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DENTAL ANATOMY
NOTE BOOK

DOUGLAS GABILL

KING'S COLLEGE HOSPITAL
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REFERENCE BOOK

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DENTAL ANATOMY

BOOK

FOURTH EDITION



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DENTAL ANATOMY NOTE BOOK

*FOR USE IN CONJUNCTION WITH TOMES' "DENTAL ANATOMY,"
THE SOUTH KENSINGTON MUSEUM
AND
PERSONAL INSTRUCTION.*

KING'S COLLEGE HOSPITAL
MEDICAL SCHOOL.

BY

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[2ND ED.]

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DENTAL ANATOMY NOTE BOOK

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DENTAL ANATOMY

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.

DENTAL ANATOMY.

TEETH are hard, calcified, or bony, tissues placed in the mouth for the purpose of mastication of food.

The FUNCTIONS of teeth are:

PREHENSION	As in the Tiger, etc.
CONSTRUCTION	Tiger, Elephant, etc.
CORRAT	Tiger, Pig, Rabbit, etc.
LOCOMOTION	Walrus
ANCHORAGE	Dinosaurian
TRANSPORT	Elephant
SPEECH	Man

ORIGIN AND HOMOLOGUES of the Teeth.

Homologous: Hence the relation to a tubular type of correspondence in type in structure.

Kind of a rough outline of EMBRYOLOGY: EPIDERMIS, MESODERM, and NEURODERM.

The mouth is lined with Epithelium.

Note the similarity and continuity of the Epithelium which will form the enamel.

Note the similarity of form with the mammalian teeth.

Insulin: Teeth are Homologous with Dental Spines, but in origin and structure.

Teeth may be classified as:

HORN teeth, which consist of the dentin and enamel. Stratum Corneum covers the enamel surface.

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

Dental teeth **ALWAYS** have an Enamel, even if it is absent in form. Cementum may occur as a matrix or partially replaced 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,	<table border="0"> <tr> <td>(</td> <td>CALCIUM PHOSPHATE</td> <td>)</td> </tr> <tr> <td>(</td> <td>Calcium carbonate</td> <td>)</td> </tr> <tr> <td>(</td> <td>Calcium fluoride</td> <td>)</td> </tr> <tr> <td>(</td> <td>Magnesium phosphate</td> <td>)</td> </tr> </table>	(CALCIUM PHOSPHATE)	(Calcium carbonate)	(Calcium fluoride)	(Magnesium phosphate)	95 %
		(CALCIUM PHOSPHATE)										
		(Calcium carbonate)										
		(Calcium fluoride)										
(Magnesium phosphate)												
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.

ENAMEL

is very hard, brittle, translucent and semi-transparent
and composed of distinct layers or a cellular matrix

CHEMICAL COMPOSITION

Weight	Organic Matter	Amount (%)
Water	Physically combined with the salts	4.2
Salts	Magnesium phosphate Calcium fluoride Calcium carbonate Calcium phosphate	88.7
		NOTE

THE MATRIX

is very much a cement substance, but is not easily dissolved by acids than the prisms

THE PRISMS

are the large, translucent, rod-like and rhombic crystals, which are usually more easily dissolved
by acids than the matrix

In the Enamel	In the Matrix
Large	Small
Translucent	Opaque
Layer	Irregular
Prismatic	Amorphous
Uniform	Irregular
Well defined	Ill defined
Sharp edges	Rounded edges
Well defined	Ill defined

- The Transverse Striae of prisms are due to a series of
1. Interruption of the prisms
 2. Interruption of the prisms
 3. Interruption of the prisms
 4. Interruption of the prisms
 5. Interruption of the prisms

It is important that the structure of the enamel is not uniform, but is composed of distinct layers, and
the structure of the enamel is not uniform, but is composed of distinct layers, and
the structure of the enamel is not uniform, but is composed of distinct layers, and

LEARN TO RECOGNISE AND DESCRIBE

- BROWN STRIAE OF RETZIUS
- SCHREIBER'S LINES
- TOOTH LAMINAE
- ROBERTSON'S THINNING
- PIGMENT IN THE ENAMEL
- IRREGULAR STRIAE OF THE DENTINE

DISTRIBUTION OF ENAMEL

Enamel is found on the crown of the tooth, and is not found on the root or the neck of the tooth.
It is composed of distinct layers, and the structure of the enamel is not uniform, but is composed of distinct layers, and
the structure of the enamel is not uniform, but is composed of distinct layers, and

LEARN HOW TO SHOW

ENAMEL PRISMS, TRANSVERSE STRIAE, STRIAE OF RETZIUS, SCHREIBER'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.

DENTINE

Varieties

Hard dentine, Pitted-dentine, Vaso-dentine and Osteo-dentine.

Hard Dentine

Is hard elastic yellowish and translucent and composed of a cellular matrix permeated by tubes containing fibrils.

CHEMICAL COMPOSITION

Percentage	Component	Category
30%	Collagen Elastin	Organic matter
32%	Calcium phosphate Calcium carbonate Calcium fluoride	Salts
37%	Hydroxyapatite Hydroxyfluorapatite	Water

THE MATRIX

Is a soft yellowish matrix with cells. When hardened a very hard fibrous network is apparent.

THE TUBES

Run in spiral paths 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 circular primary cavity. Those in the root have many small spiral secondary cavities. Many little lateral branches are given off and the tubules terminate in closed extremities. In root and crown the tubules are in the granular layer. In dentine in the crown the tubules are in the secondary matrix. The tubules are filled with the contents of the dentin and are the source of the dentin and pulp and reach the crown of teeth and alveolar bone.

THE FIBRILS

Are soft rod-like flattened processes of the fibroblasts. Present in dentin and secondary matrix.

LEARN TO RECOGNISE and explain

- "SCHREIBER'S LINES"
- "OWEN'S LINES"
- "INTERDENTULAR SPACES"
- "GRANULAR LAYER OF DENTIN"

LEARN HOW TO SHOW

OWEN'S LINES, INTERDENTULAR SPACES, SCHREIBER'S LINES, GRANULAR LAYER, DENTIN OF DENTIN, DENTINAL FIBRIL, FIBRILS, 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 trabeculae of dentine containing **Canaliculi** and sometimes **Lacunæ**, and between the trabeculae 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.

Plico-Dentine

The pulp is seen as low ridges. No secondary dentine.
 Various layers: Organic, Lamellar, Pulpal, Pulpal, Organic, Pulpal
 and Pulpal layers.
 The pulp is seen as low ridges.

Vaso-Dentine

The dental pulp and dentin are composed of organic and inorganic matter.
 The dentin is often laminated (see "Dentin" page 2) and in the outer part a blood vessel is often visible.
 The dentin is often laminated (see "Dentin" page 2) and in the outer part a blood vessel is often visible.
 In the dentin, the organic matter is composed of collagen and elastin fibers.
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 In the dentin, the organic matter is composed of collagen and elastin fibers.
 In the dentin, the organic matter is composed of collagen and elastin fibers.
 In the dentin, the organic matter is composed of collagen and elastin fibers.

Osteo-Dentine

Calcified tissue found in the substance of the dentin, as well as in the surface of the pulp.
 There is usually an outer layer of fine granules, a middle layer of coarse granules, and an inner layer of fine granules.
 and secondary dentine, and between the lamellae are spaces filled with pulp tissue and lined with
 flattened cells.
 The dentin is composed of organic and inorganic matter.

NOTE THE GRADATIONS BETWEEN

HARD PULP - BOTH ENDS - OSTEO-DENTINE AND BONE

Secondary Dentine

It is found in part of the dentin after removal of the pulp, and is composed of dentin.
 It is found in part of the dentin after removal of the pulp, and is composed of dentin.
 It is found in part of the dentin after removal of the pulp, and is composed of dentin.
 It is found in part of the dentin after removal of the pulp, and is composed of dentin.

