. In fig. 41 is shown the appearance of the teeth under ordinary circumstances at a year and three

Fig. 41.*

* Fig. 41. Front part of the lower jaw of a sheep one year and three quarters old, showing the second pair of permanent incisors, 2, 2, *in situ*. Natural size.

quarters old, the second pair of permanent incisors 2, 2, being up, but not as yet fully developed.

In further explanation of the dentition of this animal we come again to the molars. Our last illustration of these teeth (fig. 40, page 91) showed the sixth molar *cutting* at eighteen months. This tooth attains its proper height by the time the sheep is two years old.

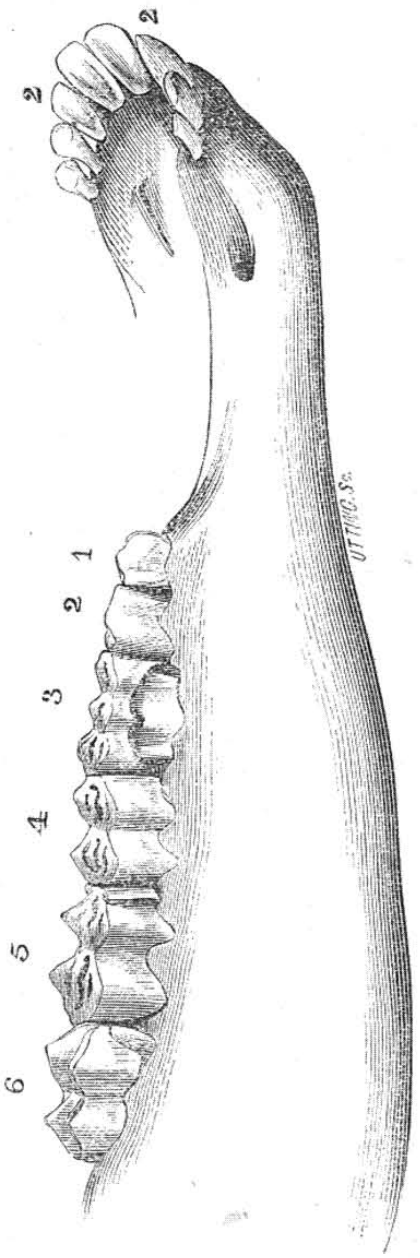
After the cutting of the sixth molar, the three temporary molars are replaced by the permanent, They are renewed nearly all together, and do not appear to follow any definite order in giving place to their successors. Frequently the *second* falls before the *first*, but the *third* is rarely changed before either of the other two. In the annexed illustration (fig. 42, page 94) we have exhibited one-half of the lower jaw of a sheep at two years of age. Here it will be seen that the sixth molar has gained the level of the others, and that the two anterior temporary molars are replaced by the permanent.

The third temporary molar in this illustration is represented in the act of giving place to its successor. The central part of the body of the tooth has become absorbed from the pressure of the one beneath it, but upon this tooth, the crown of the temporary molar adheres, being confined in that situation chiefly by the hold it still has with the gum. Subsequent to these changes being perfected, which is usually by two years and a quarter, the molar teeth can only assist our judgment by our ascertaining the amount of wear which they have undergone. This, as previously explained, is shown by the comparative flatness of their surface, and the width between the outer and inner reflections of the enamel.

To return to the incisors. From two years we come to *two* and a *quarter*, when the earliest cases of *six* permanent incisors are found. The third pair of permanent teeth does not, even in sheep of *early dentition*, succeed the second pair in the same order of time as those teeth did the first pair; there being *six* months only between the cutting of the first and the second pair, but *nine* months between the second and the third. It is somewhat difficult to account for this difference. It may be that the small size of the jaw of the animal, and the great amount of room required by the perfecting so quickly of the first and second pairs, together with the concentration of the developing process in them, that the growth of the third pair is retarded, and that

thus the break in the regularity is produced. In sheep of *late* dentition, as has been explained, the *second* pair of permanent incisors is not in the mouth till two years; and in these same

Fig. 42.*



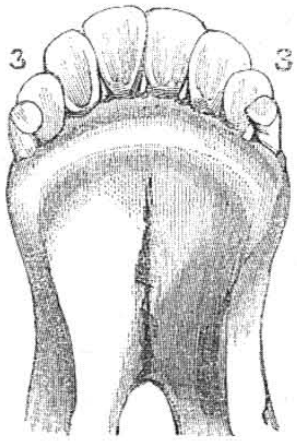
* Fig. 42. Side view of the lower jaw of a sheep at two years old; showing the last molar on a level with the others, the two anterior temporary molars replaced by permanent, and the third in the act of being changed, part of its body still adhering to the gum and capping the upper surface of the permanent tooth. Natural size.

animals the *third* pair is sometimes not cut till about two years and three quarters—adding to the difficulty of forming a correct opinion upon a few examinations, and without standards of comparison.

Fig. 43 gives a view of the front part of the lower jaw of a sheep at *two years and a half* old, the intermediate period between the dates which are cited.

Six permanent incisors are here seen to be well up; the relative size of each of the three pairs is also nicely depicted.

Fig. 43.*



To come to the cutting of the fourth pair, the last of the series. Another *nine* months will sometimes elapse between the cutting of the third and the fourth pair. During this period, from the daily attrition which is going on, the four central teeth will give increased evidence of wear. They will in many instances be flat on their surface, or it may be that this is worn into hollows. The amount of change from this cause will necessarily be regulated by the system of management which has been pursued, and the kind of food upon which the animals have been kept. Even in sheep which have been manger-fed, wear will be apparent, and also not unfrequently an open space will exist between the fangs of the central pair in particular, from the rising of the incisors in their sockets to compensate for their diminished length.

In many districts, as on the heath lands of Norfolk, it often happens that long before the permanent *corner* incisors are put up, the centrally-placed teeth are broken across their bodies, by the

* Fig. 43. Front view of the lower jaw at two years and a half, showing that the third pair of permanent teeth, 3, 3, are *in situ*. Natural size.

rough plants on which the sheep graze. Such animals are called "crones," a term which is clearly derived from χρόνος, age, although in truth it cannot be said that these sheep are really old.

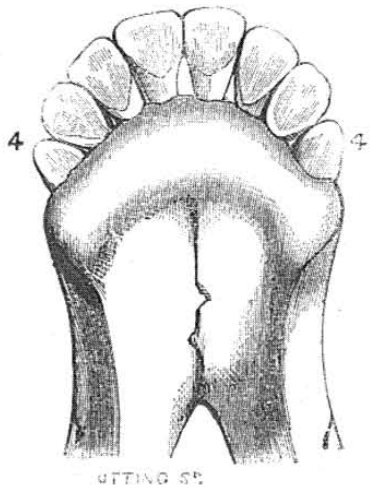
The Norfolk heath-land farmer has to look well to his flock, and to draft such sheep, as they daily lose condition and value. When removed into other districts where they can live on good grass-land, and have "manger food," these animals are however profitable both for breeding and other purposes. They nevertheless require great care; but, with this, "broken-mouthed" ewes are not unfrequently kept for breeding purposes until they become ten, twelve, or fifteen years old, as we see in Leicestershire and other counties. There is this important difference, however, between the *old* sheep of Leicestershire and the "*crones*" of Norfolk, namely, that in the one instance the incisors have been gradually worn away, while in the other they have been prematurely forced out or broken off. A broken incisor often leads to displacement of the other teeth near to it. It will also occasionally lacerate the dental pad, and even not unfrequently work its way through the substance of this pad down to the bone itself. Such things as these require the especial attention of the purchaser of Norfolk "crones."

