DENTAL ANATOMY NOTE BOOK

DOUGLAS GABELL

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DENTAL ANATOMY NOTE BOOK

FOR USE IN CONJUNCTION WITH TOMES' "DENTAL ANATOMY," THE SOUTH KENSINGTON MUSEUM

AND

PERSONAL INSTRUCTION.

BY

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[2ND ED.]

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PREFACE TO THE SECOND EDITION.

THE first edition of the DENTAL ANATOMY NOTE BOOK was no sooner published than it was sold; and, having since had numerous requests for copies, I have decided to amend and reprint it.

In spite of complaints as to its unwieldiness, I have kept to the original size, because I wish the book to remain essentially a "Note Book," the blank pages and the spaces in the text being left for diagrams and notes to be made by the student when reading up the subject of Dental Anatomy or being "coached."

The first part is practically Tomes' *Dental Anatomy* condensed, the second is intended as a guide to the study of the cases in the Central Hall of the South Kensington Museum, and the third is compiled from various sources.

All through the work an attempt has been made to tabulate concisely and to accentuate the principal points; details must, of course, be sought for in other books and in the examination of the actual specimens. The "How to show" and "Learn to *recognise* and explain" notes refer to microscope work, and are reminders to the student of *his* duty to a "**Note Book.**"

DOUGLAS GABELL.

CHILTERN VILLA,
NEW BARNET.
November, 1900.

DENTAL ANATOMY.

TEETH are hard calcified or horny masses placed in or near the orifice of the alimentary canal, for the prehension or comminution of food.

The **FUNCTIONS** of teeth are:

PREHENSION . .	as in the **Pike, &c.**
COMMINUTION . .	" " " **Tiger, Elephant, &c.**
COMBAT	" " " **Tiger, Pig, Narwal, &c.**
Locomotion . . .	" " " **Walrus.**
Anchorage . . .	" " " **Dinotherium.**
Transport . . .	" " " **Elephant.**
Speech	" " " **Man.**

ORIGIN AND HOMOLOGIES of the Teeth.

(**Homologous.**—Having like relations to a fundamental type; or, corresponding in type of structure.)

Read up a rough outline of **EMBRYOLOGY; EPIBLAST, MESOBLAST, and HYPOBLAST.**

The mouth is lined with **Epiblast.**

Note the similarity and continuity of the Placoid scales and teeth in a young dog-fish.

Note the similarity of fishes' teeth to mammalian teeth.

Therefore **Teeth** are **Homologous** with **Dermal Spines** both in origin and structure.

Teeth may be classified as

HORNY teeth, which consist of the hardened and thickened **Stratum Corneum** covering enlarged papillæ, and having an **Albuminous** matrix, and

CALCIFIED teeth, which consist of **Enamel, Dentine,** and **Cementum,** and have a matrix composed of **Collagen.**

Calcified teeth **ALWAYS** have an Enamel Organ even if no enamel is formed. Cementum only occurs on socketed or partially socketed teeth.

ENAMEL

Is very hard, brittle, bluish-white, and semi-translucent.
And composed of **Calcified Prisms** in a **Calcified Matrix.**

CHEMICAL COMPOSITION.

Organic Matter,	(mucin ?)	**NONE.**
Salts,	CALCIUM PHOSPHATE, Calcium carbonate, Calcium fluoride, Magnesium phosphate	**95 %**
Water,	(chemically combined with the salts)	**5 %**

THE MATRIX

Is very small in amount, absolutely calcified, but is more easily dissolved by acids than the prisms.

THE PRISMS

Are long hexagonal varicose rods, solid, and absolutely calcified, but the centre is usually more easily dissolved by acids than the external part.

In the **Eel**	No structure is visible.
Manatee	Straight prisms.
Sciuridæ	Lamellate thus :—
Beaver	Lamellate and flexuous prisms thus :—
Porcupine	Lamellate and spiral prisms.
Leporidæ	No lamellæ, only flexuous prisms.
Muridæ	Serrated prisms.
Man	Straight or slightly flexuous prisms.

The **Transverse Striæ** of prisms are due to either:—1. Varicosity of the prisms.
2. Intermittent calcification.
3. Decussation of the prisms.
4. Boedecker's "thorns."
or 5. The action of acids (balsam).

In all **Marsupials** (bar the **Wombat**), some **Rodents (Jerboa)**, some **Insectivora** (**Soricidæ**), **Hyrax**, and some **Fishes (Barbel, Porbeagle Shark)**, the central portions of the prisms remain **Uncalcified**, *i.e.*, **Tubular Enamel.**

Sometimes this happens at the inner parts of the enamel only, sometimes at the outer part (**Sargus**); often this condition is irregularly distributed.

LEARN TO RECOGNISE and explain :—

"BROWN STRIÆ OF RETZIUS."
"SCHREGER'S LINES."
"TOMES' LINES."
"BOEDECKER'S THORNS."
"PIGMENT IN THE ENAMEL."
"IRREGULAR FISSURES NEAR THE DENTINE."

DISTRIBUTION OF ENAMEL.

Absent from	**Edentata, Narwal,** some **Cetacians, Reptiles,** and **Fish.**
Tip only in	**Hake, Eel, Elephant's** tusk.
All over crown in	**Man** and most **Mammalia.**
Front or sides only of tooth in	**Rodents'** incisors. Canines of **Suinæ, Iguanodon.**

LEARN HOW TO SHOW:—

ENAMEL PRISMS, TRANSVERSE STRIÆ, STRIÆ OF RETZIUS, SCHREGER'S LINES.

DENTINE.

Varieties.

Hard (unvascular), **Plici-dentine, Vaso-dentine,** and **Osteo-dentine.**

Hard Dentine

Is hard, elastic, yellowish and semi-translucent, and composed of a **Calcified Matrix,** permeated by **Tubes** containing **Fibrils.**

CHEMICAL COMPOSITION (dried dentine).

Organic matter,	Collagen, Elastin	**20 %**
Salts,	CALCIUM PHOSPHATE, Calcium carbonate, Calcium fluoride, Magnesium phosphate	**72 %**
Water,	(chemically combined with salts)	**8 %**

FRESH dentine also contains 10 % of FREE water.

THE MATRIX

Is collagen impregnated with salts. When decalcified a very faint fibrous structure is apparent.

THE TUBES (Sheaths of Neumann)

Run at right angles to the surface of the pulp, and
Decrease in diameter as they near the periphery;
Those at the neck of the tooth have a large flexuous **Primary Curve,**
Those in the root have many small spiral **Secondary Curves.**
Many little lateral branches are given off, and
The tubes terminate:—In forked extremities,
in loops with each other,
in the granular layer,
in fissures in the enamel,
or by anastomosing with the **canaliculi** in the cementum.

The tubes are said to be composed of **Elastin** and **lime salts,** and **resist** the action of acids and alkalies.

THE FIBRILS

Are soft, sentient, branched processes of the odontoblasts.
Proofs = stretching and contraction. **Functions** are nutritive and sentient.

LEARN TO RECOGNISE and explain:—

"SCHREGER'S LINES."
"OWEN'S LINES."
"INTERGLOBULAR SPACES."
"GRANULAR LAYER OF TOMES."

LEARN HOW TO SHOW:—

OWEN'S LINES, INTERGLOBULAR SPACES, SCHREGER'S LINES, GRANULAR LAYER, SHEATH OF NEUMANN, DENTINAL FIBRIL, FIBROUS MATRIX.

Plici-Dentine.

The pulp is more or less folded. No cementum intervenes.

Varanus, Lepidosteus Oxyurus, Lepidosteus Spatula, Labyrinthodon, Myliobates, Orycteropus (Cape Ant-eater), and **Pristis** (dermal spines).

The last three might be regarded as fused simple teeth.

Vaso-Dentine.

The dentinal tubes and fibrils are replaced by **Canals** containing **Capillary** blood-vessels.

The **Matrix** is often laminated (also "thorns"), and in its outer part a fibrous structure is often visible.

Vaso-Dentine is softer than hard dentine.

In the **Hake, Chætodonts,** and **Ostracion** there are no dentinal fibrils.

In the **Flounder, Megatherium, Iguanodon, Odontostomus,** and **Haddock** there are both capillaries and fibrils.

In the **Lotella** there are neither.

Sargus and **Manatee** show the remains of a vascular system.

Vascular canals are rarely found in **Human** dentine.

Osteo-Dentine.

Calcification takes place in the substance of, as well as on the surface of, the pulp.

There is usually an outer layer of fine tube dentine, then irregular trabeculæ of dentine containing **Canaliculi** and sometimes **Lacunæ**, and between the trabeculæ are spaces filled with pulp tissue and lined with flattened cells;

Pike and **Lamna.**

NOTE THE GRADATIONS BETWEEN

HARD, PLICI-, VASO- (BOTH SORTS), OSTEO-DENTINE AND BONE.

Secondary Dentine

May be of any of the varieties above mentioned, or structureless, or irregular.

It occurs very readily in **Elephants'** tusks and **Whales'** teeth,

And normally in the pulps of **Persistent** growing teeth;

Also in any pulp as a **Pathological** condition.

LEARN HOW TO SHOW:—

PLICI-, VASO-, OR OSTEO-DENTINES. (a) WITH; (b) WITHOUT SOFT PARTS.