LEARN HOW TO SHOW

PULO, YASO, OR OSTEO-DENTINE - WITH & WITHOUT PULP

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 filaments 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.

BULB

Diagram of Bulb, Cells, Fibrous Tissue, Vessels, and Nerves

FUNCTIONS

Resistant, nutritive, nervous

THE MATRIX

Is granular, soft and jelly-like

THE CELLS

The central cells are numerous and have fine processes

The chromatophore (pigment) cells form a complete surface layer; they are large elongated granular cells and send out processes, 1. into the Dentin (central bulb), 2. laterally, and 3. towards the pulp.

In old age the chromatophore become smaller and more oval.

THE VESSELS

Arteries, capillaries, veins, and no lymphatics

THE NERVES

These are not peripheral nerves, rather soon lose their sheaths and form a plexus near the surface of the pulp (plexus of Beakow). The nerves probably terminate as fine varicose filaments between the chromatophore cells. Other nerves are that may join the dental floss, or run with them, or that they find the pulp (plexus) of the chromatophore.

THE FIBROUS TISSUE

Is very soft and continuous with that in the matrix of the dentin.

In old age it becomes and the cells disappear.

LEARN TO RECOGNISE and explain

"BAGALL LAYER OF WEIL"

"DENDROBLAST"

LEARN HOW TO SHOW

DENDROBLAST, 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**.

THE FIBRES

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.

THE NERVES

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.

CEMENTUM

Consists of a gelatinous matrix containing lacunae, canaliculi and sometimes blood-vessels.

CHEMICAL COMPOSITION

Absent the same as bone.

THE MATRIX

If thin, is structureless or granular.
If thick it is laminated and contains lacunae.

LEARN TO RECOGNISE and explain

"SHARPEY'S FIBRES"
INTERSTITIAL LINES OF BALTER

THE LACUNAE

Are not usually present in thin cementum.
They are more frequent in the end layers than the middle.
The canaliculi are abundant especially towards the surface.
Each lacuna is filled with a cement corpuscle.

LEARN TO RECOGNISE and explain

"ENCAPSULATED LACUNAE"

THE BLOOD VESSELS

Occur in thick cementum only and do not form a vascular system.

DISTRIBUTION

Cementum is rare in Pines and Rapeseed.
It covers the roots in all Mammalia teeth and the crowns of man.
It is the most external dental tissue.

LEARN HOW TO SHOW:-

SHARPEY'S FIBRES INTERSTITIAL LINES OF BALTER LACUNAE AND ENCAPSULATED LACUNAE

NASMYTH'S MEMBRANE

Is a thin layer of keratinized epithelial cells derived from the enamel organ, covering the crown and lying on its inner surface a thin, connective tissue membrane.

LEARN HOW TO SHOW:-

NASMYTH'S MEMBRANE IN SITU AND IN 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.

It is found in the alveolar process of the jawbone and is a part of the periodontal membrane. It is a part of the oral cavity and is a part of the oral cavity.

LEARN TO RECOGNISE and explain:-

- "GLANDS OF PERIAPICAL"
- "POCKETS" BOUND THE TEETH.
- "HEALTH LINE"

LEARN HOW TO SHOW:-

GUM IN SITU, NERVE, GLANDS OF PERIAPICAL

ALVEOLO-DENTAL MEMBRANE

It is composed of bundles of WIGG THROUGH THESE containing Blood-Vessels, Nerves and Cells between the teeth and the alveolar process of the jawbone. It is a part of the oral cavity and is a part of the oral cavity.

THE FIBRES

The fibres are found in the alveolar process of the jawbone and are a part of the oral cavity. They are found in the alveolar process of the jawbone and are a part of the oral cavity.

"SHARPEY'S FIBRES"

THE BLOOD VESSELS

The blood vessels are found in the alveolar process of the jawbone and are a part of the oral cavity. They are found in the alveolar process of the jawbone and are a part of the oral cavity.

THE NERVES

The nerves are found in the alveolar process of the jawbone and are a part of the oral cavity. They are found in the alveolar process of the jawbone and are a part of the oral cavity.

THE CELLS

The cells are found in the alveolar process of the jawbone and are a part of the oral cavity. They are found in the alveolar process of the jawbone and are a part of the oral cavity.

"GLANDS OF PERIAPICAL"

The alveolo-dental membrane is found in the alveolar process of the jawbone. It is a part of the oral cavity and is a part of the oral cavity.

LEARN HOW TO SHOW:-

PERIAPICAL IN SITU, GLANDS OF PERIAPICAL, 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 bicuspid and 2nd and 3rd molars are not yet visible.

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

DEVELOPMENT OF THE TEETH

IN FISH

In the teleostean fish there is a continuous growing tooth band, enamel teeth, and dentine papillae but no falcite, and the enamel organ is very simple in structure. In teleost fish there is no tooth band or falcite, and enamel enamel and dentine papillae is developed in rows.

IN REPTILES

There is a continuous growing tooth band, enamel teeth, and dentine papillae, the whole being enclosed in a fibrous sac, a fact in common with the "area of tooth development."

IN MAMMALIA (see Human)

There is a tooth band of limited growth, only two sets of enamel teeth and dentine papillae, each set having its own falcite.

(Continuing our description for convenience to the lower jaw, at the —

6th week

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

7th week

This ingrowth divides into two bands, an outer, called "labio-dental strand" (lipodentals), and an inner, called "dental strand" (dentals), and a groove "dental furrow" appears in the origin of the lower jaw. Calcification of the dentin centers.

8th week

The calcification "enamel buds" appear near the free end of the dental strand.

10th week

These calcifications of the mesoderm appear against the outer surface of the enamel buds "dentine papillae". The enamel buds have become "enamel organs".

11th week

Two rows dentine papillae appear, the "enamel organs" are now formed. The central cells of the lipodentals multiply to form the labio-dental enamel.

14th week

The enamel buds for the upper jaw develop into "enamel organs". The bone continues to grow up round the developing teeth. The dental lamina extends backwards from the gum.

17th week

Another enamel bud for the lower jaw appears with its corresponding dentine papillae. The dental lamina is beginning to become fenestrated at the front of the mouth.

20th week

Calcification starts in the milk teeth.

26th week

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

30th week

The enamel bud for the first temporary molar.

33rd week

The enamel bud for the first temporary premolar.

AT BIRTH

The dental lamina is evident in front but white at the back of the mouth. The nuclei of the enamel organ of the incisors have grown those of the canines and molars. The teeth are calcified thus: The canines of the permanent incisors and canines are visible to the naked eye, those of the molars and first and second molars are not yet visible. The upper and lower permanent and temporary teeth are in a common lamina.

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	$\frac{3}{5}$	$\frac{1}{3}$	$\frac{1}{4}$ (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.

PERMANENT DENTITION

Upper	1st premolar	1st molar	2nd molar	1st premolar	1st molar	2nd molar
Lower	1st premolar	1st molar	2nd molar	1st premolar	1st molar	2nd molar

PERMANENT DENTITION

Upper	1st premolar	1st molar	2nd molar	1st premolar	1st molar	2nd molar
Lower	1st premolar	1st molar	2nd molar	1st premolar	1st molar	2nd molar

ENAMEL ORGAN

The enamel organ is composed of several layers of cells and is situated in the center of the tooth. It is the source of the enamel, the hard outer covering of the tooth. The enamel organ consists of the inner enamel epithelium, the enamel organ proper, and the outer enamel epithelium. The inner enamel epithelium is a single layer of cells that forms the enamel. The enamel organ proper is a layer of cells that surrounds the inner enamel epithelium. The outer enamel epithelium is a layer of cells that surrounds the enamel organ proper.