To return to the time of the cutting of the fourth pair of permanent incisors. It has been already said that these teeth succeed the third pair after an interval of about nine months, which brings the sheep of early dentition to *three years*, and that of late to *three years and six months*. The following figure gives the appearance of the mouth at any intermediate period, namely, three years and a quarter. All the permanent teeth are now in their place, the last pair cut being marked 4, 4 (fig. 44). It is not, however, to be supposed that all sheep will be "full mouthed" even at three years and a half. There are some exceptions to this, for a greater irregularity upon the whole attends the time of the cutting of the fourth pair than of any of the others.

Allowing that there are occasional cases where these teeth are not in the mouth until four years old, we still see that with these *late* exceptions, which do not affect the interests of our Agricultural shows to the same extent as the early instances of teething, that the dentition of the sheep is completed a year before it is said to be by our authors. Mr. Youatt writes, as we have seen, "that at *four* years old the sheep has *six* teeth fully grown, and at *five* years old all the teeth are perfectly developed."

In conclusion, it should be stated that the foregoing account

Fig. 44.*



of the teething of the sheep, is the result of long investigation of the subject, and which has not been arrived at from prize animals exclusively. These sheep fortunately have furnished correct dates of age as well as facts of dentition, while other animals of all breeds, and under all circumstances of keep, have furnished facts with an approximation only to age.

To assist the inquirer into this subject I close the dentition of the sheep by inserting the two tables to which reference has been so frequently made in the course of this exposition.

DENTITION OF THE SHEEP.

TABLE OF EARLY DENTITION.			TABLE OF LATE DENTITION.		
Years.	Months.		Years.	Months.	
1	0	Central pair of temporary incisors replaced by permanent.	1	4	Two permanent incisors.
1	6	Second pair ,, ,,	2	0	Four ,, ,,
2	3	Third ,, ,, ,,	2	9	Six ,, ,,
3	0	Fourth ,, ,, ,,	3	6	Eight ,, ,,

I now proceed to a description of the teething of the animal of which I have lastly to speak, namely, the pig.

* Fig. 44. Front view of lower jaw at three years and a quarter, the fourth pair of incisors, 4, 4, being cut, thus completing dentition. The central pair give evidence of slight wear, and from rising in the sockets an open space is seen between their fangs. Natural size.

DENTITION OF THE PIG.

The importance of a knowledge of the teething of Pigs is but little, if any, less than that of the Ox or Sheep. Perhaps we should not be far wrong in stating, that in several respects it is even of greater moment that the agricultural public should be well informed respecting the evidences which the teeth of the pig afford in determining the age of the animal.

The paucity of precise information which hitherto has existed upon the dentition of the pig, has doubtless led to many of these animals being exhibited at Agricultural shows, whose correct age, if known, would justly have led to their disqualification. Besides this, it has also happened, and from the same cause, that many pigs have been objected to and hence excluded from competing for prizes for which they could have legitimately contended. Opinions of their age have been based almost entirely on the amount of the development of the tushes, and when these teeth have happened to be either large or early formed, the animals have been put aside as being above the age stated in the owner's certificate.

The improvement of our several breeds of pigs has of late years received, and very properly so, much attention from those to whom Agriculture is greatly indebted for her advancement. The result of these efforts has been that we now possess several breeds which not only vie with each other in the rapidity with which they arrive at maturity, but also in their beauty of form, as well as in their aptitude for early fattening. We have therefore, as in cattle, to investigate these causes of improvement, with a view to determine their effects on the dentition of the pig—or rather, perhaps, to master the facts which appertain to the teething of our established breeds.

There exists, as we have seen, amid great diversity of opinion, but little on which we can rely; still, however, it is necessary to give the statements of other writers upon this interesting subject.

The most lengthy description of the dentition of this animal with which I am acquainted—but nevertheless, from its numerous errors, a very unsatisfactory account—is the one given by Mr.

Youatt. He says, in his work on 'The Pig,' quoting from Girard's 'Traité de l'Age du Cochon,' that the hog is born with two molars on each side of the jaw. By the time he is three or four months old, he is provided with his incisive milk teeth and the tushes; the supernumerary molars protrude between the fifth and seventh month, as does the first back molar; the second back molar is cut at the age of about ten months; and the third generally not until the animal is three years old. The upper corner teeth are shed at about six or eight months, and the lower ones at about seven, nine, or ten months old, and replaced by the permanent ones. The milk tushes are also shed and replaced between six and ten months old. The age of twenty months, and from that to two years, is denoted by the shedding and replacement of the middle incisors, or *pincers*, in both jaws, and the formation of a black circle at the base of each of the tushes. At about two years and a half or three years of age, the adult middle teeth in both jaws protrude, and the pincers are becoming black and rounded at the ends.

"After three years the age may be computed by the growth of the tushes; at about four years, or rather before, the upper tushes begin to raise the lip; at five they protrude through the lips; at six years of age the tushes of the lower jaw begin to show themselves out of the mouth, and assume a spiral form. These acquire a prodigious length in old animals, and particularly in uncastrated boars, and as they increase in size they become curved backwards and outwards, and at length are so crooked as to interfere with the motion of the jaws to such a degree that it is necessary to cut off these projecting teeth, which is done with the file or with nippers."*

Such is the history of dentition of the pig as given in the principal work we possess on the diseases, &c. of this animal, and which with the mere opinions of those persons who may have examined a few pigs, either of their own breeding or otherwise, constitutes nearly all the information we have on the subject. To point out the numerous errors, even in the foregoing extract, would draw too much on the reader's patience, and therefore I proceed to more important matter.

First, I may observe, that finding so little to guide my investigations on which reliance could be placed, I resolved to study the teething of this animal from the period of its birth onwards until

* Youatt on the Pig, p. 71.