PULP.

Composed of **Matrix, Cells, Fibrous Tissue, Vessels** and **Nerves.**

FUNCTIONS.

Formative; Nutritive; Nervous.

THE MATRIX

Is plentiful, soft and jelly-like.

THE CELLS.

The **central** cells are numerous and have fine processes.

The odontoblasts (membrana eboris) form a complete surface layer; they are large elongated granular cells and send out processes: 1, into the **Dentine** (dentinal fibril), 2, **laterally**, and 3, towards the **pulp.**

In old age the odontoblasts become smaller and more oval.

THE VESSELS.

Arteries, capillaries, veins, and **no** lymphatics.

THE NERVES.

Three or four medullated nerves, which soon lose their sheaths and form a plexus near the surface of the pulp (plexus of Raschkow). The nerves probably terminate as fine varicose filiments between the odontoblast cells. Other views are that they join the dentinal fibrils, or run with them, or that they join the pulp processes of the odontoblasts.

THE FIBROUS TISSUE

Is very faint and continuous with that in the matrix of the dentine.

In old age it increases and the cells disappear.

LEARN TO RECOGNISE and explain:—

"BASAL LAYER OF WEIL."
"ODONTOBLASTS."

LEARN HOW TO SHOW:—

ODONTOBLASTS, PULP TISSUE IN SITU, NERVE TRUNKS, NERVE ENDINGS.

CEMENTUM

Consists of a **Calcified Matrix** containing **Lacunæ**, **Canaliculi** and sometimes blood-vessels.

CHEMICAL COMPOSITION.

Almost the same as bone.

THE MATRIX,

If thin, is **structureless** or granular.

If thick it is **laminated** and contains **lacunæ**.

LEARN TO RECOGNISE and explain:—

"SHARPEY'S FIBRES."

"INTERCREMENTAL LINES OF SALTER.

THE LACUNÆ

Are not usually present in thin cementum.

They are more irregular in size and shape than **bone lacunæ**.

The **Canaliculi** are abundant, especially towards **the surface**.

Each lacunæ is filled with a **Cement Corpuscle**.

LEARN TO RECOGNISE and explain:—

"ENCAPSULED LACUNÆ."

THE BLOOD VESSELS

Occur in thick cementum only, and do not form **Haversian systems**.

DISTRIBUTION.

Cementum is rare in Fishes and Reptiles.

It covers the roots in all Mammalia teeth and the **crowns** of some.

It is the **most external** dental tissue.

LEARN HOW TO SHOW:—

SHARPEY'S FIBRES, INTERCREMENTAL LINES OF SALTER, LACUNÆ AND ENCAPSULED LACUNÆ.

NASMYTH'S MEMBRANE

Is a thin layer of **Hardened Epithelial Cells** (derived from the enamel organ), covering the enamel, and having on its inner surface a thin, structureless membrane.

LEARN HOW TO SHOW:—

NASMYTH'S MEMBRANE IN SITU, also its STRUCTURE.

GUM

Is composed of **Stratified Epithelium** covering broad **Papillæ,** which contain numerous **Blood-Vessels** and a few **Nerves,** bound together by much FIRM **Fibrous Tissue,** the latter blending with the periosteum of the alveolus.

It is hard, dense, firmly adhered to the bone, very vascular and only slightly sentient.

LEARN TO RECOGNISE and explain:—

"GLANDS OF SERRES."
"POCKETS" ROUND THE TEETH.
"HEALTH LINE."

LEARN HOW TO SHOW:—

GUM IN SITU, NERVES, GLANDS OF SERRES.

ALVEOLO-DENTAL MEMBRANE

Is composed of bundles of **White Fibrous** Tissue containing **Blood-Vessels, Nerves** and **Cells** between the meshes.

It serves to fix the teeth, to prevent shock and damage to the nerves, and to nourish the cementum.

THE FIBRES

Are non-elastic and run **obliquely** from the bone to the tooth.

The ends of these fibres become imbedded in the hard tissues to form

"SHARPEY'S FIBRES."

THE BLOOD VESSELS

Are very numerous and derived from the bone, gum and apical vessels.

They form a capillary net-work close to the cementum.

Lymphatics are plentiful and most visible near the apex.

THE NERVES

Are derived from the bone and apical nerves and render the membrane HIGHLY sensitive.

THE CELLS

Are found between the fibres, especially near the cementum (osteoblasts).

Nests of Epithelial cells are also often found, which are remnants of the **Epithelial Sheath of Hertwig,** and form the so-called

"GLANDS OF SERRES."

The alveolo-dental membrane is thickest near the neck and apex. In old age it becomes thinner.

LEARN HOW TO SHOW:—

PERIOSTEUM IN SITU, GLANDS OF SERRES, BLOOD-VESSELS.

DEVELOPMENT OF THE TEETH.

IN FISH.

In the Elasmobranch fish there is a continuous growing **tooth band, enamel buds,** and **dentine papillæ,** but no follicle, and the enamel organ is very simple in structure.

In Teleost fish there is no tooth band or follicle, and each simple **enamel bud** and **dentine papilla** is developed *de novo*.

IN REPTILES

There is a continuous growing **tooth band, enamel buds,** and **dentine papillæ,** the whole being enclosed in a fibrous sac, a sort of common follicle, forming the **"area of tooth development."**

IN MAMMALIA (*e.g.*, Human)

There is a **tooth band** of limited growth, only two sets of **enamel buds** and **dentine papillæ,** each pair having its own **follicle.**

Confining our description for convenience to the lower jaw, at the:—

6th week

An ingrowth of epithelium occurs all round the margin of the jaw.

7th week

This ingrowth divides into two bands, an outer vertical **"labio-dental strand"** (lippenfurche), and an inner more horizontal **"dental lamina"** (zahnleiste), and a groove **"dental furrow"** appears at the origin of the latter from the surface. Calcification of the bone starts.

9th week

Ten enlargements, **"enamel buds,"** appear near the free end of the dental lamina.

10th week

Eight thickenings of the mesoblast appear against the under surface of the enamel buds **"dentine papillæ."** The enamel buds have become club shaped.

11½th week

Two more dentine papillæ appear, *i.e.*, ten "tooth **germs"** are now formed.

The central cells of the lippenfurche atrophy to form the labio-dental sulcus.

14th week

The enamel buds for the incisors develop into **"enamel organs."** The bone commences to grow up round the developing teeth. The dental lamina extends backwards free from the gum.

17th week

Another enamel bud (for the six-year old molar) appears with its corresponding dentine papilla. The dental lamina is beginning to **become fenestrated** at the front of the mouth.

20th week

Calcification starts in the **milk incisors.**

24th week

Enamel buds and dentine papillæ for the permanent incisors and canines appear. Calcification commences in the temporary canines and molars.

29th week

The enamel bud for the 1st bicuspid appears.

33rd week

The enamel bud for the 2nd bicuspid appears.

AT BIRTH

The dental lamina is cribriform in front, but whole at the back of the mouth.

The necks of the enamel organs of the incisors have gone, those of the molars are whole.

The teeth are calcified thus:—

The germs of the permanent incisors and canines are visible to the naked eye, those of the bicuspids and 2nd and 3rd molars are not yet visible.

The crypts are incomplete and the permanent and temporary teeth are in a common loculus.

TEMPORARY DENTITION.

	CENTRAL.	LATERAL.	CANINE.	1st MOLAR.	2nd MOLAR.
Enamel buds appear	9th week.	9th week.	9th week.	9th week.	9th week.
Calcification starts	20th week.	20th week.	20th week.	24th week	24th week.
Condition at birth	1 (crown).	$\frac{4}{5}$	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{1}{2}$
Eruption occurs	6th month.	9th month.	18th month.	14th month.	26th month.
Calcification ends	3rd year.	$3\frac{1}{2}$th year.	$4\frac{1}{2}$th year.	5th year.	6th year.
Absorption starts	4th year.	5th year.	9th year.	7th year.	8th year.

PERMANENT DENTITION.

	C.	L.	C.	B_1.	B_2.	M_1.	M_2.	M_3.
Enamel bud appears	24th wk.	24th wk.	24th wk.	29th wk.	33rd wk.	17th wk.	4th mth.	3rd yr.
Calcification starts.	1st mth.	2nd mth.	6th mth.	$1\frac{1}{2}$th yr.	2nd yr.	At birth.	2nd yr.	12th yr.
Condition at 6 years	1 (crown).	$\frac{4}{5}$	1	$\frac{2}{3}$	$\frac{1}{3}$	$\frac{1}{4}$ (root).	$\frac{1}{3}$ (crown).	—
Eruption occurs	7th yr.	8th yr.	11th yr.	10th yr.	11th yr.	7th yr.	13th yr.	24th yr.
Calcification ends	10th yr.	10th yr.	11th yr.	13th yr.	13th yr.	9th yr.	16th yr.	?

ENAMEL ORGAN.

The enamel bud is composed of cubical epithelial cells, and is at first only a thickening of the lower end of the tooth band; it then becomes club shaped, and then bell shaped, growing out on the **Labial** side of the tooth band. Next as it increases in size and encloses the dentine papilla it becomes differentiated into four layers: the **External Epithelium,** composed of oval cells; the **Stellate Reticulum,** composed of stellate cells; the **Stratum Intermedium,** composed of one or two layers of oval cells; and the **Internal Epithelium,** composed of large, long, granular, columnar cells with the nucleus at the outer end.