DENTINE PAPER

The dentine paper is a thin layer of dentine that covers the root of the tooth. It is formed by the deposition of dentine on the root of the tooth. The dentine paper is composed of dentine and is situated between the root of the tooth and the periodontal ligament. It is the source of the dentine, the hard tissue that makes up the bulk of the tooth. The dentine paper is formed by the deposition of dentine on the root of the tooth. The dentine paper is composed of dentine and is situated between the root of the tooth and the periodontal ligament.

DENTAL FOLIOLE

The dental follicle is a layer of tissue that surrounds the root of the tooth. It is formed by the deposition of tissue on the root of the tooth. The dental follicle is composed of connective tissue and is situated between the root of the tooth and the periodontal ligament. It is the source of the periodontal ligament, the fibrous tissue that surrounds the root of the tooth. The dental follicle is formed by the deposition of tissue on the root of the tooth. The dental follicle is composed of connective tissue and is situated between the root of the tooth and the periodontal ligament.

When a tooth is in the process of development, it is surrounded by a layer of tissue called the dental follicle. This layer of tissue is the source of the periodontal ligament, the fibrous tissue that surrounds the root of the tooth. The dental follicle is formed by the deposition of tissue on the root of the tooth. The dental follicle is composed of connective tissue and is situated between the root of the tooth and the periodontal ligament.

CALCIFICATION—Impregnation with lime salts.

Excretion theory (mollusks) ; 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.

CALCIFICATION

Enzymes (e.g. phosphatase, aspartate aminotransferase)
Calcium phosphate and calcium carbonate
(Weinmann, 1954; Fagan, 1954)

ENAMEL

Enamel is a highly organized, crystalline, non-cellular tissue which is the hardest and most highly mineralized tissue in the body. It is composed of approximately 96% inorganic material and 4% organic material. The inorganic material is primarily hydroxyapatite, a calcium phosphate salt. The organic material is primarily protein, which is thought to be involved in the growth and development of the enamel. It is believed that the protein acts as a template for the deposition of the mineral ions.

Theory

The theory of enamel formation is based on the concept of a liquid phase. It is believed that the enamel is formed from a liquid phase of calcium phosphate and water. This liquid phase is thought to be secreted by the enamel-forming cells (ameloblasts) and then solidifies as the enamel matures.

DENTINE

Dentine is a highly organized, crystalline, non-cellular tissue which is the second hardest tissue in the body. It is composed of approximately 70% inorganic material and 30% organic material. The inorganic material is primarily hydroxyapatite, a calcium phosphate salt. The organic material is primarily protein, which is thought to be involved in the growth and development of the dentine. It is believed that the protein acts as a template for the deposition of the mineral ions.

Theory

The theory of dentine formation is based on the concept of a liquid phase. It is believed that the dentine is formed from a liquid phase of calcium phosphate and water. This liquid phase is thought to be secreted by the dentine-forming cells (odontoblasts) and then solidifies as the dentine matures.

VASO-DENTINE

The theory of vaso-dentine formation is based on the concept of a liquid phase. It is believed that the vaso-dentine is formed from a liquid phase of calcium phosphate and water. This liquid phase is thought to be secreted by the vaso-dentine-forming cells and then solidifies as the vaso-dentine matures.

OSTEO-DENTINE

The theory of osteo-dentine formation is based on the concept of a liquid phase. It is believed that the osteo-dentine is formed from a liquid phase of calcium phosphate and water. This liquid phase is thought to be secreted by the osteo-dentine-forming cells and then solidifies as the osteo-dentine matures.

CEMENTUM

The theory of cementum formation is based on the concept of a liquid phase. It is believed that the cementum is formed from a liquid phase of calcium phosphate and water. This liquid phase is thought to be secreted by the cementum-forming cells and then solidifies as the cementum matures.

Theory

The theory of cementum formation is based on the concept of a liquid phase. It is believed that the cementum is formed from a liquid phase of calcium phosphate and water. This liquid phase is thought to be secreted by the cementum-forming cells and then solidifies as the cementum matures.

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 $\frac{2}{3}$ across the orbit.
 Teeth. $\frac{1}{2}$ root, $\frac{1}{3}$ root, $\frac{2}{3}$ 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.)

DEVELOPMENT OF THE JAW

LEARN THE DEVELOPMENT OF THE HEAD AND THE CENTER OF ORIENTATION OF THE JAW.

COMPARISON OF THE JAW

Before Birth

At Birth

The lower jaw is in one piece.
The mandible grows from the angle of the head and the anterior margin of the body of the
The mandible is level with the alveolar
The symphysis is the point of contact between the lower border of the jaw in front.
The center is one, triangular and broad.
The upper part is opposite the second maxillary molar.
The suture is a true suture. (From the right side.)
The suture is a true suture.

6 Months

The lower jaw is in one piece.
The mandible grows from the angle of the head and the anterior margin of the body of the
The symphysis is the point of contact between the lower border of the jaw in front.
The center is one, triangular and broad.
The upper part is opposite the second maxillary molar.
The suture is a true suture. (From the right side.)
The suture is a true suture.

1 Year

The mandible grows from the angle of the head and the anterior margin of the body of the
The symphysis is the point of contact between the lower border of the jaw in front.
The center is one, triangular and broad.
The upper part is opposite the second maxillary molar.
The suture is a true suture. (From the right side.)
The suture is a true suture.

Old

The mandible is in one piece.
The symphysis is the point of contact between the lower border of the jaw in front.
The center is one, triangular and broad.
The upper part is opposite the second maxillary molar.
The suture is a true suture. (From the right side.)
The suture is a true suture.

GROWTH OF THE JAW

At all stages the jaw grows

through the symphysis

in the midline of the jaw

The anterior portion grows in a straight line and gives a sharp angle as it is joined to the jaw.
The posterior portion grows according to the structure of the jaw and as a result a little more
is on the jaw.

The anterior portion grows more rapidly than the posterior to provide room for the teeth.
of the jaw and of the jaw.

THE LOWER JAW increases in length as growth
1. through the symphysis behind the ascending ramus.
2. in an anterior direction of the anterior part of the jaw.

THE LOWER JAW increases in width as
1. thickness of the jaw increases of itself.
2. the posterior portion grows on each side of the jaw.
3. through the suture between the halves. (From the right side.)

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 " " 2½ 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 bicuspid 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	7½	8½	11½	10½	11½	7½	12½	24 years.
Lower	7½	8½	10½	10½	11½	7	12½	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 ATTACHMENT OF TEETH

By the following teeth, whether in situ.

BY FIBROUS MEMBRANE

The teeth are attached to a fibrous membrane which covers the jaw, the alveolar process and the soft parts of the mouth. This membrane is called the fibrous membrane of the teeth.

BY A HINGE

(1) ELASTIC. The teeth are attached to the jaw by a hinge joint. The hinge joint is formed by the union of the teeth and the jaw.

- 1. Elastic
- 2. Fibrous
- 3. Ligamentous
- 4. Synovial

BY ANCHYLOSIS

The teeth are fixed to the jaw by a process called anchylosis, which is a bony union between the teeth and the jaw.

- 1. Elastic
- 2. Fibrous
- 3. Ligamentous
- 4. Synovial
- 5. Anchylous

BY SOCKET

The teeth are fixed to the jaw by a socket. The socket is a bony cavity in the jaw which receives the root of the tooth.

- 1. Elastic
- 2. Fibrous
- 3. Ligamentous
- 4. Synovial
- 5. Anchylous
- 6. Socket

Conclusion: The teeth are attached to the jaw by various methods, but the most common is by the socket.