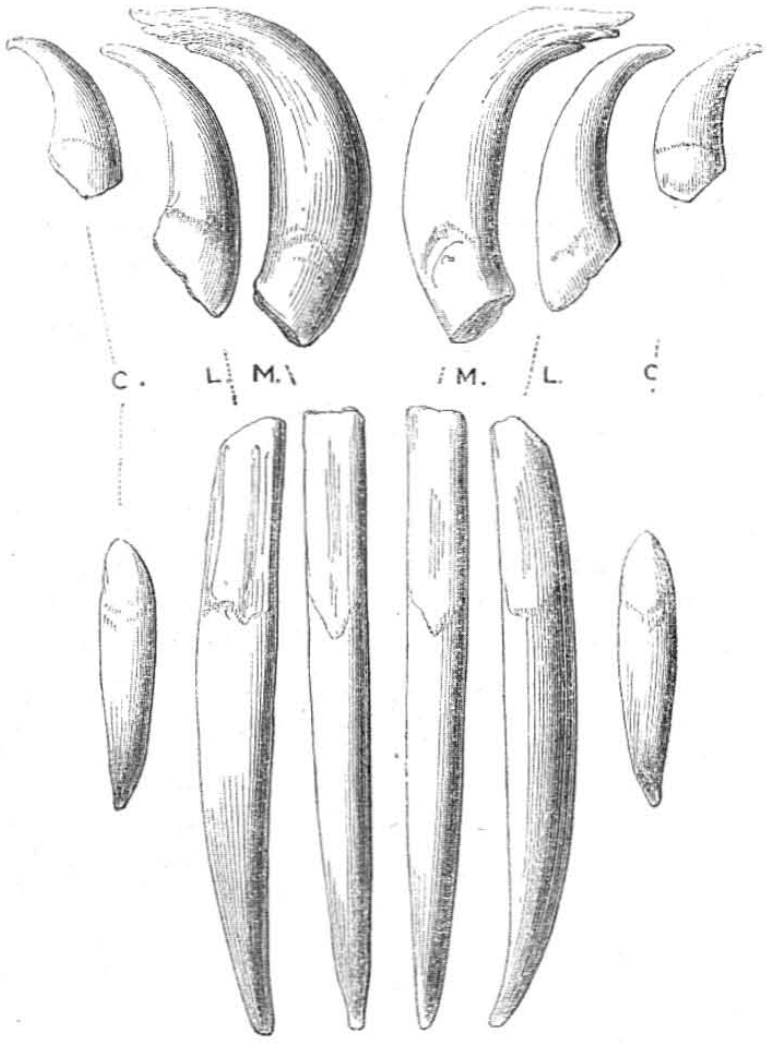
the permanent set of teeth should be completed, and to mark the changes these organs might afterwards undergo, depending either on wear or increasing age. In carrying out this resolve I have availed myself of the opportunities afforded me of examining these animals at the meetings of the Royal Agricultural Society, and of comparing the state of their dentition with their certified ages. Besides this I have from time to time inspected the herds of several of the principal exhibitors at our annual cattle shows, and who, as such, have kept properly arranged entries of the births of their animals. In addition I have also collected a mass of interesting facts by repeated attendance at the slaughter-houses of the metropolis, and have procured from this and other sources specimens of the skulls of pigs from birth to a very advanced age. Upon the whole the conclusions arrived at with regard to the dentition of the pig, as an evidence of its age, have been drawn from the examination of upwards of 500 animals of attested ages, which will probably be considered as a sufficient basis on which to found opinions.

To proceed:—The incisors of the pig, when perfected, differ more from each other in shape and size than do those of any other domesticated animal. Their position also in the upper and lower jaws is varied; those in the upper jaw are vertically placed, while those in the lower have a procumbent direction. Fig. 45, in the following page, represents the permanent incisors as removed from their sockets in a two-years' old pig: the teeth in the upper row belong to the corresponding jaw, as do those in the lower row. The letter M denotes the two middle or centrally-placed pairs, L the lateral, and C the corner. A simple inspection of the illustration is sufficient to point out the great differences in the form and dimensions of these teeth, rendering therefore a further description of them unnecessary in this place.

Unlike both the ox and sheep, the pig is born with a given number of teeth which have cut the gums. These are always *eight*, and are well developed: four of them are situated in the upper and four in the lower jaw. They have very much the appearance of small tushes—a fact which the engraving, fig. 46, page 102, very correctly represents. It will be observed that these teeth, which I have named the *fœtal* incisors and tushes, partly from the circumstance that the place of the former is subsequently occupied by the corner incisors and that of the latter by the permanent tushes, are situated by the sides of the mouth, and consequently they do

not injure the nipple of the sow when it is grasped by the young animal in the act of sucking. In connexion with the position of these teeth is an interesting fact with regard to the tongue of the

Fig. 45.*

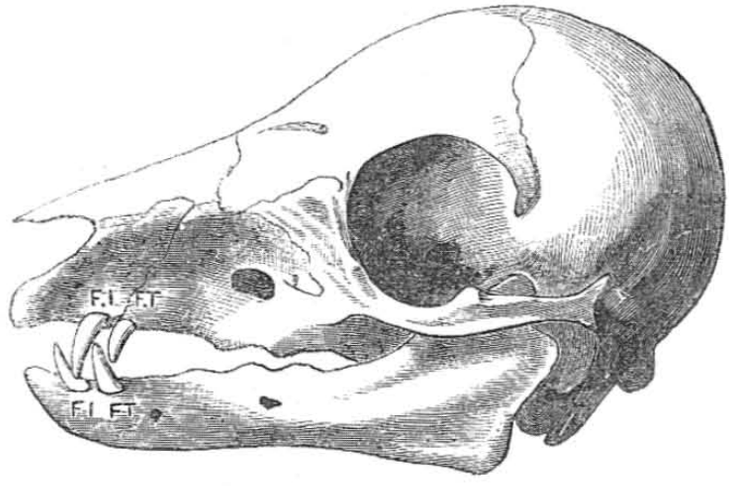


young pig. Most persons are aware that when the pig lays hold of the nipple, he is with some difficulty removed, and that even when the sow rises, the young creature will often be found hanging to the teat. This is partly explained by the circumstance that the tongue is fringed upon its border, and as, in the act of sucking, the organ is doubled along its middle, so these fringes are brought into such a position that they can partially overlap the nipple and produce the grasping power alluded to. It is also pro-

* Fig. 45. Permanent incisors of the pig, removed from their sockets. M M, the middle pair of the upper and lower jaw; L L, the lateral, and C C the corner.

bable that by this peculiar condition of the tongue the teats of the sow are further protected against injury from these pointed teeth.

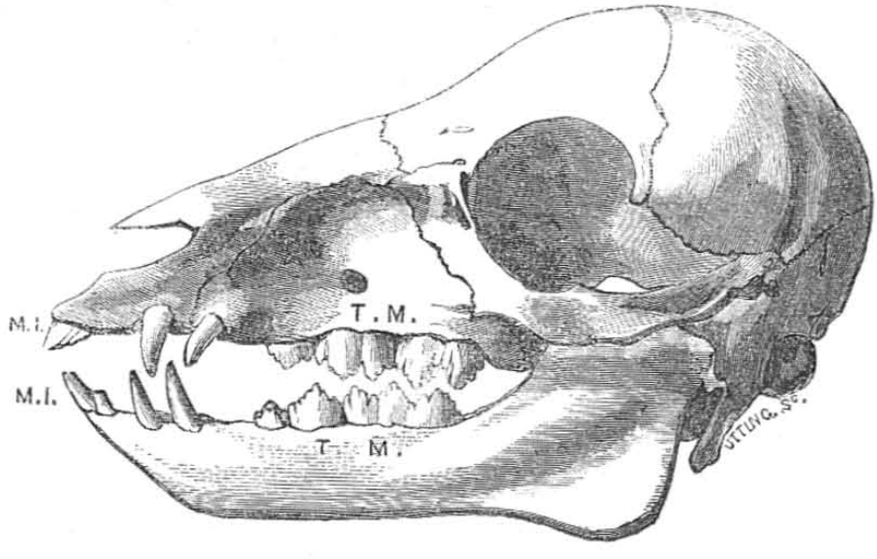
Fig. 46 *



At one month old important additions are made to the fœtal teeth. The young animal at about this time puts up *four* incisors, which are situated directly in the front of the jaws, two above and two below. These belong to the temporary or deciduous set, and are miniature portraits of those teeth which will succeed them.