The **functions** of the:—

Internal epithelium (ameloblasts) is to form enamel,
Stratum intermedium is to recruit the internal epithelium,
Stellate reticulum is to act as a packing material,
External epithelium is to form Nasmyth's membrane.

The enamel organ only becomes thus specialised where it is going to produce enamel. It is continued on as a thin layer of oval cells so as to invest the whole of the roots of the tooth; this continuation is called the **"Epithelial Sheath of Hertwig."**

DENTINE PAPILLA.

The dentine papilla is at first only a thickening of the mesoblast in front of the enamel bud, but presently the surface cells develop into columnar cells (odontoblasts), smaller and less regular than the ameloblasts, but still well marked off from the underlying round cells of the rest of the papilla, which is well supplied with blood vessels and nerves.

DENTAL FOLLICLE or sac.

The follicle at first appears as a thickening of the mesoblast cells outside the enamel organ and continuous below with the dentine papilla. At first it is composed of very loosely packed cells, but later on it becomes differentiated into an outer firm fibrous layer and an inner very vascular more cellular layer; little processes from the latter project into the enamel organ a short way. The **functions** of the outer layer are to protect the developing tooth and later on to form the dental periosteum, those of the inner layer are to nourish the enamel organ and eventually to form the cementum.

When a very thick layer of cementum has to be formed the inner layer of the follicle becomes **cartilaginous** before calcification takes place, this cartilage is called the **"Cement organ."**

A **small foramen** exists behind the necks of the temporary teeth for the transmission of a small artery and a little fibrous tissue from the gum to the follicle of the permanent tooth.

CALCIFICATION—Impregnation with lime salts.

Excretion theory (molusks) ; **Conversion** theory.

CALCOSPHERITES and CALCOGLOBULIN.

(Woodhead's theory of Degeneration and Dialysis.)

ENAMEL.

Facts.

Large granular Ameloblast cells, with nuclei at their outer end, exist.

In the corners of these cells, Fibrils appear (Osteo-genetic fibres).

The corners become tougher (calcoglobulin, "membrane").

Lime salts are deposited in the corners (middle soft part is Tomes' process).

All these changes spread inwards and upwards.

(In **Marsupials** the centre of the prisms remain uncalcified).

Theories.

Cells grow at nucleus end and become impregnated with lime salts at the other end (Conversion theory).

Cells grow at inner end, and the new part becomes impregnated.

Cells do not grow, but excrete matter from the inner end which becomes impregnated (Excretion theory).

DENTINE.

Facts.

Odontoblasts with large nuclei and rounded ends, imbedded in a slightly fibrous matrix, exist. Toughening of the matrix occurs, then a deposit of calcospherites. The Odontoblasts move off, but leave strips behind them (Dentinal fibrils). The toughness follows and surrounds them (Sheath of Neumann). Lime salts are deposited in between the fibrils (Dentine matrix).

Theories.

Odontoblasts form matrix sheath and fibrils.

Odontoblasts secrete a fibrous matrix, and themselves form the fibrils.

Odontoblasts form fibrils, and Intercellular substance forms matrix (Mummery).

VASO-DENTINE.

Fact.

The fibrous matrix is better seen.

Theory.

Same as before, but the Odontoblasts move away completely, and the Capillaries do not.

OSTEO-DENTINE.

Fact.

Calcification occurs on the surface and IN THE SUBSTANCE of the pulp also.

Theory.

Same as for Ossification in membranous bone.

CEMENTUM.

Facts.

A fibro-cellular membrane exists and becomes impregnated with lime salts.

When a very thick mass of cementum is formed, the fibrous membrane becomes cartilaginous before calcification occurs (Cement organ).

Theory.

Cementoblasts form both Matrix and Lacunæ.

DEVELOPMENT OF THE JAWS.

LEARN THE DEVELOPMENT OF THE HEAD AND THE CENTRES OF OSSIFICATION OF THE JAWS.

CONDITION OF THE JAWS:—

Before Birth.

At Birth.

The lower jaw is in two halves.
The coronoid process rises at angle of 45° from the anterior margin of the crypt of M_{1}.
The condyle is level with the alveolus.
The symphysis is flat behind, no chin, the lower border of the jaw is convex.
The CRYPTS are open, incomplete, and packed.
The malar process is opposite the second temporary molar.
The ANTRUM is a mere depression. (Teeth up against orbit.)
TEETH:—

8 Months.

The halves of the lower jaw are uniting.
The coronoid process is farther back, the condyle is rising.
The symphysis bulges behind, chin, the lower border of the jaw is concave.
The CRYPTS in front have closed and re-opened; at the back are incomplete.
The antrum extends ⅔ across the orbit.
Teeth. ½ root, ⅓ root, ⅔ crown, all crown, all crown, cusps united.

Adult AGE.

The coronoid process rises at a right angle from behind the wisdom tooth.
The condyle stands high above the alveolus.
The sockets are all regularly arranged.
The malar process is opposite the first permanent molar.
The antrum forms a wide space between the teeth and orbit.

Old AGE.

The alveolus has all gone.
The angle has been much absorbed.
The chin is protruded. (Closure of bite.)

GROWTH takes place

At all sutures (till united).
Beneath the periosteum.
In the sub-articular cartilage.

The **Alveolar** portion grows, is absorbed and grows again exactly as it is required by the **Teeth.**

The **Basal** portion steadily grows according to the **Muscular** development, and so becomes a little wasted in old age.

The **Ascending Ramus** grows more rapidly than the **basal portion**, to provide room for the teeth. (Depth of bite and of antrum.)

THE LOWER JAW increases in **length** by growth:—

1. Beneath the periosteum behind the ascending **ramus.**
2. In the sub-articular cartilage of the OBLIQUE set ramus.
3. Beneath the periosteum in front of the jaw.

THE LOWER JAW increases in **width** by:—

1. Elongation of the jaw (continuance of arch).
2. Sub-periosteal growth on outer side of jaw.
3. Growth between the halves. (Mainly intra-uterine.)

ERUPTION OF THE TEETH.

FACTS.

Large multinucleated cells appear on the under side of the roof and front wall of the bony crypts.

The roof of the crypt is absorbed away, and more than enough room made for the tooth to pass out.

The soft tissues disappear and the tooth moves up.

The alveolus closes in around the neck of the tooth and both grow up together.

THEORIES.

No fully satisfactory theory is at present known, but the following have been hatched.

That the eruption of teeth is due to:—

1. **The elongation of the roots, BUT** teeth move farther than the length of their roots.
2. **The enamel of the tooth acting as a foreign body, BUT** the teeth of the sloth, which have no enamel, erupt.
3. **The blood pressure, BUT** why do they stop?
4. **Enamel being an epithelial structure and therefore tending to return to the surface, BUT** glands and nerves do not erupt.

TIMES OF ERUPTION OF THE TEMPORARY TEETH.

Lower centrals	about **6th** month and take	10	days followed by a rest of	**2** months.
Upper incisors	„ **9th** „ „	1	month „ „ „	**2** months.
L. laterals and 1st molars .	„ **12th** „ „	$2\frac{1}{2}$	months „ „ „	**3** months.
Canines	„ **18th** „ „	2	months „ „ „	**5** months.
2nd molars	„ **26th** „ „	3	months.	

Struma and syphilis accelerate the eruption of teeth, rickets retards the eruption.

CONDITION OF THE JAWS AT THE AGE OF SIX YEARS.

The temporary teeth are fully calcified, spaced, partly absorbed, and vertical in direction.

There is a wide space behind the last temporary molar.

The permanent teeth are packed, partly calcified, obliquely placed, and placed behind or between the roots of the temporary teeth.

LEARN THE POSITION AND DIRECTION OF EACH TOOTH.

ROOM FOR THE PERMANENT TEETH IS MADE BY:—

1. The oblique direction of the erupting teeth.
2. The thickening of the jaw by sub-periosteal growth externally.
3. The smaller antero-posterior diameter of the bicuspids than of the temporary molars.
4. The elongation of the jaw backwards.

ABSORPTION OF THE TEMPORARY TEETH is caused by an "ABSORBENT ORGAN," not by pressure.

LEARN TO RECOGNISE and explain:—

"GIANT CELLS."
"HOWSHIP'S LACUNÆ."

TIMES OF ERUPTION OF THE PERMANENT TEETH.

	I_1.	I_2.	C.	B_1.	B_2.	M_1.	M_2.	M_3.
Upper	$7\frac{1}{4}$	$8\frac{3}{4}$	$11\frac{3}{4}$	$10\frac{1}{4}$	$11\frac{1}{4}$	$7\frac{1}{2}$	$12\frac{3}{4}$	24 years.
Lower	$7\frac{1}{4}$	$8\frac{1}{4}$	$10\frac{3}{4}$	$10\frac{3}{4}$	$11\frac{1}{4}$	7	$12\frac{1}{2}$	24 years.

Girls cut their **canines** and **2nd molars** earlier than boys.

Rich children cut their teeth earlier than poor children.

THE ATTACHMENT OF TEETH

Is by:—Membrane, hinge, anchylosis, or socket.

BY FIBROUS MEMBRANE.