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, <i>e.g.</i> , Carcharias, &c., &c.
Slender rods	Chætodonts { dents en velours. " " brosse. " " cardes.
Flat plates	Rays, <i>e.g.</i> , Rhynceobates.
A few are Heterodont	{ Anarchus Lupus, Cestracion Phillipi.
One shows Sexual differences	Raja 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, <i>e.g.</i> , Pike (<i>next case</i>).
Vertical succession	{ File Fish, Lamprey, Wrasse, Pseudo-Scarus, Baraeuda Pike (sphyraena pic).
	{ Porcupine Fish (gymnodont).
	{ Parrot Fish (scarus) (").
	{ Lepidosiren (mud fish).
Fused vertical succession	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

Morphology and function of the teeth of fishes

HOMOLOGY

Comparison of the teeth of fishes with the teeth of other vertebrates

STRUCTURE

General structure of the teeth of fishes

Structure of the teeth of different groups

CARVED TEETH

Structure of the teeth of different groups

GROUPS

Structure of the teeth of different groups

GROUPS

Structure of the teeth of different groups

Structure of the teeth of different groups

Structure of the teeth of different groups

MODE OF ATTACHMENT

FORMS

Structure of the teeth of different groups

Structure of the teeth of different groups

Structure of the teeth of different groups

Structure of the teeth of different groups

Structure of the teeth of different groups

Structure of the teeth of different groups

Structure of the teeth of different groups

Structure of the teeth of different groups

SUCCESSION

Structure of the teeth of different groups

Structure of the teeth of different groups

Structure of the teeth of different groups

Structure of the teeth of different groups

Structure of the teeth of different groups

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Structure of the teeth of different groups

Structure of the teeth of different groups

Structure of the teeth of different groups

DISTRIBUTION

Structure of the teeth of different groups

Structure of the teeth of different groups

Structure of the teeth of different groups

Structure of the teeth of different groups

Structure of the teeth of different groups

Structure of the teeth of different groups

THE TEETH OF FISHES.

Fishes are divided into—Leptocardii, Cyclostomata, Palaeiethyes, 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; ankylosis; 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	Double enamel tips.
Salamanders }	
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; ankylosis; 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 monophodont.
Chameleon	is monophodont.

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, ankylosed; 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*).

BATRACHIANS

Two rows in the upper and one in the lower jaw (homodont, haplodont; endless vertical succession; anachlystia; two rows dentine enamel tips)

Two rows in the upper and one in the lower jaw (heterodont, heterodont; endless vertical succession; anachlystia; two rows dentine enamel tips)

REPTILES

CHELONIAN REPTILES

Two rows in the upper and one in the lower jaw (heterodont, heterodont; endless vertical succession; anachlystia; two rows dentine enamel tips)

SARONIAN REPTILES

Two rows in the upper and one in the lower jaw (heterodont, heterodont; endless vertical succession; anachlystia; two rows dentine enamel tips)

DIPODIA REPTILES

Two rows in the upper and one in the lower jaw (heterodont, heterodont; endless vertical succession; anachlystia; two rows dentine enamel tips)

Two rows in the upper and one in the lower jaw (heterodont, heterodont; endless vertical succession; anachlystia; two rows dentine enamel tips)

Two rows in the upper and one in the lower jaw (heterodont, heterodont; endless vertical succession; anachlystia; two rows dentine enamel tips)

COELUROSA

Two rows in the upper and one in the lower jaw (heterodont, heterodont; endless vertical succession; anachlystia; two rows dentine enamel tips)

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Two rows in the upper and one in the lower jaw (heterodont, heterodont; endless vertical succession; anachlystia; two rows dentine enamel tips)

CROCODILIA.

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

Crocodile $\frac{1}{1} \frac{3}{4} \frac{0}{11}$ 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.

Dielynodon 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 Tollopieus 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 $\frac{14}{13}$ 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.

CROCODYLIA

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

Crocodylia
Dental

Extinct Reptiles

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

ICHTHYOSAURUS

has incomplete socket (lower jawline)

DIPOSAURUS

frontal and dental process

ANOMODONTIA

Heterodont

THEPOCHELONIA

the greatest degree of heterodonty; lower jaw (1)

THEPODONTIA

Not continuous succession

THEPODONTIA

homodont and heterodont

PTEROSAURIA

3- tooth at the base of jaw
2- tooth in front of jaw
1- tooth at the base of jaw

Pterosauria
Pterosauria
Pterosauria

BIRDS

Ectothous, horny plates, often serrated
Wedge
obovate, flattened
Anteroposterior

ODONTOURIA

II homodont, naquadont, hard dentine and cementum
continuous vertical

ODONTOURIA

II homodont, naquadont, hard dentine and cementum
continuous vertical

Some are "egg tooth" - some are a thick at the end of the jaw; egg teeth also occur in snakes

HOMOLOGIES OF THE TEETH.

THEORIES.

1. That several simple teeth become fused to form a complex tooth.
(*Rose, Kükenthal, 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. Metacone, -id.
4.	Tritubercular	Spalacotherium	

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-conide.*)
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 **Sulna** the cingulum is raised distally to form cusps (*e.g.*, **Phæochærus**, 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 **Slots** 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.

HOMOLOGIES OF THE TEETH

THEORIES

1. That enamel might have become fixed to form a complete tooth.
(Van Kesteren and Jordan)
2. That the cusps are developed on an original single tooth.
(See Van Kesteren's "Zooloogische Atlas")

STAGES OF TRITUBERCULISM

	(The body of the tooth)	
Tribuculus	Dentition	1. Tubercular
Tribuculus	Tribuculus	2. Tubercular
Tribuculus	Tribuculus	3. Tubercular

The Tribuculus is fixed and the Tribuculus is fixed to the Tribuculus

Tribucular teeth are formed from an original tooth

1. Addition of cusps. (Van Kesteren and Jordan)
2. Addition of some cusps and suppression of others.
3. Elevation of the cingulum.
4. Folding of the enamel tissue.
5. Suppression of some of the dental tissue.
6. Addition of new tissue. (Van Kesteren and Jordan)
7. Lengthening of the cusps.

EXAMPLES

1. Addition of cusps. The lower molar tooth of the dog, in which the posterior tubercle and anterior tubercle are united to form the distal and a small fixed tubercle is united to the base of the tooth.
 2. Addition and suppression of cusps. In the lower molar tooth of the pig the anterior tubercle is fixed and the posterior tubercle is fixed to the base of the tooth.
 3. Elevation of the cingulum. In the incisor the cingulum is raised from the lingual and buccal sides to form a ridge.
 4. In the molar the cingulum is raised mainly to form a ridge (i.e. the cingulum) and to a less extent the tip.
 5. In the molar and tribuculus we have another example of the same thing, from a widening of the cusps and a shortening of the teeth.
 6. Folding of the tissue. In the molar of the horse and the molar of some rodents.
 7. Suppression of tissue. The partial cusp of the molar of the horse of the molar of the horse.
 8. Addition of tissue. In the posterior molar tooth of the horse and human the pulp reaches the distal end of the tooth.
 9. Lengthening of cusps. In the hypobulb tooth of luminant and still more in the posterior molar tooth of the horse.
- The molar of the horse shows an addition and lengthening of cusps, an elevation of the cingulum and a widening of the cusps.

Many people do not accept the Tribucular theory in toto because:

1. The oldest known mammals had "tribucular" teeth.
2. Mammals differ as to the classification of cusps in many cases.
3. It shows the growth of the cingulum in a very peculiar way.
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 **Orycteropus** has **HETERODONT** and **ROOTED** milk teeth, and homodont, persistent growing permanent teeth;

The **Balaenoptera Rostrata** has **HETERODONT** 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?

TOOTH SUCCESSION

FISHES	Two sets (Diphyodont)	One tooth band	Sharks and Rays
REPTILES	Two sets (Diphyodont)	One tooth band	Snakes
BIRDS (Passer)	Two sets (Diphyodont)	One tooth band	Keats and Hawks
BIRDS (Struth)	Two sets (Diphyodont)	One tooth band	Wingless
MAMMALIA	Two sets (Diphyodont)	One tooth band	Man
	One set (Monophyodont)	One tooth band	Ant

Reading from top to bottom: a "MILK MIX" and a "POST-PERMANENT" set in some mammals.