In fig. 47, which gives a side view of the skull at a month

Fig. 47. †



* Fig. 46. Skull of the pig at birth, seen on the left side. F. I. denote the fœtal incisor, and F. T. the fœtal or temporary tush. This and all the succeeding figures are of natural size.

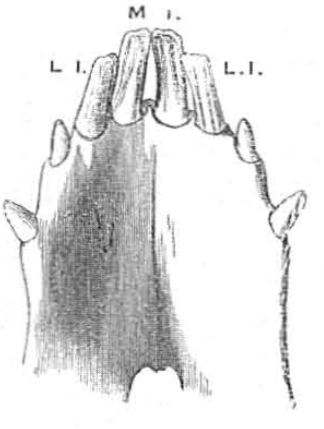
† Fig. 47. Skull of the pig, one month old, showing in addition to the fœtal teeth M. I., the middle incisors; and T. M., the temporary molars.

old, two of these incisors are seen, one in either jaw—upper and lower. They are marked M. I., denoting middle incisors. Although placed in front, these teeth are at first so little developed that no injury to the teat of the sow is likely to be done by them. Within a few weeks their increase of size enables the young animal, by collecting its own food, to live comparatively independent of its dam, and hence arises the fact that young pigs can be safely weaned when about six or seven weeks old.

Besides the cutting of the central incisors at this period, the young pig has now three *temporary molars* on either side of each jaw, T. M., fig. 47. The first of these in situation is generally less forward than the others, and not unfrequently at a month old this tooth has hardly cut the gum. It is also to be noted that the third deciduous molar of the lower jaw agrees in form with the corresponding tooth of the ox and sheep, having three 'semi-cylindrical lobes.' In the preceding illustration it is seen to occupy a space greater than that possessed by the other two molars, and it will be observed how beautifully this increase of size adapts its cusps to fit between those of the upper molar teeth.

At three months of age two more temporary incisors are added to *each* jaw, making, exclusive of the *fœtal corner* teeth, four in the *lower* jaw, as represented in fig. 48, where these teeth are marked L. I., signifying lateral incisors. The full number of temporary incisors is now complete, and the jaws when examined seem to be fairly filled with teeth. The middle incisors, as well as the fœtal corner teeth, and also the temporary tushes and molars, are by

Fig. 48.*



* Fig. 48. The anterior part of the lower jaw of a three months' old pig, showing the fœtal and the temporary teeth. M. I., middle; L. I., lateral incisors.

this time sufficiently grown, that the young animal can be safely left to "shift for himself." No difficulty can exist in judging of the age of the pig at this date: 'first dentition,' as it has been called in medical language, being perfected.

From three to six months the size of the teeth increases with increasing age. At about six months the temporary incisors of the lower jaw, which are always longer but narrower than those in the upper jaw (see fig. 45, page 101), will likewise have attained their greatest length. After this period the incisors will begin sensibly to diminish in length from the daily attrition to which they are exposed. The ultimate amount of this diminution, as well as the rate of its progress, will very much depend on the system of management to which the animal is exposed, as also on the quality of food on which he is kept. The coarser the food and the more the pig has to shift for himself, the greater will be the wear of these teeth, and the shorter consequently will they become. The other changes marking the attainment of six months of age belong to the molar teeth, but in a practical point of view they are of the first importance.

At about this time, in most animals, but not in all, a small tooth comes up on either side of the lower jaw behind the temporary tushes, between them and the molars, and in the upper jaw *directly in front* of the molars. These teeth have a very pointed appearance (see P. M., fig. 49), and they have in consequence not unfrequently been mistaken for the permanent tushes, especially in the *lower* jaw. The pig has therefore been thought to be older than he really is, and objections have been taken to the correctness of the owner's certificate. An error of this kind is more likely to be made should the temporary tushes be either broken off near to the gum or worn away—circumstances of very common occurrence in pigs of this age.

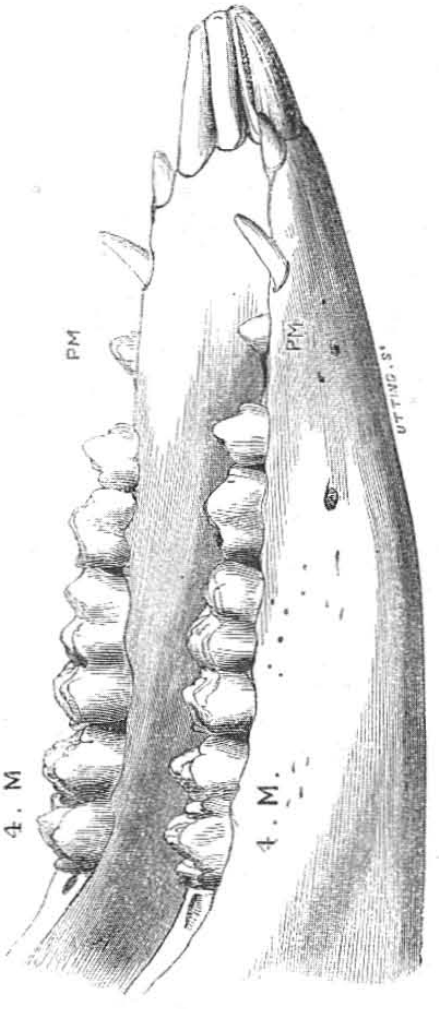
Many persons who call themselves practical have asserted that the pig cuts his tush at six months old. Such, however, is not the case. As we have seen, it is these *pre*molars which have been mistaken for the tushes.

Other interesting particulars likewise belong to these teeth. Professor Owen has applied the term *premolars* to the teeth which succeed the temporary or deciduous set of molars. He limits the ordinary word molar to those teeth which are *not preceded* by similar ones. The term *premolar* is therefore intended to signify the *pre*-existence of other teeth in the situation of these

The premolar in lower jaw may be perceived at 3½ months.

molars. After describing the temporary incisors of the pig, he thus writes: "The other teeth of the first set are the deciduous

Fig. 49 *



molars, the teeth which displace and succeed them vertically are the premolars, the more posterior teeth which are not displaced by vertical successors are the molars properly so called." † Now the teeth of the six months' old pig, to which the reader's attention has been especially drawn, *are not renewed*. They may therefore be correctly called permanent teeth, and as such they are true molars.

In the horse we have the analogues of the premolars, called in this animal 'the wolf's teeth.' It is probable that this name has

* Fig. 49 gives a lateral view of the lower jaw of a pig six months old. P. M., the premolar; 4 M. the fourth molar in situation, but the *first* permanent which is put up

† Cyclopedia of Anatomy and Physiology, vol. iv. p. 903.

been given to them from the circumstance of their being small in size and tush-like in form; the tush being designated the canine (dog's) tooth.

The ox and sheep will also now and then be found to possess a similar teeth, adding to the normal number, and hence termed in these animals the *supernumerary molars.* The existence of these teeth, however, in the horse, ox, and sheep is an exception, but in the pig it is the rule, there being comparatively few of these animals in which they are not found. The *premolars* of the pig, *wolf's teeth* of the horse, *supernumerary* molars of the ox and sheep, are never renewed in any of these animals, if they should be removed naturally or be surgically extracted, thus agreeing in this particular with the permanent teeth.