The teeth are embedded in a fibrous membrane which revolves over the jaw, *e.g.*, **Sharks** and **Rays.**

Or the teeth are bound down to a pedestal of bone by an annular ligament, *e.g.*, **Sargus.**

BY A HINGE.

(*a.*) ELASTIC. The hinge itself is elastic and pushes up the tooth, *e.g.*:—

Lophius (angler).

Hake (merlucius).

Odontostomus.

Bathysaurus.

(*b.*) NON-ELASTIC. The tooth is erected by elastic fibres in the pulp cavity, *e.g.*:—

Pike (esox).

BY ANCHYLOSIS.

The teeth are fixed to the jaw bone by "Bone of Attachment," which is probably formed from the periosteum of the jaw, *e.g.*:—

Pike and **Python.**

Eel, Chameleon. (Acrodont, *i.e.*, on a pedestal of bone.)

Frog, Iguanodon, Varanus. (Pleurodont, *i.e.*, to an external parapet of bone.)

Haddock.

Mackerel.

BY SOCKET *(gomphosis).*

The teeth are bound to the walls of a socket by a fibrous membrane, *e.g.*:—

Man, and most **Mammals.**

Also the **File Fish,**

Lepidosteus,

Baracuda Pike,

The Dermal Spines of the **Pristis,**

Ichthyosaurus,

Crocodile. (The same socket serves throughout life; only the teeth change.)

THE TEETH OF FISHES.

Morphology (MORPHOLOGY is the science of structure and form).

HOMOLOGY.

Diagrams to show that **Dermal Spines** and **Teeth** have the same ORIGIN and STRUCTURE.

STRUCTURE.

HORNY TEETH consist of Hardened **Epithelium** only, *e.g.*:—
Lamprey, Myxine.

CALCIFIED TEETH consist of:—

Dentine	Fine tubed dentine	**Carcharias,** and many others.
	Plici-dentine	**Lepidosteus** and diagram.
	Vaso-dentine	**Hake, Flounder.**
	Osteo-dentine	**Shark, Pike.**
Enamel	Tips only	**Eel, Hake, Chætodonts.**
	Thin layer (?)	**Sharks, Pike.**

(Sometimes the enamel is **Tubular**, *e.g.*, **Porbeagle Shark** and **Sargus.**)
Cementum is rare.
"Bone of Attachment" . . . . **Eel, Hake,** &c.

MODE OF ATTACHMENT (*see page* 13).

FORMS. Most are **Homodont** and of simple forms.

Cones	**Sharks,** *e.g.*, **Carcharias,** &c., &c.
Slender rods	**Chætodonts** { dents en velours. / " " brosse. / " " cardes.
Flat plates	**Rays,** *e.g.*, **Rhyncobates.**
A few are **Heterodont**	**Anarchus Lupus, Cestracion Phillipi.**
One shows **Sexual** differences	**Raia Clavata.**

SUCCESSION is continuous.

Several rows at a time	**Raia Maculata, American Shark.**
One row at a time	**Carcharias Lamna** (alternate teeth), **Greenland Shark.**
Irregular succession	The teleostei, *e.g.*, **Pike** (*next case*).
Vertical succession	**File Fish, Lamprey, Wrasse, Pseudo-Scarus, Baracuda Pike** (sphyræna pic).
Fused vertical succession	**Porcupine Fish** (gymnodont). **Parrot Fish** (scarus) ("). **Lepidosiren** (mud fish). **Ceradotus Forsteri.**

(**Scarus,** pharyngeal teeth; *next case*).

DISTRIBUTION.

Margins of the jaws only, in the **Sharks** and **Rays.**
All over the mouth and pharynx in the **Teleostei** (*see next case*).
e.g.:—**Amia Calva, Cod, Pike, Sun Fish, Wrasse, Scarus.**
Some fish are **edentulous.**
e.g.:—**Pipe Fish, Hippocampus, Sturgeon.**

THE TEETH OF FISHES.

Fishes are divided into—**Leptocardii**, **Cyclostomata**, **Palaeicthyes**, and **Teleostei**.

LEPTOCARDII. **Amphyoxus**, no jaw and no teeth. (*Wall case.*)

CYCLOSTOMATA. **Lamprey**, horny teeth; vertical succession.
Myxine, horny teeth; rudimentary calcified teeth.

PALAEICTHYES. Ganoids, Sharks and Rays (*Elasmobranchii and Ganoidii.*)

GANOIDS.

Lepidosiren . . } have grooved teeth made up of superimposed plates of enamel only;
Ceradotus Forsteri } and a few teeth on the vomer.
Sturgeon . . . Edentulous.
(The Larval **Sturgeon** has teeth.)
Polyodon . . . has many minute teeth.

SHARKS. Polyphyodont; homodont; conical teeth; osteo-dentine and a thin covering of enamel (?).
Cestracion . . is heterodont.

RAYS. More flattened teeth, plici-dentine.

Myliobates.
Aetobates.
Pristis has socketed Dermal spines of continuous growth. Plici-dentine. Teeth like ordinary ray's.
Raia Clavata has sexual teeth.

TELEOSTEI.

Pike.	Osteo-dentine, hinged and anchylosed teeth. Teeth on the vomer, palate, and pharynx.
Lophius.	Vaso-dentine. Elastic hinged and anchylosed teeth.
Wolf Fish.	Heterodont. (Chrysophys laticeps.)
Gymnodonts.	Fused vertical succession, pharyngeal teeth.
Pseudo-Scarus.	Vertical succession.
Sargus.	Tubular enamel, vertical succession, sockets, remains of Vascular canals (in the dentine).
Pipe Fish.	Edentulous.
Hippocampus.	Edentulous.
Carp.	Edentulous mouth, but pharyngeal teeth.
File Fish.	Vertical succession and socketed teeth.
Amia Calva.	Shows well the bones on which teeth grow.
Wrasse.	Peculiar succession of pharyngeal teeth, vertical succession of front teeth.

BATRACHIANS. *(Case on the wall.)*

Two rows in the upper and one in the lower jaw; homodont, haplodont; endless vertical succession; anchylosis; fine tube dentine, enamel tips.

Toad	Edentulous.
Frog	One row in upper and none in lower jaw; (a few teeth on the vomer).
Tadpole	HORNY plates and hooks on lip.
Newts, **Salamanders**	Double enamel tips.
Labyrinthodon	Plici-dentine.

REPTILES.

CHELONIAN REPTILES. *(Turtles and tortoises.)* Horny Plates.

CARNIVOROUS. . Sharp-edged plates, **Hawk's-bill Turtle.**
HERBIVOROUS. . Blunt and serrated plates, **Common Turtle.**

SAURIAN REPTILES. *(Lizards, &c.)*

Teeth confined to edge of jaws; continuous vertical succession; homodont, haplodont; anchylosis; hard dentine and enamel.

Varanus	has plici-dentine.
Iguanodon	has vaso-dentine.
Heloderma	has poisonous, grooved teeth.
Sphenodon	Large upper incisors bite on BARE bone of lower jaw. It is monophyodont.
Chameleon	is monophyodont.

OPHIDIAN REPTILES. *(Snakes.)*

Two rows of teeth in the upper jaw (the OUTER row on the SUPERIOR MAXILLARY bone, and the INNER row on the PALATE and PTERYGOID bones), and one row in the lower jaw (MANDIBLE); continuous succession, homodont, recurved cones, anchylosed; hard dentine and enamel.

NOTE THE METHOD OF SWALLOWING AND ADAPTATION THERETO OF DEVELOPING TEETH.

PYTHONS . . . . are non-poisonous; their teeth have no grooves; they have two complete upper rows of teeth.

COLUBRINE.

1. A-GLYPHA . . . Teeth not grooved; non-poisonous.

Dasypeltis (Rachiodon), egg snake, has few teeth.
Common English Snake.

2. OPISTHO-GLYPHA. Post. Max. teeth are grooved; slightly poisonous.

Tree and **Whip Snakes.**

3. PROTERO-GLYPHA. Ant. Max. teeth are grooved or tubular. Post. Max. and Pterygoid teeth are small and few; Max. bone is fixed; poisonous.

Hydrophis.
Cobra has slight movement of the Max. bone.
Crait.
Australian Death Adder and **Hamadryad.**

VIPERINE . . . . have a Movable Max. bone; a large poison fang with a complete tube

Puff Adder.
Rattle Snake.
Viper.

STUDY THE MECHANISM, STRUCTURE, SUCCESSION OF THE POISON FANG *(see previous case)*.

CROCODILIA.

A single row; continuous vertical succession; homodont; haplodont; socketed; hard dentine, enamel and cementum.

Crocodile . . . . 1. $\frac{3.}{4.}$ $\frac{9.}{11.}$ are large, a tendency towards a carnivorous formula.
Garial . . . . Slender teeth (Piscivorous).

Extinct Reptiles.

Some are more primitive, some much more specialised than modern reptiles.

ICHTHYOSAURUS . . . . has incomplete sockets. (Several varieties.)

DINOSAURUS.

Iguanodon . . . . Enamel—hard dentine—vaso-dentine. Keep sharp.

ANOMODONTIA . . . . . . Heterodont.

THERO-CHELONIA.

Dicynodon . . . . has persistent growing upper canines; horny plates (?).

THERO-SUCHIA.