THEORIES TO EXPLAIN THE TWO SET THEORY

1. Inactive first Polyphyodont dentition
2. Folding of tooth band into dentition of jaw

The Milk Dentition resembles the permanent Dentition

There is a close resemblance between the milk and permanent dentitions in many mammals. The arrangement of the teeth in the milk dentition is similar to that of the permanent dentition. The arrangement of the teeth in the milk dentition is similar to that of the permanent dentition. The arrangement of the teeth in the milk dentition is similar to that of the permanent dentition.

Permanent Molars are absent

1. Inactive first Polyphyodont dentition
2. Folding of tooth band into dentition of jaw
3. Folding of tooth band into dentition of jaw
4. Folding of tooth band into dentition of jaw

DEGREE OF DEVELOPMENT OF MILK TEETH

1	Not formed at all	Sharks
2	Formed but not functional	Snakes
3	Calculus not developed	Keats
4	Formed but not functional	Wingless
5	Formed but not functional	Man
6	Formed but not functional	Keats and Hawks
7	Formed but not functional	Wingless
8	Formed but not functional	Man

In many mammals, the dentition is similar to that of the permanent dentition. The dentition is similar to that of the permanent dentition. The dentition is similar to that of the permanent dentition.

SOME DETAILS ABOUT THE MILK TEETH OF MAMMALIA.

EDENTATA.		(Homodont and monophyodont.)	
But in			
9 Banded Armadillo		Milk teeth till nearly full size.	
Orycteropus		7 Rudimentary, calcified, heterodont, unerupted milk teeth; plicidentine, non-persistent growth.	
CETACEA.		(Monophyodont.)	
Milk teeth persist all life. Permanent rudiments unerupted.			
SIRENIA.			
Dugong		Milk tusk only. (2nd Incisor?)	
Manatee		$\begin{matrix} 2 & 0 & 0 \\ 3 & 1 & 3 \end{matrix}$ Milk teeth. Perpetual succession of molars <i>à la</i> Elephant.	
UNGULATA.		(Typical diphyodonts.)	
In many dm_1 (pm_1 f) has no successor.			
Timms found a "Pre-milk" tooth in the pig (f).			
Phacochoerus sheds m_1 , pm_2 , m_2 , pm_4 of its permanent set.			
RODENTS.		(Few milk teeth.)	
Hares		$\begin{matrix} di_1 & di_2 & dm_1 & dm_2 & dm_3 \\ di_1 & & dm_1 & dm_2 & \end{matrix}$	$\left. \begin{matrix} di_1 \text{ lost in utero.} \\ di_2 \text{ and } dm_3 \text{ lost in 18 days} \\ \text{(non-persistent growth).} \end{matrix} \right\}$
Rabbits		$\begin{matrix} di_1 & di_2 & dm_1 & dm_2 & dm_3 \\ di_1 & & dm_1 & dm_2 & \end{matrix}$	
Squirrel		$\begin{matrix} di_1 & di_2 & di_3 \\ di_1 & & \end{matrix}$	
Mouse		$\begin{matrix} di_1 \\ di_1 \end{matrix}$	
Beaver		$\begin{matrix} dm \\ dm \\ dm \\ dm \\ dm \end{matrix}$	last till half grown.
Erethizon		$\begin{matrix} dm \\ dm \\ dm \\ dm \end{matrix}$	
Guinea Pig		$\begin{matrix} dm \\ dm \end{matrix}$	lost in utero.
Dasyprocta	}	$\begin{matrix} dm \\ dm \end{matrix}$	
Ctenodactylus			
Hystrix			
Atherina			
Rat		Monophyodont.	
CARNIVORA.		(Typical diphyodonts.)	
In many dm_1 (pm_1 f) has no successor.			
Felidae		$\begin{matrix} 3 & 1 & 3 \\ 3 & 1 & 2 \end{matrix}$	Milk teeth.
All others		$\begin{matrix} 3 & 1 & 3 \\ 3 & 1 & 3 \end{matrix}$	Milk teeth.
Bear			Loses milk tooth early.
Seals			Have degenerate milk teeth.
Otaria		$\begin{matrix} 3 & 1 & 3 \\ 3 & 1 & 3 \end{matrix}$	Milk teeth. Last a few weeks.
Phocan Greenlandica		$\begin{matrix} 1 & 1 & 3 \\ 3 & 1 & 3 \end{matrix}$	Milk teeth. Last a week.
Cystophora proboscidea		$\begin{matrix} 2 & 1 & 3 \\ 1 & 1 & 3 \end{matrix}$	Milk teeth. Lost in utero.
Walrus		$\begin{matrix} 4 \\ 4 \end{matrix}$	Milk teeth and 2? Lost at birth.
INSECTIVORA.		(Diphyodont.)	
Galeopithecus		$\begin{matrix} 2 & 0 & 3 \\ 2 & 0 & 3 \end{matrix}$	Milk teeth. Cut late. Work with true molars, di_1 lost early. Resemble pre-molars.
Hedgehog (erinaceus)		$\begin{matrix} 123 & 1 & 1234 \\ 123 & 1 & 1234 \end{matrix}$	Milk teeth. Those in italics functionless.
Gymnura		$\begin{matrix} 123 & 1 & 1234 \\ 123 & 1 & 1234 \end{matrix}$	Milk teeth. " " "
Shrew (sorex)		$\begin{matrix} 22 & 1 & 34 \\ & & 4 \end{matrix}$	All uncalcified.
Mole (talpa)		$\begin{matrix} 123 & 1 & 1234 \\ 123 & 1 & 1234 \end{matrix}$	Milk teeth. Lost early.
Centetes	}	$\begin{matrix} dm_2 \\ dm_1 \end{matrix}$	$\begin{matrix} dm_2 \text{ has no functional successor, and is retained late; } dm_4 \text{ is two rooted and} \\ \text{molariform.} \end{matrix}$
Hemioentetes			
Macroscelides			
Tupaia			
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		$\begin{matrix} 2 & 1 & 2 \\ 2 & 0 & 2 \end{matrix}$	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		$\begin{matrix} 1 & 1 & 1 \\ 0 & 1 & 1 \end{matrix}$	Milk teeth. Lost early.
OTHER VIEWS.			
Kuwenthal 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.

MAMMALIA

PROTHERIA (Monotremata)

Embryonic development of the placenta and embryonic teeth from the yolk sac.

EUTHERIA

EDENTATA

Monophyodont, mandibular, no factors, persistent growth. No enamel hard dentine and secondary dentine.

BOVINE

Two-rooted teeth, three-rooted teeth, deciduous, permanent, and succedaneous teeth.

ANT-EATERS

Sharp-edged, triangular, and other specialized teeth.

ARMADILLO

Two-rooted, specialized, and other specialized teeth.

ORYZOMYS (Rodentia)

Isodent, hypodont, and other specialized teeth.

CETACEA

ODONTOCETI

Monophyodont, homodont, hypodont, socketed teeth; hard dentine (osteodentine) present.

The functional teeth of whales are said to be the milk teeth, which are shed in the early stages of life.

MYSTACOCETI

Edentulous, rudimentary teeth. Whales.

Whales - Edentulous and the rudiment of teeth, and with the whale teeth.

SIRENIA

During the early stages of embryonic development, the rudimentary teeth, and a milk tooth is present in the mouth, which is shed in the early stages of life.

Whales and manatee have rudimentary teeth, which are shed in the early stages of life.

UNGULATA.

UNGULATA VERA

Diphyodont; heterodont $\begin{smallmatrix} 1143 \\ 3143 \end{smallmatrix}$; 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 Pecary are typical.

Phacochoerus has non-sexual canines (large in both sexes). A large M₃.

Sus Babirussa has the longest canines (no enamel).