It will be observed that, although not strictly correct according to Professor Owen's definition, I have retained the term *premolars* for these teeth, and which I have been induced to do because they stand in the front of or before the other molars. I have likewise adopted our usual veterinary nomenclature in designating the other molars temporary and permanent. Something like this arrangement was required, it being necessary to mark in an especial manner these particular teeth from the importance which evidently belongs to the period of their cutting.

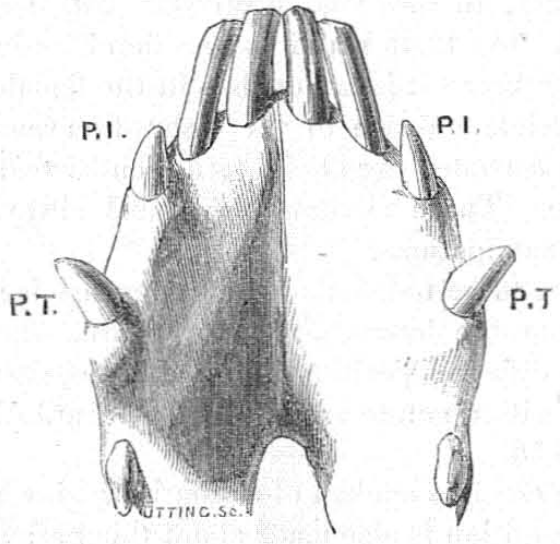
I have now to direct attention to another practical fact which will likewise assist an investigator into the age of pigs, namely, the putting up of the first *permanent* molar at the age of six months. This tooth is marked 4 P. M., in fig. 49, page 105, because it is the fourth in situation. As one of these teeth exists now on either side of both the upper and lower jaws, an addition of four teeth is evidently made at this period.

To proceed :—At nine months old, or very near to this date, the pig has other important changes taking place in his teeth. The fœtal incisors and tushes, which rarely fall before this period, notwithstanding they be worn to the gums, now give place to the permanent incisors and tushes. Thus we see that the first *permanent* incisor is a corner tooth; the pig differing altogether from our other domesticated animals in respect to the renewal of the *corner* teeth before the others. This no doubt depends somewhat on the circumstance, that the teeth displaced were earlier through the gums than the middle or the lateral incisors. Besides this change of the incisors, the permanent tushes, as has been just remarked, also supplant the temporary. These peculiarities

are depicted in the annexed engraving (fig. 50), which represents the front part of the lower jaw at nine months of age.

The permanent incisors in this illustration are marked P. I., and the permanent tushes P. T. It will also be seen that the temporary incisors are short when compared with the figures representing other ages. This diminished length has been before alluded to. It has

Fig. 50.*



been going on since these teeth at six months of the pig's age had nearly acquired their full length, and it assists the inquirer in his researches into the age of the animal. I may add that, in pigs "hard kept," it often happens that by the time they are ten months old, the lower incisor teeth are so worn away, that on a slight inspection of the front part of the mouth, the animals seem to be nearly toothless. One of the most remarkable instances of this kind was brought to my notice when examining the pigs belonging to Mr. Stewart Marjoribanks, of Bushy Grove, Watford. The subject was a young boar, aged ten months, which he had bought to cross with his stock, and which we judged to have been kept on coarse food, or to have been turned into the fields to seek his own living. Notwithstanding this state of the mouth, the animal was in fair condition, and showed no incapability in collecting the food on which he was then living.

With regard to the cutting of the permanent tushes, which as we have seen takes place at about nine months, it may be here

* Fig. 50 represents the cutting at nine months of age of the corner incisors and the permanent tushes. P. I. incisors; P. T. tushes.

repeated that these teeth are subject to more variations in their development than either the incisors or the molars. Breed, sex, character of food, system of management, castration, &c., all exert more or less influence over their size and form. In pigs of "small breed," and especially when great care has been exercised to improve all their good and profitable points, and to lessen the amount of their "offal," the tush is always small. On the contrary, in our "large breeds," with long heads and coarse frames, this tooth acquires considerable dimensions. In the male of any breed it is larger than in the female. Castration invariably restricts the size of the tush, often rendering it even smaller in the castrated pig at eighteen months than in the *entire* male at twelve. These circumstances must always be remembered in our examinations.

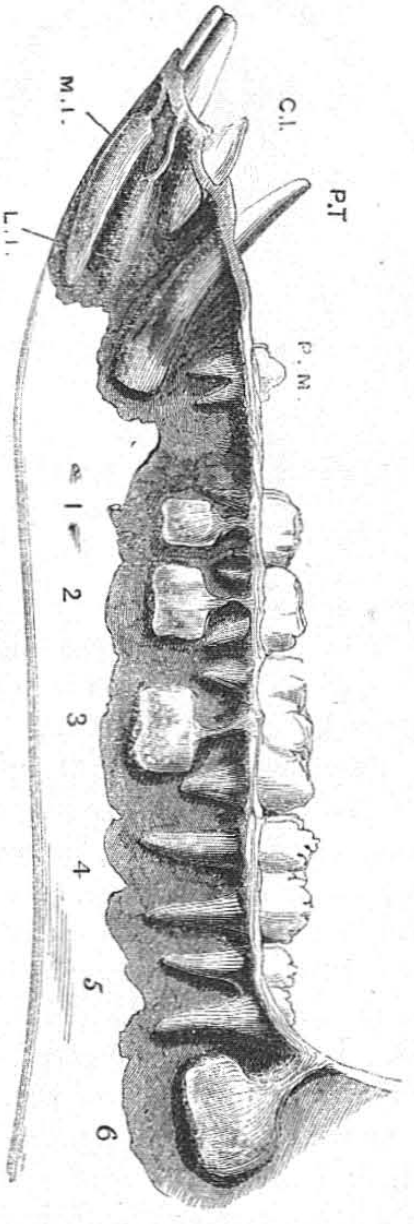
It is likewise to be noted, that the upper tush is always shorter and broader than the lower. This tooth also, when fully developed, takes a different position from the lower, passing outwards from the jaw, with a gentle sweep in a backward direction. See fig. 56, page 115.

Besides the changes spoken of as marking nine months of the pig's age, an addition is also made about this period to the number of the molars, by the cutting of the *fifth* tooth in position, or, as it is sometimes called, the second permanent molar. To render the description more clear, I have added, as in the ox and sheep, an engraving of a dissected jaw, showing the condition of all the teeth—temporary and permanent—at ten months of age. This is the more required, as at the ages above stated many pigs are forwarded to our agricultural shows to compete for prizes.

The letters M. I., and L. I., fig. 51, page 109, denote the middle and lateral permanent incisors, which, being as yet uncut, are depicted as imbedded in the jaw, and covered by their membranous capsules. The corresponding temporary incisors are seen above them, protruding from their sockets and shortened from the wear to which they have been exposed. By the side of the lateral incisor is seen the corner *permanent* tooth C. I. Behind this appears the *permanent* tush P. T., and between this and the molar teeth, the *pre*molar (P. M.). Beneath the three anterior molars, which are temporary, are seen the permanent molars 1, 2, 3, contained in their capsules. The numerals 4 and 5 also represent the corresponding permanent molars—the latter of these is just cutting the gum ; a fact which materially assists us in arriv-

ing at a correct opinion of the animal's age. Behind the fifth molar, the sixth or last (6, fig. 51), is seen, being, like the three anterior permanent molars, covered by its capsule and also deeply imbedded in the jaw.