Therodonts . . . . Not continuous succession.

Cynognathus . . . . . Carnivorous, 4. 1 5. 4.
Placodus Gigas . . . . . Incisors and flattened molars.

PTEROSAURIA . . . . *(Flying Reptiles.) (Geological Gallery.)*

Pterodactyles . . . . Slender sharp teeth all along the jaw.
Rhamphorhynchus . . . . No teeth in front, horny plates (?).
Pteranodon . . . . No teeth at all, horny plates (?).

BIRDS.

Edentulous, horny plates, often serrated.

Merganser . . . . Serrated beak.
Odontopteryx Toliopicus . . . . Bony prominences to correspond.
Archæopteryx . . . . Teeth.

ODONTOTORNÆ.

Ichthyornis . . . . 21 homodont, haplodont teeth (horny plates in front?); continuous vertical succession, socketed, hard dentine and enamel.

ODONTOLCÆ.

Hesperornis . . . . $\frac{14}{33}$ homodont, haplodont teeth, continuous vertical succession, incomplete sockets; hard and osteo dentine and enamel.

Notice the **"egg tooth"** shown on a **chick** at the far end of the case; egg teeth also occur in **snakes.**

HOMOLOGIES OF THE TEETH.

THEORIES.

1. That several simple teeth become fused to form a complex tooth.
   (Rose, Kukenthal, and Virchow.)
2. That new cusps are developed on an originally simple tooth.
   (Cope and Osborn's Tritubercular theory.)

STAGES OF TRITUBERCULISM. *(You must draw diagrams.)*

1.	**Haplodont**	*(No early example)*	Protocone, -id.
2.	**Protodont**	**Dromatherium**	" "
3.	**Triconodont**	**Triconodon**	Paracone, -id.
4.	**Tritubercular**	**Spalacotherium**	Metacone, -id.

The Protocone is Inside and the Protoconid is Outside. Para- is Anterior.

From the **Tritubercular** tooth all existing forms are derived by :—

1. **Addition** of cusps. *(Hypocone -id.; Entacone, -id.; Proto- and Meta-conule.)*
2. **Addition** of some cusps and **suppression** of others.
3. Elevations of the **cingulum.**
4. **Foldings** of the dental tissues.
5. **Suppression** of some of the **dental tissues.**
6. **Addition** of new **tissues.** Secondary dentine and cementum on the crown.
7. **Lengthening** of the cusps.

EXAMPLES.

1. **Addition of cusps.** The lower carnassial tooth of the **Dog,** in which the paraconid, protoconid, and metaconid are united to form the blade, and a small heel (hypoconid) is added behind. In the **Bear** an entaconid is also added.
2. **Addition and suppression of cusps.** In the lower carnassial tooth of the **Tiger** the metaconid is gone (hence there are only two cusps to the blade), and a heel (hypoconid) is added.
3. **Elevation of the cingulum.** In the **Insectivora** the cingulum is raised both on the lingual and buccal aspects to form extra cusps.

   In the **Suina** the cingulum is raised distally to form cusps (*e.g.*, **Phæcochærus,** and to a less extent the **Pig**).

   In the **Mastodon** and **Elephants** we have another example of the same thing, plus a lengthening of the cusps and a shortening of the roots.
4. **Folding of the tissues.** In the incisors of the **Horse** and the molars of some **Rodents.**
5. **Suppression of tissues.** The partial covering of enamel on the incisors of **Rodents,** canines of **Pigs;** and its entire absence from the teeth of **Edentata.**
6. **Addition of tissues.** In the persistent growing teeth of the **Sloths** and **Rodents** the pulp cavities are filled up with secondary dentine of a different type.
7. **Lengthening of cusps.** In the hypsodont teeth of **Ruminants,** and still more in the persistent growing teeth of **Rodents.**

The molars of the Horse show an addition and lengthening of cusps, an elevation of the cingulum, and a thickening of cementum.

Many people **do not accept** the "Tritubercular theory" **in toto,** because :—

1. The earliest known mammals had "Multitubercular" teeth.
2. Authorities differ as to the identification of cusps in many cases.
3. It places the growth of the cingulum in a very secondary place.
4. The order of calcification does not always agree with the accepted homologies of the cusps.

TOOTH SUCCESSION.

FISHES	Continuous succession **(Polyphyodont)**	One tooth band	**Sharks** and **Rays.**
		No tooth band	**Pike,** &c.
REPTILES	Continuous succession **(Polyphyodont)**	One tooth band	**Newt** and **Snake.**
BIRDS (extinct).	Continuous succession **(Polyphyodont)**	One tooth band	**Hesperornis.**
MAMMALIA	Two sets **(Diphyodont)**	One tooth band	**Man.**
	One set **(Monophyodont)**	One tooth band	**Rat.**

Possibly there are also a "**PRE-MILK**" and a "**POST-PERMANENT**" set in some mammalia.

THEORIES to account for TWO (or more) sets:—

1. Descent from **Polyphyodont** ancestors.
2. **Folding** of tooth band from shortening of face.

The **Milk Dentition** resembles the permanent **Dentition.**

Hence milk MOLARS resemble permanent MOLARS, not premolars.

But, **Sexual** teeth are ill marked, also

The **Oryceteropus** has HETERODONT and ROOTED milk teeth, and homodont, persistent growing permanent teeth;

The **Balænoptera Rostrata** has HERERODONT rudimentary milk teeth, and no permanent teeth;

The **Chiroptera** have small hook-shaped milk teeth, and very heterodont permanent teeth;

The **Aye-Aye** has LEMURINE milk and a RODENT permanent dentition;

The **Wombat** has milk CANINES and a RODENT permanent dentition.

Permanent **Molars** are either:—

1. Milk teeth (*Rose, Kukenthal, and Leche*).
2. Permanent teeth (*Woodward, Magitot, and Tomes*).
3. A fusion from both sets (*Kukenthal and Schwalb*).
4. Terminal members of separate sets.

DEGREES OF DEVELOPMENT OF MILK TEETH.

1. Not formed at all . . . . **Sloths.**
2. Partly formed, but uncalcified . . . . **Shrews.**
3. Calcified, but unerupted . . . . **Seals.**
4. Erupted, but soon shed . . . . **Bears.**
5. A few only formed and functional . . . . **Dugong, Hedgehog.**
6. All erupted and last some time . . . . **Dogs.**
7. Last all life . . . . **Whales.**

(*Some "permanent" teeth are shed early* . . . . *Dugong, Kangaroo, Wart-hog.*

In many Ungulata, Carnivora, and Insectivora,

The first tooth behind the canine is small, cut late, lost early, and has no successor. Is it a first milk molar or a pre-molar?

SOME DETAILS ABOUT THE MILK TEETH OF MAMMALIA.

EDENTATA. (*Homodont and monophyodont.*)

But in

- 9 Banded Armadillo . . . . . . Milk teeth till nearly full size.
- Orycteropus . . . . $\frac{7}{4}$ Rudimentary, calcified, heterodont, unerupted milk teeth; plici-dentine, non-persistent growth.

CETACEA. (*Monophyodont.*)

Milk teeth persist all life. Permanent rudiments unerupted.

SIRENIA.

- Dugong . . . . Milk tusk only. (2nd Incisor ?)
- Manatee . . . . $\frac{2}{3'}\frac{0}{1'}\frac{0}{3'}$ Milk teeth. Perpetual succession of molars *à la* Elephant. ?

UNGULATA. (*Typical diphyodonts.*)

In many dm_1 (pm_1 ?) has no successor.
Timms found a "Pre-milk" tooth in the pig (?).
Phacochœrus sheds m_1, pm_3, m_2, pm_4 of its permanent set.

RODENTS. (*Few milk teeth.*)

Hares	$\frac{di_1\ di_2}{di_1}$	$\frac{dm_1\ dm_2\ dm_3}{dm_1\ dm_2}$	$\frac{di_1}{di_1}$ lost in utero.
Rabbits	$\frac{di_1\ di_2}{di_1}$	$\frac{dm_1\ dm_2\ dm_3}{dm_1\ dm_2}$	di_2 and dms lost in 18 days (non-persistent growth).
Squirrel	$\frac{di_1\ di_2\ di_3}{}$		
Mouse	di_1 ?		
Beaver		$\frac{dm}{dm}$	last till half grown.
Erethizon		$\frac{dm}{dm}$	
Guinea Pig		$\frac{dm}{dm}$	lost in utero.
Dasyprocta, Ctenodactylus, Hystrix, Atherina		dm	
Rat	Monophyodont.		

CARNIVORA. (*Typical diphyodonts.*)

In many dm_1 (pm_1 ?) has no successor.

Felidæ	$\frac{3\,1\,3}{3\,1\,2}$ Milk teeth.	
All others	$\frac{3\,1\,3}{3\,1\,3}$ Milk teeth.	
Bear	Loses milk teeth early.	
Seals	*Have degenerate milk teeth.*	
Otaria	$\frac{3\,1\,3}{3\,1\,3}$ Milk teeth.	Last a few weeks.
Phocan Greelandica	$\frac{1\,1\,3}{3\,1\,3}$ Milk teeth.	Last a week.
Cystaphora proboscidia	$\frac{2\,1\,3}{1\,1\,3}$ Milk teeth.	Lost in utero.
Walrus	4 Milk teeth and 2 ?	Lost at birth.