HIPPOPOTAMI Both incisors and canines are of persistent growth.

SELENODONTS (ruminants) $\begin{smallmatrix} 0143 \\ 2152 \end{smallmatrix}$ No upper incisors.

TYLOPODIA.

Camel has good canines; $1_1 1_2$ 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 $\begin{smallmatrix} 1 & 4 & 2 \\ 0 & 4 & 2 \end{smallmatrix}$ 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.

UNGUJATA VERA
UNGUJATA

Diphyodont; heterodont
Brachyodont and hypsodont
VEGETABLE DIET
1. LOWER BARRAGE ACID
2. REGRESSION OF FRONT TEETH
3. SUPPRESSION OF CANINES
4. DEVELOPMENT OF CHEEK TEETH
5. GLANDULAR GONDYLE

Premolars differ markedly from true molars (simplex).
have large sexual deciduous growing canines.
The deciduous canines (true to dog teeth) A large M.
The largest canine (in animal)
The lower and canine are of deciduous growth.
No upper incisors.
The dog teeth, etc. are lost early.
The lower deciduous canine canines.

There are canines; hypsodont teeth and thick cementum over the enamel.
have small canines; brachyodont teeth and no cementum on the crown.
The large sexual canines
The large sexual and small lower
The large canines
The large canines
The large canines

Premolars and molars form an undivided series and are almost equally complex.
The pattern in the upper is the same as in the lower, and lower
The "claw" of the lower is present in the case of the upper.
The canines are a small canine, in the case of the lower are rudimentary.

SUBUNGUJATA
HYRACOIDEA

Hyax
The deciduous is greatly lost, but it has smaller than the fibrous and as upper second
The lower is lost early, and the lower deciduous are not of deciduous growth, and
The last upper deciduous is of deciduous growth.

PROBOIDEA
The deciduous is a double, below the 2nd tooth, and the milk canines and permanent molars form one
The deciduous is a double, below the 2nd tooth, and the milk canines and permanent molars form one
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The deciduous is a double, below the 2nd tooth, and the milk canines and permanent molars form one
The deciduous is a double, below the 2nd tooth, and the milk canines and permanent molars form one

RODENTIA.

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

Hydromys	$\begin{smallmatrix} 1002 \\ 1002 \end{smallmatrix}$, 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 $\begin{smallmatrix} 1002 \\ 1022 \end{smallmatrix}$, 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, $\begin{smallmatrix} 3131 \\ 3121 \end{smallmatrix}$

- CARNIVOROUS DIET
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. $\begin{smallmatrix} 3m_1 \\ m_3 \end{smallmatrix}$, "SECTORIAL" OR "CARNASSIAL" TEETH.
 6. ARCH SQUARE, AND ZYGOMA BROAD.
 7. CONDYLES FORM A PURE HINGE JOINT.

$\begin{smallmatrix} (3131) \\ (3121) \end{smallmatrix}$

TERRESTRIAL.

CELURIDEA (*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	$\begin{smallmatrix} 3m_1 \\ m_3 \end{smallmatrix}$ typical mixed feeder. Milk "carnassials" $\begin{smallmatrix} dm_4 \\ dm_1 \end{smallmatrix}$
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, $\begin{smallmatrix} 3143 \\ 3143 \end{smallmatrix}$, small canines, MANY CUSPS on the molars.

Galeophtieus	has lower comb-like incisors.
------------------------	-------------------------------

W PATTERN.

Mole (<i>talpa</i>)	(Draw a diagram.)
Hedgehog (<i>erinaceus</i>)	is typical.
Shrew (<i>sorex</i>)	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	

RODENTIA

Almost monophyodont, heterodont. Hypodont or persistent growing incisors (enamel on the front only). Hypodont or persistent growing molars. Grows at the sides, condyle long antero-posteriorly.

COMPARE THE PATTERN IN THE ENAMEL OF - MAMMALS: MANY PRIMATE BEARS, SQUIRREL, RODENTINE, RAT, SERPENT, MAMMALS.

CARNIVORA

CARNIVOROUS DIET

Diphyodont, heterodont. 1 INCISOR IN A STRAIGHT ROW. 2 CANINES, LARGE AND WIDE APART. 3 PREMOLARS, SMALL, INCREASING IN SIZE BEHIND AND BEING LARGER. 4 MOLARS, RUDIMENTARY. 5 "CARNASSIAL" OR "CARNASSIAL" TEETH. 6 FROM SQUARE AND ZYGOMA BROAD. 7 CONDYLE FOR A PURE HINGE JOINT.

TERRESTRIAL

Sharp "carnassial", bulky good molars. 2 "CARNASSIAL" OR "CARNASSIAL" TEETH. 6 FROM SQUARE AND ZYGOMA BROAD. 7 CONDYLE FOR A PURE HINGE JOINT.

AQUATIC

Diphyodont, heterodont. 1 INCISOR IN A STRAIGHT ROW. 2 CANINES, LARGE AND WIDE APART. 3 PREMOLARS, SMALL, INCREASING IN SIZE BEHIND AND BEING LARGER. 4 MOLARS, RUDIMENTARY. 5 "CARNASSIAL" OR "CARNASSIAL" TEETH. 6 FROM SQUARE AND ZYGOMA BROAD. 7 CONDYLE FOR A PURE HINGE JOINT.

INSEktivora

Diphyodont, heterodont. 1 INCISOR IN A STRAIGHT ROW. 2 CANINES, LARGE AND WIDE APART. 3 PREMOLARS, SMALL, INCREASING IN SIZE BEHIND AND BEING LARGER. 4 MOLARS, RUDIMENTARY. 5 "CARNASSIAL" OR "CARNASSIAL" TEETH. 6 FROM SQUARE AND ZYGOMA BROAD. 7 CONDYLE FOR A PURE HINGE JOINT.

W PATTERN

Diphyodont, heterodont. 1 INCISOR IN A STRAIGHT ROW. 2 CANINES, LARGE AND WIDE APART. 3 PREMOLARS, SMALL, INCREASING IN SIZE BEHIND AND BEING LARGER. 4 MOLARS, RUDIMENTARY. 5 "CARNASSIAL" OR "CARNASSIAL" TEETH. 6 FROM SQUARE AND ZYGOMA BROAD. 7 CONDYLE FOR A PURE HINGE JOINT.

V PATTERN

Diphyodont, heterodont. 1 INCISOR IN A STRAIGHT ROW. 2 CANINES, LARGE AND WIDE APART. 3 PREMOLARS, SMALL, INCREASING IN SIZE BEHIND AND BEING LARGER. 4 MOLARS, RUDIMENTARY. 5 "CARNASSIAL" OR "CARNASSIAL" TEETH. 6 FROM SQUARE AND ZYGOMA BROAD. 7 CONDYLE FOR A PURE HINGE JOINT.

CHIROPTERA

Diphyodont, heterodont. 1 INCISOR IN A STRAIGHT ROW. 2 CANINES, LARGE AND WIDE APART. 3 PREMOLARS, SMALL, INCREASING IN SIZE BEHIND AND BEING LARGER. 4 MOLARS, RUDIMENTARY. 5 "CARNASSIAL" OR "CARNASSIAL" TEETH. 6 FROM SQUARE AND ZYGOMA BROAD. 7 CONDYLE FOR A PURE HINGE JOINT.

PRIMATES. Diphyodont, heterodont $\begin{matrix} 2133 \\ 2133 \end{matrix}$

LEMURS.

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

SIMIADÆ.

NEW-WORLD (platyrrhine). $\begin{matrix} 2133 \\ 2133 \end{matrix}$

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.

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

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

LEARN THE ANATOMY OF EACH HUMAN TOOTH IN ABSOLUTE DETAIL.

COMPARE THE MOLARS OF APES, ABORIGINES, NEGROES, AND EUROPEANS.