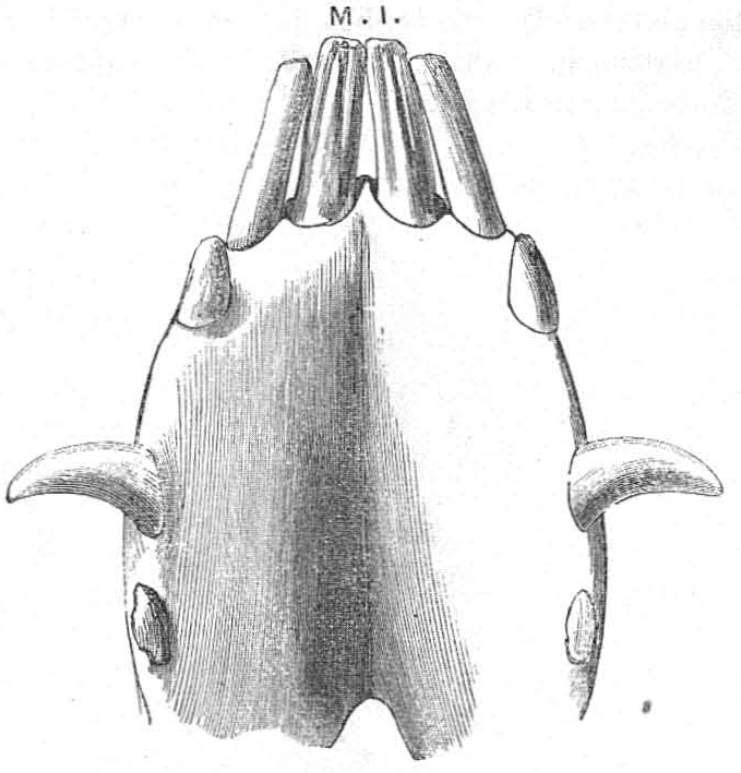
Fig. 51.*



To pass to twelve months. At this date the most important change which takes place is the fall of the *middle* temporary

* Fig. 51. One half of the lower jaw of a pig ten months old dissected to show the condition of the temporary and permanent teeth at that age. For the description see page 109.

Fig. 52.*



incisors and the occupancy of their site by the permanent teeth. The tushes also are now well grown (see fig. 52). The permanent incisors, M, I, differ less from the temporary than perhaps might be expected. An attentive examination, however, will show that, as they are recently put up, so they are of a whiter colour than the others. They are also a little broader and flatter in form. Their chief difference, however, consists in the existence, on their upper or inner surface, of a well-marked ridge running parallel with their long axis, and bounded on either side by a deepish hollow. In the *recently-cut* incisor these hollows unite at the apex of the tooth, giving a pointed extremity to the ridge just described. It should be observed that these remarks apply especially to the teeth of the lower jaw.

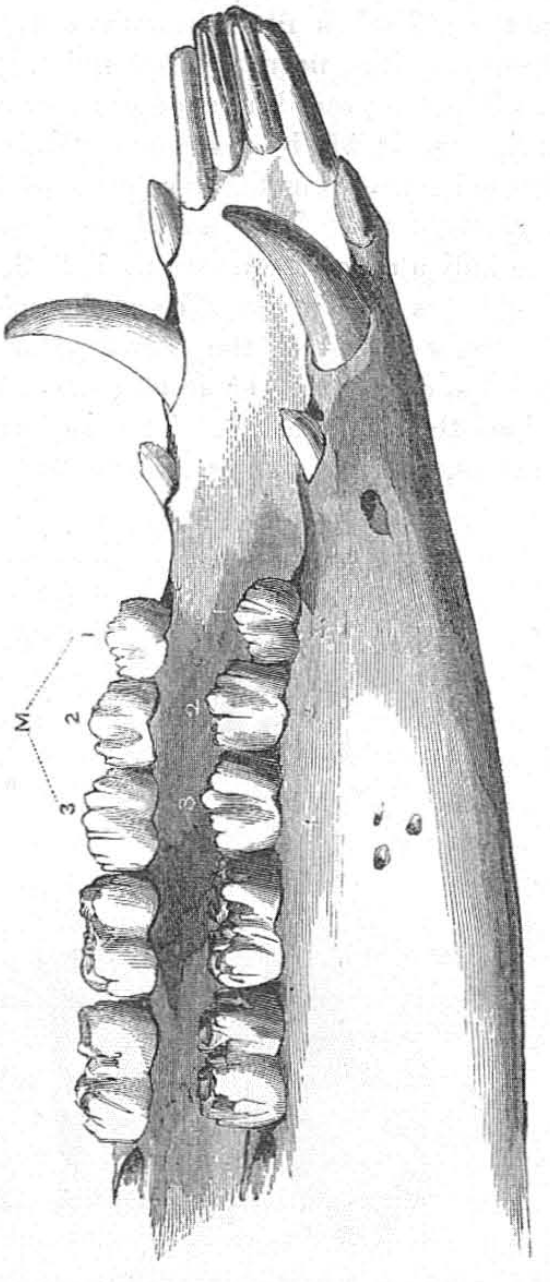
If the particulars above described are borne in mind, the permanent incisors cannot possibly be confounded with the temporary. Most of them are rendered sufficiently apparent in the annexed engraving to prevent such a mistake.

From the preceding remarks it is evident that a person, instead of judging of the age of a pig from the size of the tush alone, must also consider the state of the incisor teeth, and par-

* Fig. 52 represents the front part of the lower jaw at one year old.

ticularly when he is examining an animal said to be a year old. The lower tushes are often at this time fully three quarters of an inch long; but by themselves, these teeth possess hardly any value in determining the question of age. In combination with the incisors they are of value, and the condition of both incisors and tushes must be taken together or not taken at all.

Fig. 53.*



* Fig. 53. Lower jaw of a pig fifteen months old, showing the increased length of the tushes and incisors, and the putting up of the three anterior permanent molars—1, 2, 3, M.