INSECTIVORA. (*Diphyodont.*)

Galeopithecus	$\frac{2\,0\,3}{2\,0\,3}$ Milk teeth. Cut late. Work with true molars, di_1 lost early. Resemble pre-molars.	
Hedgehog (erinaceus)	$\frac{123\ 1\ 1234}{123\ 1\ 1234}$ Milk teeth. Those in italics functionless.	
Gymnura	$\frac{123\ 1\ 1234}{123\ 1\ 1234}$ Milk teeth. " " "	
Shrew (sorex)	$\frac{23\ 1\ 34}{4}$ All uncalcified.	
Mole (talpa)	$\frac{123\ 1\ 1234}{123\ 1\ 1234}$ Milk teeth.	Lost early.
	$\frac{dm_1}{dm_1}$ has no functional successor, and is retained late; dm_4 is two rooted and molariform.	
Centetes, Hemicentetes, Macroscelides, Tupaia	Have good functional milk teeth.	

CHIROPTERA.

Milk teeth ill-developed. Functionless. Often unerupted. Some persist with the permanent teeth, and are of very simple form, e.g., Vampire.

PRIMATES. (*Diphyodont.*)

- Aye-aye . . . . $\frac{2\,1\,2}{2\,0\,2}$ Milk teeth. Lost early.

MARSUPIALS.

According to Wilson and Hill the **Functional** *set are the* **Permanent** *set, and the* **Milk** *teeth are in various states of reduction.*

- Wombat . . . . $\frac{1\,1\,1}{0\,1\,1}$ Milk teeth. Lost early.

OTHER VIEWS.

- Kukenthal and Rose. . . . . . . Functional MILK teeth and rudimentary PERMANENT.
- Woodward (didelphys) . . . . . . Rud. PRE-MILK; Funct. MILK; Rud. PERMANENT.
- Timms (didelphys) . . . . Rud. MILK; Funct. PERMANENT; Rud. POST-PERM.
- Leche (myrmecobius) . . . . . . Rud. PRE-MILK; Funct. MILK.

MAMMALIA.

PROTOTHERIA (*Monotremata.*)

Echidna . . . . is edentulous.
Ornithorhynchus . . . . has horny plates and rudimentary teeth above them.

EUTHERIA.

EDENTATA.

Monophyodont, homodont, no incisors, persistent growth. No enamel, hard dentine, and secondary dentine.

SLOTHS.

Two-toed Sloth . . . . has one tooth larger than the rest.
Three-toed Sloth . . . . is typical.
Megatherium . . . . has vaso-dentine and cementum. Grooved molars.

ANT-EATERS.

Manis, Mutica, Tamandua . . . . . are edentulous.

ARMADILLOS.

Six-banded Armadillo . . . . . . has rudimentary incisors.
Nine-banded Armadillo . . . . . . is diphyodont.

ORYCTEROPUS (Cape ant-eater). (Aard-Vark.)

Is diphyodont, heterodont, and has plici-dentine.
Clyptodon . . . . had grooved molars.

CETACEA.

ODONTOCETI.

Monophyodont, homodont, haplodont, socketed teeth; hard dentine (interglobular spaces), enamel tips, cementum.

Dolphin. Porpoise. Grampus . . . . are typical.
Sperm Whale . . . . has rudimentary upper teeth and a few large lower teeth.
Hyperodens Bidens . . . . has rudimentary upper teeth and two lower teeth.
Ziphoids . . . . have two odd-structured lower teeth.
Narwals . . . . have rudimentary and sexual incisors and an edentulous mouth.

The **functional** teeth of whales are said to be the **milk** teeth (CONTRAST WITH THE SEALS).

MYSTACOCETI.

Edentulous, rudimentary teeth. Whalebone.

Balænoptera Rostrata . . . . has heterodont rudimentary MILK teeth.

Whalebone is homologous with the **enamel** of teeth, and not with the whole tooth.

SIRENIA.

Dugong has horny plates over rudimentary teeth. Five semi-persistent molars; and a tusk which is persistent growing in the male, rudimentary in the female. It is preceded by a milk tooth. An old animal loses some of its molars.

Manatee has horny plates and rudimentary teeth; many molars which erupt behind and move forwards in the jaw; straight prisms in the enamel, and the remains of vascular canals in the dentine.

Rhytina is extinct, was edentulous, and had horny plates.

UNGULATA.

UNGULATA VERA

Diphyodont; heterodont $\frac{1143}{3143}$; enamel, hard dentine, cementum.

Brachyodont and hypsodont; bunodont, selenodont and lophodont.

VEGETABLE DIET:—
1. LONG NARROW ARCH.
2. REDUCTION OF FRONT TEETH.
3. SUPPRESSION OF CANINES.
4. DEVELOPMENT OF CHEEK TEETH.
5. GLOBULAR CONDYLE.

ARTIODACTYLES (*even toed*).

Premolars differ markedly from true molars (simpler).

BUNODONTS . . . . . . (*non-ruminants*).

SUINA . . . . have large sexual persistent growing canines.

Pig and **Collared Peccary** . are typical.

Phacochœrus . . . . has non-sexual canines (*large in both sexes*). A large M_3.

Sus Babirussa . . . . has the longest canines (no enamel).

HIPPOPOTAMI . . . . Both incisors and canines are of persistent growth.

SELENODONTS . . . . . (*ruminants*) $\frac{0133}{3133}$ No upper incisors.

TYLOPODIA.

Camel . . . . has good canines; $\underline{i_1 i_2}$ are lost early.

TRAGULIDÆ.

Chevrotians . . . . . have large sexual persistent growing canines.

PECORA.

Bovidæ . . . . have no canines; hypsodont teeth and thick cementum over the enamel.

Sheep. **Oxen.** **Antelopes.**

Giraffidæ.

Giraffe . . . . . . has no canines.

Cervidæ . . . . . . have small canines: brachyodont teeth and no cementum on the crowns.

Musk Deer . . . . has large sexual canines.

Muntjak . . . . . has large canines and small horns.

Hydropotes Inermis . has large canines.

Michie's Deer . . . has large canines.

A few deer have no canines at all.

PERISSODACTYLES (*odd toed*).

Premolars and molars form an unbroken series and are almost equally complex.

Study the pattern on the molars of the **Tapir**, **Rhinoceros**, and **Horse**.
Study the "**Mark**" on the **Horse's** incisor in the case in the next alcove.
The **Stallion** has a small canine, in the **Mare** the canine is rudimentary.

SUBUNGULATA.

HYRACOIDEA.

Hyrax . . is rodent-like in general form, but it has molars like the rhinoceros and an upper second incisor, which is lost early, and the two lower incisors are not of persistent growth and bite on the upper gum. The first upper incisor is of persistent growth.

PROBOSCIDEA.

Elephant . is diphyodont, heterodont $\frac{1\,0\,3}{0\,0\,3}$ in each set, the milk molars and permanent molars erupt one after the other into the same situation; they are hypsodont, poly-lophodont, and composed of cementum, enamel and dentine.

The tusk is of persistent growth, tipped with enamel, covered with cementum, and the dentine is less calcified, apt to contain interglobular spaces, and the tubules have well marked secondary curvatures.

Mastodon . had brachyodont teeth and tusks in both jaws.

Dinotherium had tusks in the lower jaw only.

RODENTIA.

Almost monophyodont, heterodont, $\frac{1013}{1013}$, persistent growing incisors (enamel on the front only), hypsodont or persistent growing molars, grooved at the sides, condyle long antero-posteriorly.

Hydromys . . . . $\frac{1002}{1002}$, few teeth.
Agouti . . . . has non-persistent growing molars.
Coast Rat . . . . has non-persistent growing molars.
Capybara . . . . has persistent growing molars and a large 3rd molar.
Beaver. . . . . has persistent growing molars.
Hare and **Rabbit**. . . . . . have $\frac{2033}{1023}$, no pattern in the enamel; many milk teeth; some lateral movement to the jaw; 2 upper incisors.

COMPARE THE PATTERN IN THE ENAMEL OF:—

(MANATEE), (MAN), RABBIT, BEAVER, SQUIRREL, PORCUPINE, RAT, JERBOA (MARSUPIALS).

CARNIVORA.

Diphyodont, heterodont, $\frac{3131}{3121}$.

CARNIVOROUS DIET . . .

($\frac{3131}{3121}$)

1. INCISORS, 6 IN A STRAIGHT ROW.
2. CANINES, LARGE AND WIDE APART.
3. PREMOLARS, SMALL, INCREASING IN SIZE BEHIND AND BLADE-LIKE.
4. MOLARS, RUDIMENTARY.
5. $\frac{pm_4}{m_1}$, "SECTORIAL" OR "CARNASSIAL" TEETH.
6. ARCH SQUARE, AND ZYGOMA BROAD.
7. CONDYLES FORM A PURE HINGE JOINT.

TERRESTRIAL.

ŒLURIDEA (*cat-like*). Sharp "carnassials," rudimentary molars.

Tiger and **Cat** . . . . . . Typical carnivora.
Hyæna. . . . . has short stout teeth.
Aard-Wolf . . . . has rudimentary premolars and molars.
Binturong and **Herpestes** . . . Herbivorous diet and Insectivorous diet.