MARSUPIALS. Diphyodont? heterodont $\begin{matrix} 3 & 1 & 3 & 4 \\ 3 & 1 & 3 & 4 \end{matrix}$; tubular enamel.

DIPROTODONTS. $\begin{matrix} 3 \\ 1 \end{matrix}$ incisors, small canines, molars ridged.

- Kangaroo Rats Herbivorous; $\frac{1}{1}$ persistent growth; pm₄ large.
 Cast of Thalacoleo is herbivorous, not carnivorous.
 Kangaroos Herbivorous; $\frac{1}{1}$ persistent growth, pm₄ replaces dm₄; pm₃ is shed later on.
 Australian Opossum is herbivorous.
 Phascolarectos 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.

PRIMATES: Diphodont, heterodont

LEMURS

Two incisors
No canine
No premolars
No molars

Typical Lemur: $\frac{11}{11}$

has only one lower incisor

A rodent type, functional molar incisors: but milk teeth $\frac{11}{11}$

SIMIAE

NEW WORLD (platyrrhini)

Incisors
Canines

has only two molars

Old World (catarrhini)

Incisors
Canines

Same formula as man

Incisors have flat cusps

Chimpanzee and Gorilla

Anthropoid Apes

Gorilla
Orang
Gibbon

has very long teeth
Large cusps in canines
A rodent like molar

DIFFER FROM MAN

- 1. MOLAR INCREASE IN SIZE BACKWARDS
- 2. PREMOLARS UPPER THREE, LOWER TWO-ROOTED
- 3. CANINE SEXUAL DIMORPHISM
- 4. LATERAL CURVATURE DIAPHYSE
- 5. METADIAPHYSE
- 6. SQUARE JAW (mass protruding behind)
- 7. PROGNATHOUS (late closure of sutures)

MAN

$$\text{Gonial Index} = \frac{L - I}{2}$$

$$\text{Dental Index} = \frac{M + P + M}{2}$$

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

MARSUPIALS: Diphodont, heterodont, tubular enamel

DIPROTODONTS

Kangaroo Rat
East of Wallaby
Kangaroo
Australian Dipodomys
Pseudothylacynus
Wombat

Incisors: permanent lower; two large

in upper jaw and canines

Incisors: permanent, growth, rapid, replace that, but, is shed later on

in heterodont

in rodent-like

is rodent-like. All the teeth are of permanent growth, no tubes in the enamel; permanent teeth all round the mouth. Has $\frac{11}{11}$ milk teeth.

but rudimentary molars

POLYPROTODONTS

Thylacine
Tasmanian Devil
Dasyurus Vombat
Asar's Dipodomys
Kangaroo

in dog-like alignment

is carnivorous

is insectivorous

is insectivorous

has diprotodont form; many milk teeth formed but uniserial

EDENTULOUS.

Adult Sturgeon, Pipe-fish, Hippocampus.
 Toad.
 Echidna.
 Manis, Mutica, Rhytina, Mystacoceti.
 Birds.
 The Narwal, Sword-fish, and Carp have edentulous 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, Hysiprymnus.
 Lower Incisors of Kangaroo, Hysiprymnus.
 Upper and Lower Incisors of Rodents, Aye-Aye.
 Molars of many Rodents.
 All the Teeth of Edentata, Dugong, Wombat.

KING'S COLLEGE HOSPITAL
 MEDICAL SCHOOL

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:—

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

GLOSSARY.

Aero-dont	Eel.
Pleuro-dont	Iguanodon.
Haplo-dont	Dolphin.
Proto-dont	Dromotherium.
Triceno-dont	Triceno-don (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 $\frac{1}{4}$ % 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.

PREPARATION OF HARD TISSUES

1. Saw into thin slices. (Get stained with a diamond disc.)
2. Place on a carborundum wheel, as this is possible.
3. Cool between two bits of ground plate glass, with paraffin and water.
4. Wash.
5. Dry lightly on the lamp.
6. Mount in some hard Canada balsam.

PREPARATION OF SOFT TISSUES

1. Fix in Muller's fluid or any other suitable.
 2. Harden in 95% alcohol.
 3. Dehydrate in alcohol.
 4. Stain in fast green, etc.
 5. Clear in oil of cloves, etc.
 6. Imbed in paraffin.
 7. Cut.
 8. Mount in Canada balsam or any other resin.
- If required, the sections may be stained, dehydrated and cleared, after being cut, instead of before.

PREPARATION OF HARD AND SOFT TISSUES TOGETHER

WIRE PROCESS

- | | | |
|----|---------------|---|
| 1 | about 4 hours | 1. Saw a fresh block into thin pieces, under water. |
| 2 | " | 2. Fix in a suitable fixative. |
| 3 | " | 3. Wash in running water. |
| 4 | 12 " | 4. Harden in 95% alcohol. |
| 5 | 12 " | 5. " 70% " |
| 6 | 12 " | 6. " 50% " |
| 7 | 12 " | 7. " 30% " and a few drops of oil of cedar. |
| 8 | 3 weeks | 8. Stain in alcoholic borax carmalum. |
| 9 | 12 hours | 9. Fix the stain with 10% alcohol and 1% HCl. |
| 10 | " | 10. Dehydrate in 80% " |
| 11 | " | 11. " 70% " |
| 12 | 0 " | 12. Clear in oil of cedar. |
| 13 | " | 13. Wash in alcohol. |
| 14 | 1 day | 14. Back in chloroform. |
| 15 | 2 days | 15. Imbed in a wax of Canada balsam. |
| 16 | " | 16. " in a tray. |
| 17 | 1 day | 17. " in fast green, etc. in 70% C. |
| 18 | 2 days | 18. " in 50% C. |
| 19 | " | 19. Grind when cool and brittle. |
| 20 | " | 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 HNO₃ „ 33 „
7. „ add 1.5 c.c. pure HNO₃ 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.

STAINS

ALCOHOLIC BORAX CARMINE

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.

HOPWELL SMITH'S PROCESS

1. Immerse the paper into a weak solution
2. Fix in Methyl red
3. Harden in 5% alcohol
4. Wash in alcohol with constant flow, fix and protect the soft parts with collodion
5. Decolorize in 1% KOH
6. All 1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-31-32-33-34-35-36-37-38-39-40-41-42-43-44-45-46-47-48-49-50-51-52-53-54-55-56-57-58-59-60-61-62-63-64-65-66-67-68-69-70-71-72-73-74-75-76-77-78-79-80-81-82-83-84-85-86-87-88-89-90-91-92-93-94-95-96-97-98-99-100

about 3-4 weeks

20 days

15 hours

10 ..

27 ..

1 ..

15 ..

MULLER'S FLUID

- BICROMATE OF POTASH
- SULPHATE OF SODA
- WATER

- 1/2 parts
- 1 part
- 100 parts

CHROMIC ACID PROCESS

1. Place the stuff in 10% chromic acid
2. Wash in water
3. Wash in alcohol
4. Wash in water
5. Wash in alcohol
6. Wash in water
7. Wash in alcohol
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85. Wash in alcohol
86. Wash in water
87. Wash in alcohol
88. Wash in water
89. Wash in alcohol
90. Wash in water
91. Wash in alcohol
92. Wash in water
93. Wash in alcohol
94. Wash in water
95. Wash in alcohol
96. Wash in water
97. Wash in alcohol
98. Wash in water
99. Wash in alcohol
100. Wash in water