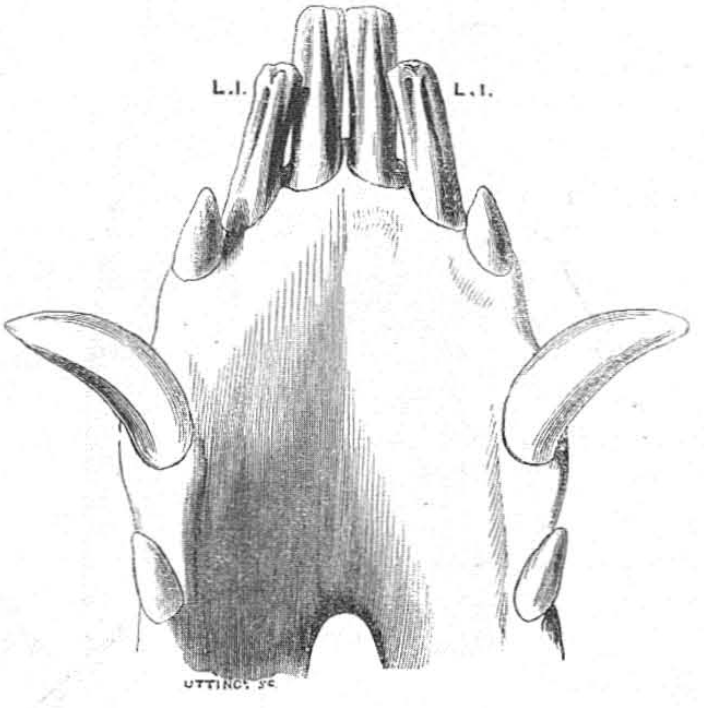
From the corner permanent incisors being put up at nine months, and the middle at twelve, the pig will now have but two *temporary* incisors, the *lateral*, in either jaw.

Another important change also marks the completion of the year, namely, the shedding of the deciduous molars and their succession by the permanent. The two anterior teeth are generally the first to fall, and they are presently followed by the third.

By the time the animal is fifteen months old these permanent molars will have acquired nearly, if not quite, the level of the others. Fig. 53 in the preceding page gives a side-view of the lower jaw at this age. It will be observed that the teeth I am now describing give evidence, from the sharpness of their points, of having been recently cut. They stand in front of the other molars, and are indicated by the numerals 1, 2, 3.

The other changes which are effected between twelve and fifteen months, refer chiefly to the growth of the teeth. The permanent incisors, occupying the front part of the lower jaw, have now attained their full length. The tushes are grown to a still greater extent, and are taking, as segments of a circle, a

Fig. 54.*



* Fig. 54. Front view of the lower jaw at 18 months. L. I., the lateral, *permanent*, incisors are represented as being recently cut and not yet on a level with the middle pair.

gentle sweep upwards and backwards. The corner teeth are likewise large, and the lateral *temporary* incisors are still *in situ*.

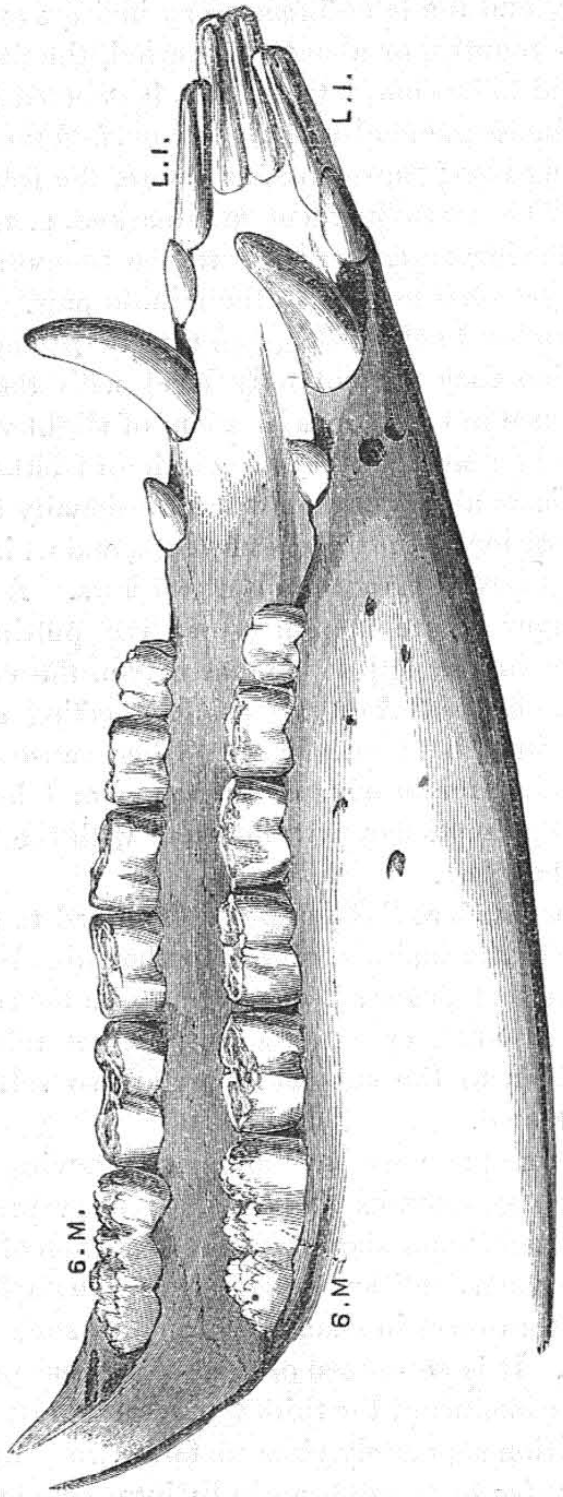
At eighteen months, or about this period, the dentition of the pig may be said to be completed. This is effected by the cutting of the *lateral* incisors and also of the last or *sixth* molar. Fig. 54, in the preceding page, represents, as before, the front part of the lower jaw. The teeth just cut are marked L. I. It will be noticed that having recently displaced the temporary, these incisors are not yet on a level with the middle pair. A short time however will suffice to effect this, and usually by the second year of the pig's age they are not only level with the others, but will give evidence in common with them of slight wear.

It may here be remarked that the cutting of either pair of the permanent incisors above or below is occasionally delayed from an abnormal position of the temporary teeth, and which sometimes depends on an unequal breadth of the two jaws. A specimen of this kind is now before me, in which the putting up of the middle incisors in the upper jaw has driven the corresponding temporary teeth of the lower jaw aside, effecting a distance of more than an inch between them. Other causes besides the foregoing will alter the bearing of the upper and lower teeth on each other, and as such they will interfere with the regularity of the process of teething.

Circumstances such as these now and then lead to a persistency of one or more of the incisors, giving to the animal an increased number of these teeth, as has been shown to be the case occasionally in the ox. Such cases, however, cannot mislead if due attention be given to the subject: they are so self-apparent as easily to be detected.

In the following page we have another engraving (fig. 55) relating to the eighteen-months-old pig. It gives a representation of the sixth or last molar, and shows also the condition of all the teeth of the lower jaw when dentition is perfected. The sixth molar tooth greatly exceeds the others in size, and cannot as such be mistaken for any of them. It is composed of three principal parts blended together after the manner of the third temporary molar of the lower jaw. Each portion separately rises to form two principal cusps which in the *cutting* tooth are beautifully intersected with depressions of various depths, forming altogether a minute rockwork, as it were, of enamel. This condition, however, of the crown of the

