SUBJECT	FORENSIC SCIENCE
Paper No. and Title	PAPER No.11: Forensic Anthropology
Module No. and Title	MODULE No.17: Structural Variation in Teeth- Human and Non-Human
Module Tag	FSC_P11_M17

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1. Learning Outcomes

After studying this module, you shall be able to learn about-

- Human Dentition
- Structural difference between human and animal dentition
- Forensic Significance of human and animal dentition

2. Introduction

Forensic dentistry or odontology is the area which falls within the greater disciplines of dentistry and forensic science that basically assesses, manages, and presents dental evidence in legal proceedings for the purpose of justice. Casework in forensic dentistry often involves identification of unknown or missing individuals, human remains, or victims of mass fatality incidents, such as natural catastrophes and accidental tragedies. This identification is done by comparative study of a victim's dentition and supporting structures with dental records of known individuals. The latter records may be obtained from private dental offices, prison or military dental databases, or records that are retained by the Federal Bureau of Investigation by its National Crime Information Center's Missing, Unidentified, and Wanted Persons files in a Web environment. Since forensic odontology is among the several forensic specialties, the forensic dentist's part often interfaces with the work of the anthropologist, criminologist, toxicologist, pathologist, and law enforcement official involved with a case. Identification of human remains is a tough job, various measures are taken while collecting and examining human remains in order to find their true identity. The job of any forensic scientist are to collect the evidence at first, preserve it and interpret the trace evidences found at the crime scene, then to pass on the exact results found on the basis of examination to the judicial authority in a form of a report. Now these functions of examining and collecting evidence require sound knowledge in dealing with crime scenes.

By tradition, Forensic Odontology covered numerous topics which can be roughly classified into human identification and injury analysis. However, jobs of Forensic Odontologists have widened in recent years to cover matters related to crimes such as child abuse and domestic violence, human rights protection and professional ethics. The first and utmost important question that arises, when a tooth is found at the scene of crime is- "whether it belongs to human or not".

Dentition of humans varies greatly with that of animals, and even between different species of animals. Human teeth possesses a generalized design, which includes a mix of incisors which are used for slicing, canines for the purpose of puncturing, and grinding (molars) teeth. They are usually more rounded than animal teeth. Most animal teeth reflect specialized dietary adaptations. Animals that graze have more grinding teeth with specific ridges while carnivores have more shearing teeth which has sharp ridges. In addition, a lot of animals have different dental formulas when compared to humans. Dental formulas are annotated with the number of each tooth type for a quadrant of the mouth. It is seen that an adult generally have a compliment of 32 teeth, that is eight in each quadrants; which compromises of two incisors, one canine, two premolars and three molar. Although extremely variably, it is seen that many placental mammals display a generalized dental formula that includes three incisors, one canine, four premolars, and three molars (3:1:4:3).

3. Structure of Human teeth

The study of tooth anatomy is important for a forensic investigator or analyst, the knowledge of anatomy and composition leads to the identification in case of mass disaster or unknown deceased.

The tooth can be classified according to their parts:

1. The crown
2. The root

The crown-

The crown of the tooth is actually the invisible part, the crown is fully covered by enamel. Anatomically crown of the teeth is referred to the area above the cemento-enamel junction (CEJ) it is 'neck' of the tooth.

And, clinically crown is the part which is referred to any of the tooth which is invisible in the mouth. The crown of the tooth has many ridges on its top surface to aid in the chewing of food.

The root-

The region of the tooth which is below to the CEJ or the gum line is called root, which anchors the tooth into a bony socket known as an alveolus. The outer surface of the root is covered in a bone like structure which is mixture of calcium and collagen fibers known as cementum. The function of cementum is to provide grip to the periodontal ligaments that anchor the root to the surrounding alveolus. The number of roots varied from 1 to 4 in different type of tooth.

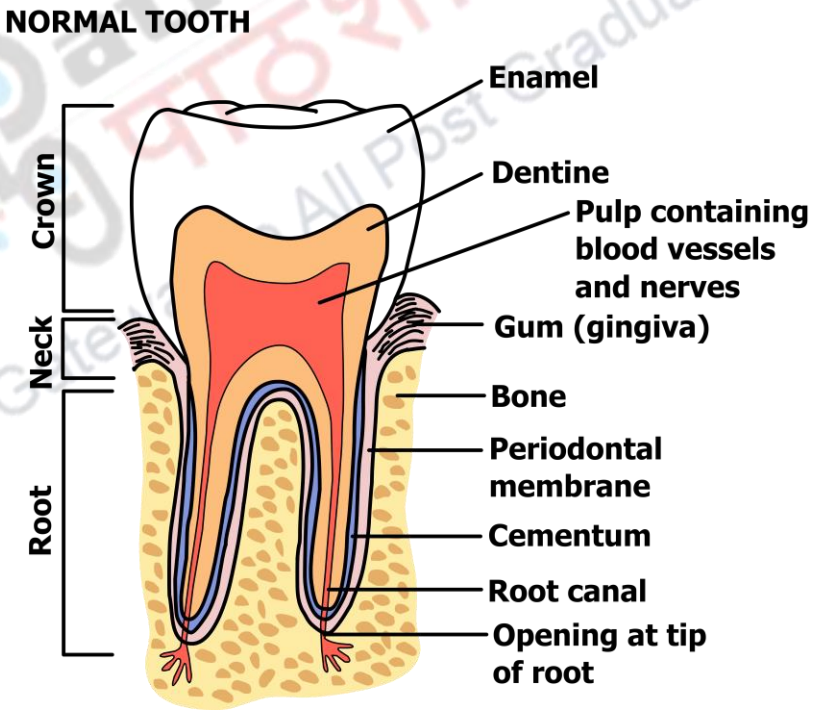


Fig.1: Diagram shows the layers of the tooth and its internal structure

Tooth is covered with three different layers which are:

1. The pulp
2. The dentine
3. Enamel

Pulp-The pulp is the most important part of the tooth and also for forensic analysis. Pulp is a vascular region of soft connective tissues which is present in the middle of the tooth. The outer hard structural tip of root is all supported by the tiny blood vessels and nerve fibers which enters in the pulp through small holes to the tip of the root. Odontoblast are the stem cells from the dentine of the tooth at the edges of the pulp.