CYNOIDEA (*dog-like*). Sharp "carnassials," fairly good molars.

Wild Dog . . . . has no lower 3rd molar.
Common Dog . . . . $\frac{3142}{3143}$ typical mixed feeder. **Milk** "carnassials" $\frac{dm_3}{dm_4}$
Otocyon . . . . has 48 teeth (4 molars).

ARCTOIDEA (*bear-like*). No "carnassials," broad topped molars.

Coati and **Suricate** . . . . . have flattened canines and blunt molars.
Bear . . . . Typical herbivorous carnivora.

Sloth Bear, Otters, Badgers, Polecats, Glutton, &c.

AQUATIC.

Degenerate carnivorous forms. Rudimentary milk teeth.

Otaria (sea lions) . . . . . A fairly carnivorous type.
Phoca (common seal) . . . . A less carnivorous type, more homodont.
Walrus . . . . has large persistent growing canines.

INSECTIVORA.

Diphyodont, heterodont, $\frac{3143}{3143}$, small canines, MANY CUSPS on the molars.

Galeopthicus . . . . has lower comb-like incisors.

W PATTERN.

Mole (talpa) . . . . (*Draw a diagram.*)
Hedgehog (erinaceus) . . . . is typical.
Shrew (sorex) . . . . has very large incisors of peculiar shape, and tubular enamel.
Tupaia.

V PATTERN.

(Less specialised).

Potomogale; Centetes; Hemicentetes.

CHIROPTERA.

Diphyodont, heterodont, large canines.

INSECTIVOROUS (Similar to W pattern Insectivora, but larger canines).

Common Bat.
Vampire . . . . has rudimentary back teeth and hook-like milk teeth.

FRUGIVOROUS. Hollow flat-topped molars.

Pteropus.
Cephalotes peronii.
Cynonycteris dupreana.

PRIMATES. Diphyodont, heterodont $\frac{2133}{2133}$

LEMURS.

Slow Lemur . . . . Typical Lemur; $\frac{2133}{2133}$
Ruffed Lemur . . . . . . ,, ,,
Indri . . . . has only one lower incisor.
Aye-Aye (cheiromys) . . . A rodent type. Persistent growing incisors; but milk teeth $\frac{212}{212}$.

SIMIADÆ.

NEW-WORLD (platyrhine). $\frac{2133}{2133}$

Hapalidæ.

Marmosets . . . . have only two molars.

Cebidæ.

Ateles and **Capuchin** . . . Gradual change from incisors to molars.

OLD-WORLD (catarrhine). Same formula as man.

Baboons . . . . *Peculiar lower first premolars.*

Chaema and **Rheus Baboons.**

Anthropoid Apes.

Orang . . . . has very long teeth.
Gorilla . . . . Late eruption of canines.
Chimpanzee . . . . is the most like man.

DIFFER FROM MAN:—
1. PROGNATHOUS (late closure of suture).
2. SQUARE JAWS (molars converging behind).
3. MEGADONT.
4. LATERALS CANINIFORM; DIASTEMA.
5. CANINES. SEXUAL, LARGE, LATE ERUPTED.
6. PREMOLARS. UPPER THREE-, LOWER TWO-ROOTED.
7. MOLARS, INCREASE IN SIZE BACKWARDS.

MAN.

Gnathic Index $= \frac{\text{B.A.} \times 100}{\text{B.N.}}$

Dental Index $= \frac{\text{L. of T.} \times 100}{\text{B.N.}}$

LEARN THE ANATOMY OF EACH HUMAN TOOTH IN ABSOLUTE DETAIL.
COMPARE THE MOLARS OF APES, ABORIGINES, NEGROES, AND EUROPEANS.

MARSUPIALS. Diphyodont? heterodont $\frac{3\ 1\ 3\ 4}{3\ 1\ 3\ 4}$; tubular enamel.

DIPROTODONTS. $\frac{3}{1}$ incisors, small canines, molars ridged.

Kangaroo Rats . . . . . Herbivorous; $\frac{1}{1}$ persistent growth; pm_4 large.
Cast of Thalacoleo . . . . is herbivorous, not carnivorous.
Kangaroos . . . . Herbivorous; $\frac{}{1}$ persistent growth, pm_4 replaces dm_4; pm_3 is shed later on.
Australian Opossum . . . . is herbivorous.
Phascolarctos Cinereus . . . is rodent-like.
Wombat . . . . is rodent-like; all the teeth are of persistent growth; no tubes in the enamel; cementum grows all round the teeth. Has $\frac{1}{0}\frac{1}{1}\frac{1}{1}$ MILK teeth.
Tarsipes . . . . has rudimentary molars.

POLYPROTODONTS. $\frac{4}{3}$ incisors, good canines, molars tuberculated.

Thalycine . . . . is dog-like; differences?
Tasmanian Devil . . . . . is carnivorous.
Dasyurus Viverinus . . . . is insectivorous.
Azar's Opossum . . . . . . is insectivorous.
Myrmecobius . . . . has fifty-four teeth; many milk teeth formed but unerupted.

EDENTULOUS.

Adult Sturgeon, Pipe-fish, Hippocampus.
Toad.
Echidna.
Manis, Mutica, Rhytina, Mystacoceti.
Birds.
The Narwal, Sword-fish, and Carp have endentulous MOUTHS.

TEETH OF PERSISTENT GROWTH.

Pristis (dermal spines).
Dicynodon (canine tusks only).
Canines of Suina, Tragulidæ, and Cervidæ.
Canines and Incisors of Hippopotamus.
Upper Incisors of Hyrax, Elephant, Hypsiprymnus.
Lower Incisors of Kangaroo, Hypsiprymnus.
Upper and Lower Incisors of Rodents, Aye-Aye.
Molars of many Rodents.
All the Teeth of Edentata, Dugong, Wombat.

VERTICAL SUCCESSION OF TEETH.

Lamprey, File-fish, Wrasse (pharyngeal teeth), Pseudo-scarus, Sargus, Gymnodonts.
Most Reptiles.
Ichthyornis and Hesperornis.

RUDIMENTARY TEETH EXIST IN:—

Bdellestoma, Myxine, Sword-fish, Larval Sturgeon.
Rachiodon (and Elachistodon). (DASYPELTIS, new name for Rachiodon).
Ornithorhynchus and Mystacoceti.
MILK TEETH of Orycteropus, Mole, Shrews, Guinea-pig, Bats, Seals.
SECOND SET of Odontoceti.
Tusks of FEMALE Narwal, Dugong.
Canines of FEMALE Suina, Tragulidæ, Pecora, Deer, Mare.
INCISORS of Rhinoceros, 6-banded Armadillo, Manatee, Narwal, Petrogale.
UPPER CANINES of Kangaroo.
MOLARS of Tarsipes, Vampire, Aard-wolf, and True Carnivora.
1ST PREMOLAR of Horse, Bear, Pig.

HORNY TEETH, OR PLATES, EXIST IN:—

Lamprey, Myxine, Bdellestoma.
Tadpole, Turtle, Tortoise, Dicynodon (?), Rhamphorhynchus, Pteranodon (?).
Merganser.
Ornithorhynchus.
Dugong, Manatee, Rhytina.

SEXUAL TEETH ARE FOUND IN:—

Raia Clavata.
Narwal, Ziphoid cetaceans.
Dugong.
Suina, Tragulidæ, Camel, Hydropotes, Musk-deer, Stallion, Muntjak, Elaphodus.
Monkey.

GLOSSARY.

Acro-dont	Eel.
Pleuro-dont	Iguanodon.
Haplo-dont	Dolphin.
Proto-dont	Dromotherium.
Triconodont	Triconodon (Leopard Seal).
Tritubercular	Spalacotherium.
Buno-dont	Pig, Man.
Seleno-dont	Sheep.
Lopho-dont	Elephant.
Bilopho-dont	Tapir.
Brachyo-dont	Pig, Man, Mastodon.
Hypso-dont	Horse, Elephant.
Homo-dont	Dolphin.
Hetero-dont	Pig, Man.
Monophyo-dont	Dolphin.
Diphyo-dont	Pig, Man.
Polyphyo-dont	Shark.
Micro-dont	Anglo-Saxon.
Meso-dont	Nigger.
Mega-dont	Aborigines, Monkeys.
Orthognathous	Europeans.
Mesognathous	
Prognathous	Horse.

PREPARATION OF HARD TISSUES.

1. **Saw** into thin slices. (Cut enamel with a diamond disc.)
2. Grind on a **carborundum wheel,** as thin as possible.
3. Grind between two bits of **ground plate glass,** with pumice and water.
4. **Wash.**
5. **Dry lightly** on the hand.
6. Mount in warm **hard Canada balsam.**

PREPARATION OF SOFT TISSUES.

1. **Fix** in Muller's fluid or corrosive sublimate, &c.
2. **Harden** in 80 % alcohol.
3. **Dehydrate** in absolute alcohol.
4. **Stain** in borax carmine, &c.
5. **Clear** in oil of cloves, &c.
6. **Imbed** in gum mucilage, paraffin, celloidin.
7. **Cut.**
8. **Mount** in Canada balsam or glycerine jelly, &c.

If preferred, the sections may be **stained, dehydrated** and **cleared,** after being **cut,** instead of before.