Fig. 55.*



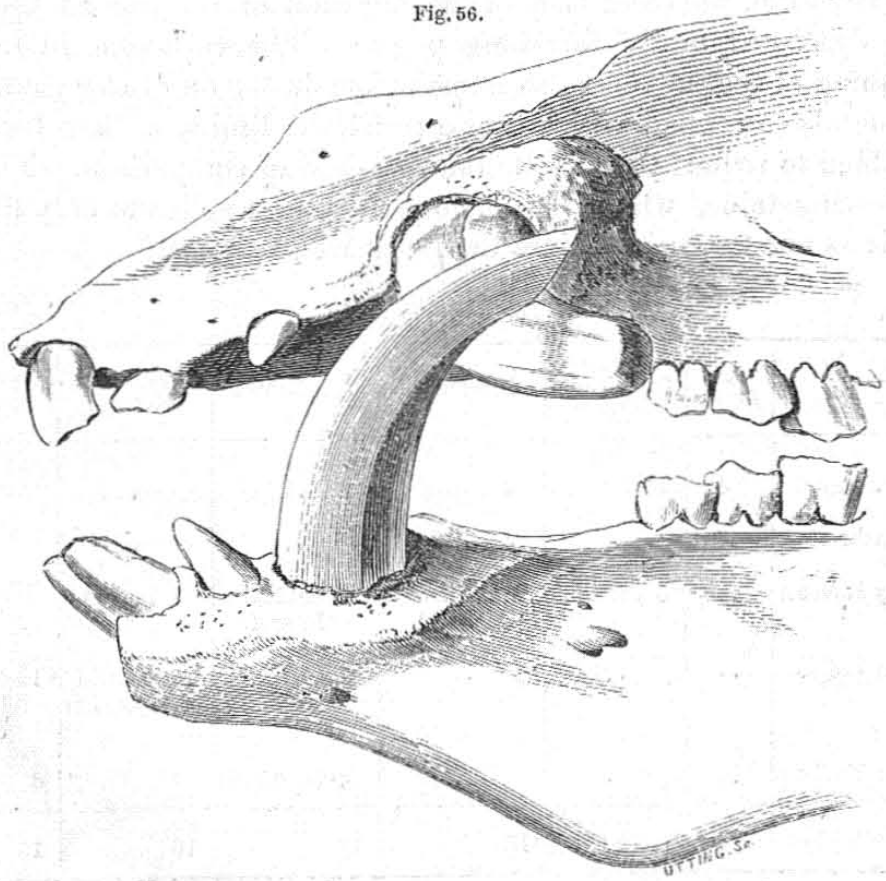
* Fig. 55. Lower jaw of an 18-months-old pig, showing that dentition is completed; all the teeth being now permanent.

tooth after it has penetrated the gum and brought into use is soon effaced by the daily attrition to which it is exposed. Its superior size over the others is nevertheless its distinguishing and persistent feature, thus easily leading to its recognition. Fig. 3, page 24, gives a representation of the cap of enamel which crowns this tooth just prior to its protrusion from its socket.

In fig. 55, also, some of the molars will be observed to already give evidence of wear, particularly the fourth and fifth, arising from their having come early into use. The first named of these teeth, it will be remembered, was cut when the animal was six months old, and the second when about nine.

Between one year and a half, and a year and three quarters, the permanent incisor teeth will reach their fullest development; and from after this period their length, in the lower jaw in particular, will begin to lessen. We are only enabled to judge of the age of the female after this time by the amount of the wear which the teeth as a whole have undergone, and by the general appearance of the animal. In the perfect male, however, the tushes will not

Fig. 56.



as yet have acquired their greatest size, and these teeth will therefore afford us some assistance in determining the animal's age.

The length to which the tushes will grow, and the elegant sweep in an upward and backward direction which is taken by the lower one, and the outward and backward course of the upper, are very correctly represented in the engraving, fig. 56, page 115. The sketch was taken from a specimen forwarded by Mr. Robinson, V.S., of Tamworth, to whose kindness I am likewise indebted for other specimens which have materially assisted my investigations.

With regard, however, to this full development of the tushes, it must not be forgotten that their position, which is subject to slight variation, will likewise influence the amount of their wear, and consequently give to them a somewhat stunted appearance, earlier in some animals than in others.

Some boars are very much addicted to the habit of champing, which action of the jaws when the tushes are so placed as to rub against each other will quickly tend to reduce both the length and size of these teeth.

I will now, as with the ox and sheep, attempt to embody, in a tabular form, the chief facts of the dentition of the pig as they are described in the foregoing pages. The variations in the teething of pigs not being so numerous as in the ox or sheep, and being also confined within more restricted limits, I have been enabled to reduce the facts to one standard of comparison. The following table, which for obvious reasons applies to only the incisors and the tushes, gives the result we require.

DENTITION OF THE PIG.

——	At Birth.	One Month.	Three Months.	Nine Months.	Twelve Months.	Eighteen Months.
Fœtal Incisors	4	4	4	..	..	..
Fœtal Tusks	4	4	4	..	..	..
Temporary Incisors	..	4 central	8 central & lateral	8 central & lateral	4 lateral	..
Permanent Incisors	..	..	..	4 corner	8 central & corner	12 central, lateral, & corner
Permanent Tusks	..	..	..	4 (*cutting.*)	4	4
Total in both jaws	8	12	16	16	16	16

From numerous cases which might be selected in proof of the value of these *data*, I shall take but two, and these are chosen because they are among the more recent ones which have been submitted to my opinion.* A gentleman connected with several of our agricultural societies being much interested in the subject of the dentition of this animal, from various circumstances which had occurred, sent me the jaws of two pigs which he had bred, having made a memorandum of the time of their birth and also of when they were killed.

After examining the first jaw (which I have now before me) I remarked that were my opinion asked on this case, as one in dispute, I should state that the appearances indicated the animal to be about nine months of age.

The other (also before me) was then examined, and the conclusion arrived at was that the animal was a year old.

The statement given by the gentleman sending them was to the following effect:—"No. 1. The jaw-bones of a male pig, farrowed on the 30th of April, 1852, killed on the 15th of February, 1853: nine months and 15 days old.—No. 2. The jaw-bones of a female pig, farrowed on the 22nd of December, 1852, killed on the 2nd of January, 1854: one year and 11 days old." It will be seen that the opinion I had given, and which was formed entirely on the state of the teeth, and without, therefore, that assistance which the growth and general appearance of a living animal affords, approached the exact age within 11 days in one case and 15 in the other.

In bringing this subject to a conclusion I will merely observe that if in our improved breeds of cattle, sheep, and pigs, dentition be perfected earlier than is generally supposed, we are nevertheless in a position, from the amount of information which has been obtained at the annual shows of the Royal Agricultural Society in particular, to do justice in all cases of disputed age. That variations do exist and to some extent in the teething of animals is sufficiently exemplified by the general description which has been herein given, as also by the tables which have been prepared for the elucidation of this subject. Still it is to be hoped that the conclusions arrived at, being, as before said,

* These cases are inserted here because they were mentioned in the lecture given before the Royal Agricultural Society. The opinion of the Secretary was asked with reference to the propriety of their being introduced on that occasion, and he was of opinion that as matters of fact they should not be withheld.

based on upwards of two thousand cases of attested ages, further experience will only tend to their confirmation. Much will be gained if only a spirit of inquiry be awakened on this important subject. In the mean time I feel justified in observing that, if the facts which have been adduced are steadily kept in view, there can be little doubt of an investigator arriving at a correct conclusion with reference to the age of any of the animals of which these pages treat; and thus one at least of the many noble objects which the Royal Agricultural Society has laboured to accomplish will be obtained, in accordance with the principle of its well-known motto—

"PRACTICE WITH SCIENCE."

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