1-3 weeks

IMBEDDING

GUM MUCILAGE IMBEDDING

1. Fix in Methyl red
2. Wash in water
3. Imbed in thin mucilage 2 parts
4. Wash in water
5. Fix in Methyl red
6. Wash in water
7. Imbed in thin mucilage 2 parts
8. Wash in water
9. Fix in Methyl red
10. Wash in water
11. Imbed in thin mucilage 2 parts
12. Wash in water
13. Fix in Methyl red
14. Wash in water
15. Imbed in thin mucilage 2 parts
16. Wash in water
17. Fix in Methyl red
18. Wash in water
19. Imbed in thin mucilage 2 parts
20. Wash in water
21. Fix in Methyl red
22. Wash in water
23. Imbed in thin mucilage 2 parts
24. Wash in water
25. Fix in Methyl red
26. Wash in water
27. Imbed in thin mucilage 2 parts
28. Wash in water
29. Fix in Methyl red
30. Wash in water
31. Imbed in thin mucilage 2 parts
32. Wash in water
33. Fix in Methyl red
34. Wash in water
35. Imbed in thin mucilage 2 parts
36. Wash in water
37. Fix in Methyl red
38. Wash in water
39. Imbed in thin mucilage 2 parts
40. Wash in water
41. Fix in Methyl red
42. Wash in water
43. Imbed in thin mucilage 2 parts
44. Wash in water
45. Fix in Methyl red
46. Wash in water
47. Imbed in thin mucilage 2 parts
48. Wash in water
49. Fix in Methyl red
50. Wash in water
51. Imbed in thin mucilage 2 parts
52. Wash in water
53. Fix in Methyl red
54. Wash in water
55. Imbed in thin mucilage 2 parts
56. Wash in water
57. Fix in Methyl red
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59. Imbed in thin mucilage 2 parts
60. Wash in water
61. Fix in Methyl red
62. Wash in water
63. Imbed in thin mucilage 2 parts
64. Wash in water
65. Fix in Methyl red
66. Wash in water
67. Imbed in thin mucilage 2 parts
68. Wash in water
69. Fix in Methyl red
70. Wash in water
71. Imbed in thin mucilage 2 parts
72. Wash in water
73. Fix in Methyl red
74. Wash in water
75. Imbed in thin mucilage 2 parts
76. Wash in water
77. Fix in Methyl red
78. Wash in water
79. Imbed in thin mucilage 2 parts
80. Wash in water
81. Fix in Methyl red
82. Wash in water
83. Imbed in thin mucilage 2 parts
84. Wash in water
85. Fix in Methyl red
86. Wash in water
87. Imbed in thin mucilage 2 parts
88. Wash in water
89. Fix in Methyl red
90. Wash in water
91. Imbed in thin mucilage 2 parts
92. Wash in water
93. Fix in Methyl red
94. Wash in water
95. Imbed in thin mucilage 2 parts
96. Wash in water
97. Fix in Methyl red
98. Wash in water
99. Imbed in thin mucilage 2 parts
100. Wash in water

3-4 weeks

15 hours

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.

COLLOIDION IMBEDDING (for large objects)

1. Dehydrate in acetone alcohol
2. Soak in a mixture of equal parts of alcohol and ether
3. Place in a jar that contains the colloidion
4. Place in a flask
5. Allow the mixture to evaporate slowly
6. Remove the object to 95% alcohol to harden
7. Cut with a microtome
8. Stain and dehydrate
9. Clear in cedar oil (not oil of cedar)
10. Mount

The time given 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 (60° after removed to 50°)
 4. Cool (falling 1/2 inch in temperature)
 5. Mount on a microtome and cut
 6. Mount and stain with paraffin with naphthalene
 7. Stain, clear, mount
- In other words, the object that is subjected to heat before imbedding it paraffin.

STAINS

ALCOHOLIC BORAX CARMINE (for staining in paraffin)

1. Place in the stain till saturated
 2. Soak in cedar oil to set the stain
 3. Embed in 90% and 100% alcohol slides
- ACID ALCOHOL... THE ALCOHOL AND 3 GRAMS HCl TO A TEST TUBE FULL.
- 8-1 week
10 hours
12 hours each

SILVER NITRATE

1. Wash the fresh tissues in distilled water
2. Soak in 1% AgNO₃ in the mixture of a yellowish-grey colour
3. Wash and mount as usual

HÆMATOXYLENE.

1. Place the section in a dark sol. of hæmat. ¼ 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 % AgNO₃ (in the dark) 1 day.
3. Dehydrate, clear, and mount in gum dammar.

UNDERWOOD'S GOLD CHLORIDE.

1. Grind section.
2. Wash in 1 % Na₂ CO₃.
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 "

HAMATOXYLINE

1. Place the sections in a dark box of paper.
 2. Wash well in water.
 3. Dehydrate in absolute alcohol.
 4. Clear in cedar oil and mount.
- To counter-stain with eosin, add eosin to the absolute alcohol used for dehydrating.

MUMFORD'S IRON AND TANNIN

1. Wash the sections in water.
2. Place in phos. acid (10%) for 10 min.
3. Wash quickly and thoroughly.
4. Place in ferric acid (10%) for 10 min.
5. Wash in water, dehydrate, clear, and mount.

GOLGI'S METHOD

1. Place the sections in a solution of 1% gold chloride in 1% potassium dichromate in water.
2. Dehydrate, clear, and mount in cedar oil.

UNDERWOOD'S GOLD CHLORIDE

1. Grind sections.
2. Wash in 1% NaCl.
3. Fix in 1% AuCl₃ in the dark.
4. Wash in water.
5. Wash in 1% formalin acid.
6. Wash in cold water.
7. Dry and mount in glycerine jelly.

TO STAIN BACTERIA

1. Place the sections in a strong solution of gentian violet.
2. Wash in Gram solution.
3. Wash in absolute alcohol or 70% ethanol.
4. Clear and mount.

GRAM SOLUTION

- WATER 100
- POTASSIUM IODIDE 2
- IODINE 1

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.

TO SHOW

ENAMEL PRISMS

(Find and name structure)

TRANSVERSE STRIÆ OF ENAMEL PRISMS

- 1. They may be slightly seen in ordinary ground sections.
- 2. (Find a section and name it in pencil H.C. and stain with carmalum.)

BROWN STRIÆ OF RETZIUS

(In ordinary ground section)

DENTINAL FIBRILS

- 1. Weil's process
- 2. Haversian sheath process

DENTINAL TUBES

- 1. (Find and name structure)
- 2. (Find and name structure)

DENTINAL SHEATHS

- 1. (Find and name structure)
- 2. (Find a section and stain in H.C. tubes only stained)

INTERCLOBULAR SPACES AND OWENS LINES

- 1. Weil's process
- 2. (Find and name structure)

VASO-DENTINE AND OSTEO-DENTINE

- 1. Weil's process
- 2. (Find and name structure)

PULP CELLS

- 1. Weil's process
- 2. (Find and name structure)

NERVES OF THE PULP

(Find and name structure)

ENCAPSULATED LACUNÆ

(Find and name structure)

SHARPEY'S FIBRES

(Find and name structure)

NASMYTH'S MEMBRANE.**CELLULAR STRUCTURE.**

1. To show nuclei.

Remove from tooth with HCl and phloroglucin, stain in Erlich's acid HEMATOXYLENE, 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.



NASMYTH'S MEMBRANE

CELLULAR STRUCTURE

1. To show nasmyth's membrane from tooth with HCl and potassium permanganate wash and stain in various solutions.
 2. To show outline of cell.
- Stains with HCl and stain with various dyes.

POSITION

Fixed a section through a tooth and wash with HCl, stain with carmalum.

PERIOSTEUM AND GUM

1. (Gross and method)
2. (Horswell Smith's method)

DEVELOPING TEETH

Section and method various stain and fixation methods.

CARIES OF THE ENAMEL

Gilman's method various

CARIES OF THE DENTINE

Wells's method

GERMS IN THE TUBES

Block of the enamel from a carious tooth.
 Wash in soft oil, and remove soft part with saw and
 stain in iron sulphate (10 parts).
 Press and stain
 with the method by Davis's method.
 Clear and mount.

TRANSLUCENT ZONE

1. Wells's method
2. (Horswell Smith's method)