PREPARATION OF HARD AND SOFT TISSUES TOGETHER.

WEIL'S PROCESS.

1.	Saw a fresh tooth into four pieces, under water.		
2.	**Fix** in a saturated sol. of $HgCl_2$	about	4 hours.
3.	**Wash** in running water	,,	2 ,,
4.	**Harden** in 30 % alcohol	,,	12 ,,
5.	,, in 50 % ,, ...	,,	12 ,,
6.	,, in 70 % ,, ...	,,	12 ,,
7.	,, in 90 % ,, and a few drops of tr. of iodine	,,	12 ,,
8.	**Stain** in **alcoholic borax carmine**	,,	3 weeks.
9.	Fix the stain with 70 % alcohol and ¼ % HCl	,,	12 hours
10.	**Dehydrate** in 90 % ,, ...	,,	24 ,,
11.	,, in absolute ,, ...	,,	24 ,,
12.	**Clear** in oil of cloves	,,	6 ,,
13.	Wash in xylol.		
14.	Soak in **chloroform**	,,	1 day
15.	**Imbed** in a weak sol. of Canada balsam	,,	2 days.
16.	,, in a strong ,, ,, ,, ...	,,	2 ,,
17.	,, in thick Canada balsam at 70° C.	,,	1 day.
18.	,, in ,, ,, 90° C.	,,	2 days.
19.	**Grind** when cool and brittle.		
20.	**Mount** in Canada balsam.		

HOPEWELL SMITH'S PROCESS.

1. Remove the apex from a fresh tooth.
2. **Fix** in Muller's fluid . . . . about 3—4 weeks.
3. **Harden** in 84 % alcohol . . . . ,, 20 days.
4. Wash in normal salt solution (·6 %), dry and protect the soft parts with collodion.
5. **Decalcify** in 12 c.c. of 10 % HCl . . . . ,, 15 hours.
6. ,, add 1·5 c.c. pure HNO_3 . . . . ,, 33 ,,
7. ,, add 1·5 c.c. pure HNO_3 again . . . . ,, 27 ,,
8. **Neutralise** in lithium carbonate (6 grs.—1 oz.) . . . . ,, ½ ,,
9. Wash in distilled water.
10. **Imbed** small pieces in gum mucilage . . . . ,, 15 ,,
11. **Freeze, cut,** and float off sections on water, stain.
12. **Dehydrate, clear,** and **mount.**

MULLER'S FLUID:—

BICHROMATE OF POTASH	2½ *parts.*
SULPHATE OF SODA	1 *part.*
WATER	100 *parts.*

CHROMIC ACID PROCESS.

1. Place the tooth in half a pint of—

Chromic acid	¼ volume.
Nitric acid	½ ,,
Water	100 volumes.

2. Change frequently. . . . . 3—4 weeks.
3. Wash thoroughly.
4. **Imbed** in paraffin, cut, stain, &c.

IMBEDDING.

GUM MUCILAGE IMBEDDING.

1. **Fix** in Muller's fluid . . . . 3—4 weeks.
2. **Wash** in water.
3. **Imbed** in—Gum mucilage 5 parts.
   Syrup 4 ,, ... 15 hours.
4. Place on a microtome and cover with mucilage.
5. **Freeze, cut,** and float off sections on water.
6. **Stain, dehydrate, clear,** and **mount.**

COLLODION IMBEDDING (for large objects).

1. **Dehydrate** in absolute alcohol.
2. Soak in a mixture of equal parts of **alcohol** and **ether.**
3. Place in a very **thin** solution of **collodion.**
4. Place in a **thick** " " "
5. Allow the solution to evaporate slowly.
6. Remove the object to 30 % **alcohol** to harden.
7. **Cut** with a microtome.
8. **Stain** and **dehydrate.**
9. **Clear** in cedar oil (**not** oil of cloves).
10. **Mount.**

The time taken will depend on the size and permeability of the object. It is better, when possible, to make cuts in the specimen to hasten penetration.

PARAFFIN IMBEDDING (for small objects and very thin sections).

1. **Dehydrate.**
2. **Clear** in cedar oil.
3. Place in **melted paraffin** (45° C.) still saturated (1 hr.).
4. **Cool** rapidly. (To prevent crystallisation.)
5. Mount on a microtome and **cut.**
6. Warm and wash out paraffin with **naphtha.**
7. **Stain, clear, mount.**

In either method the object may be stained in mass before imbedding, if preferred.

STAINS.

ALCOHOLIC BORAX CARMINE (for staining in bulk).

1. Place in the stain till saturated . . . . 2—4 weeks.
2. Place in acid alcohol to fix the stain . . . . 12 hours.
3. Dehydrate in 90 % and 100 % neutral alcohol . . . . 12 hours each.

ACID ALCOHOL:—70 % ALCOHOL AND 2 DROPS HCl TO A TEST TUBE FULL.

SILVER NITRATE.

1. Wash the fresh tissues in distilled water.
2. Place in 1 % $AgNO_3$ in the sunlight, till of a whitish-grey colour.
3. Wash and mount at once.

HÆMATOXYLENE.

1. Place the section in a dark sol. of hæmat. . . . . $\frac{1}{4}$ hour.
2. Wash well in water.
3. Dehydrate in absolute alcohol . . . . 10 min.
4. Clear in cedar oil and mount.

To counter-stain with **eosin**, add eosin to the absolute alcohol used for dehydrating.

MUMMERY'S IRON AND TANNIN.

1. Wash the sections in water.
2. Place in liquor ferri perchloridi . . . . 24 hours.
3. Wash quickly and thoroughly.
4. Place in tannic acid (2 grs.—6 c.c. of water) . . . . 5—10 min.
5. Wash in water, dehydrate, clear, and mount.

GOLGI'S METHOD.

1. Place the sections in a mixture of—
   2 % sol. potassium bichromate 8 parts.
   1 % sol. osmic acid . . . . 2 „ . . . . 24 hours.
2. Remove to 0·5 % $AgNO_3$ (in the dark) . . . . 1 day.
3. Dehydrate, clear, and mount in gum dammar.

UNDERWOOD'S GOLD CHLORIDE.

1. **Grind** section.
2. Wash in 1 % Na_2CO_3.
3. Neutral 1 % sol. of **AuCl** (in the dark) . . . . 1 hour.
4. Wash in water („ „ „) . . . . 10 min.
5. **Warm** 1 % sol. of **formic acid** („ „ „) . . . . 1 hour.
6. **Wash** in cold water.
7. Dry and mount in **glycerine jelly.**

TO STAIN BACTERIA.

1. Place the sections in a strong alcoholic sol. of **gentian violet** . . . . 3 min.
2. Wash in **Gram solution** . . . . 3 „
3. Wash in **absolute alcohol** till differentiated.
4. **Clear** and **mount.**

GRAM SOLUTION :—

IODINE . . . . 1 *part.*
POTASSIUM IODIDE 2 *parts.*
WATER . . . 300 „

TO SHOW :—

ENAMEL PRISMS.

Grind and mount unstained.

TRANSVERSE STRIÆ OF ENAMEL PRISMS.

1. They may be slightly seen in ordinary ground sections.
2. Grind a section and wash it in weak HCl, and stain with carmine.

BROWN STRIÆ OF RETZIUS.

An ordinary ground section.

DENTINAL FIBRILS.

1. Weil's process.
2. Hopewell Smith's process.

DENTINAL TUBES.

1. Unstained ground sections.
2. Underwood's gold chloride.

DENTINAL SHEATHS. (Sheaths of Neumann).

1. Golgi's method.
2. Grind a section and wash in HCl (tubes only remain).

INTERGLOBULAR SPACES AND OWEN'S LINES.

1. Weil's process.
2. Underwood's gold chloride.

VASO-DENTINE AND OSTEO-DENTINE.

1. Weil's process.
2. Chromic acid process.

PULP CELLS. *(Odontoblasts.)*

1. Weil's process.
2. Hopewell Smith's process.

NERVES OF THE PULP.

Mummery's iron and tannin stain.

ENCAPSULED LACUNÆ. *(Use a horse's tooth.)*

Stain a ground section with carmine after partially decalcifying in HCl.

SHARPEY'S FIBRES.

Same as for encapsuled lacunæ.

NASMYTH'S MEMBRANE.

CELLULAR STRUCTURE.

1. To show nuclei.

Remove from tooth with HCl and phloroglucin, stain in Erlich's acid HÆMATOXYLENE, wash and mount in Farrant solution.

2. To show outline of cell.

Remove with HCl, and stain with NITRATE OF SILVER.

POSITION.

Grind a section, mount on a slide, and wash with HCl, stain with carmine.

PERIOSTEUM AND GUM.

1. Chromic acid method.
2. Hopewell Smith's method.

DEVELOPING TEETH.

Chromic acid method, carmine stain, and paraffin imbedding.

CARIES OF THE ENAMEL.

Ordinary ground section.

CARIES OF THE DENTINE.

Weil's method.

GERMS IN THE TUBES.

Break off the enamel from a carious tooth.
Wash in salt sol. and remove soft part with one cut.
Place in gum mucilage (15 hrs.).
Freeze and cut.
Stain the sections by Gram's method.
Clear and mount.

TRANSLUCENT ZONE.

1. Weil's method.
2. Underwood's gold chloride.