Dentine- It is the layer which covers the pulp layers, it is mineralized layer of tissue. Dentine is much harder than the pulp due to the presence of collagen fibers and hydroxyl apatite, a calcium phosphate mineral that is one of the strongest minerals found in nature. Structurally, dentine layer is very porous, due to this it allows all nutrients and materials produced in the pulp to spread through the tooth. The outer layer of the crown which appears as white and provide a hard, non-porous cap over the dentine is known as enamel. It is hardest substance of the body which is made up of hydroxyapatite.

Periodontal ligament- Tissue that helps in holding the teeth tightly against the jaw.

❖ Teeth surfaces

There are many surfaces of a tooth, which are classified as according to the presence of their nearest organ.

Classification as follows:

Lingual surface: Surface near to the tongue.

Palatal surface: When lingual surface is towards the maxillary teeth beside the hard palate is known as palatal surface.

Facial surface: Surface that are nearest to the cheeks or lips are referred to as facial.

Buccal surface: when facial surface is found on posterior teeth nearest the cheeks.

Labial surface: When facial surface is found on anterior teeth

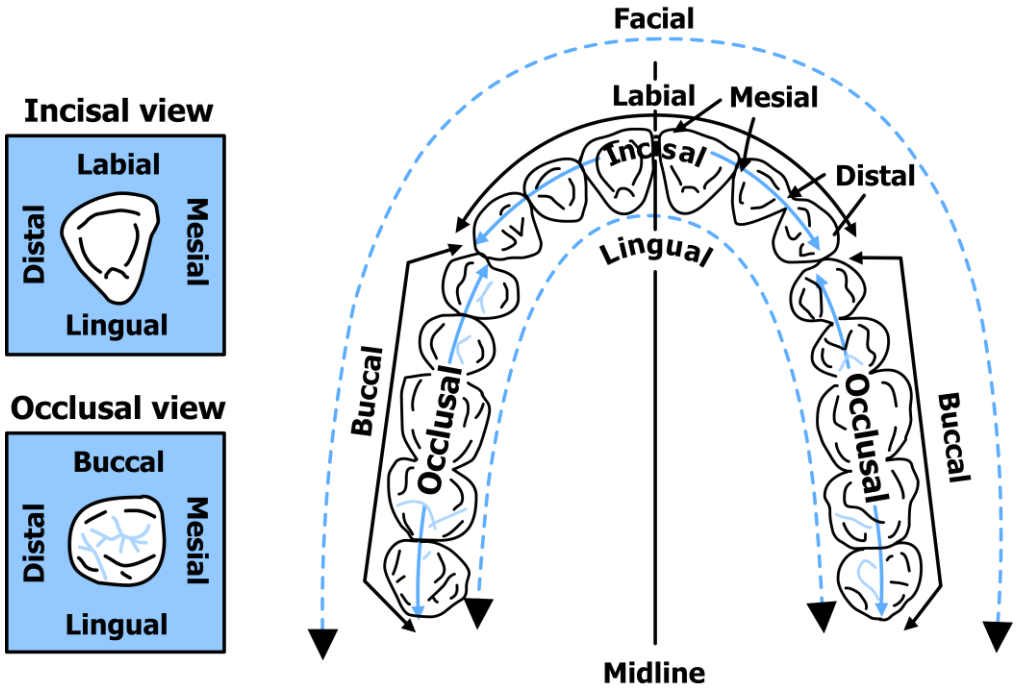


Fig.2: Different teeth surfaces

❖ Types of Cusps in Teeth

Study of cusp is important in identifying the type of teeth. Cusp is an elevation which is present on the occlusal surface of posterior teeth.

Canine- One cusp

Maxillary premolar

Mandibular 1st premolar

} Two Cusp

Mandibular 2nd premolar – Three cusp – one buccal and 2 lingual.

Maxillary molar- 2 buccal, 2 lingual.

Maxillary 1st molar has a special character of cusp called cusp of carabelli- Five cusps.

❖ Teeth Development

We began life as single cell, zygote. The zygote is a ball of cells which in turn produces the human embryo. The actual development of teeth starts at approximately 6-7 weeks after conception. Teeth develop from the interaction of the oral epithelial cells and the underlying mesenchymal cells. In humans, there are two sets of teeth develop i.e., 20 primary teeth and 32 permanent.

Tooth develops through three successive early stages:

1. Bud stage.
2. Cap stage.
3. Bell stage.

Each stage is defined according to the shape of the epithelial enamel organ which is a part of the developing tooth. In the early stages of the tooth, the germ grow and grow and the cells that is supposed to form the hard tissues of the teeth differentiate. This differentiation occurs in the bell stage, setting the stage for enamel and dentin formation. When crown part of tooth formed the roots of the teeth also begin to mineralize. After the root calcification the supporting tissues of the teeth begin to develop such as the Cementum, periodontal ligament and alveolar bone. Subsequently the completed tooth crown erupts into the oral cavity. Until a functional tooth and its supporting structures are not fully developed there is continuous formation of root and cement-genesis.

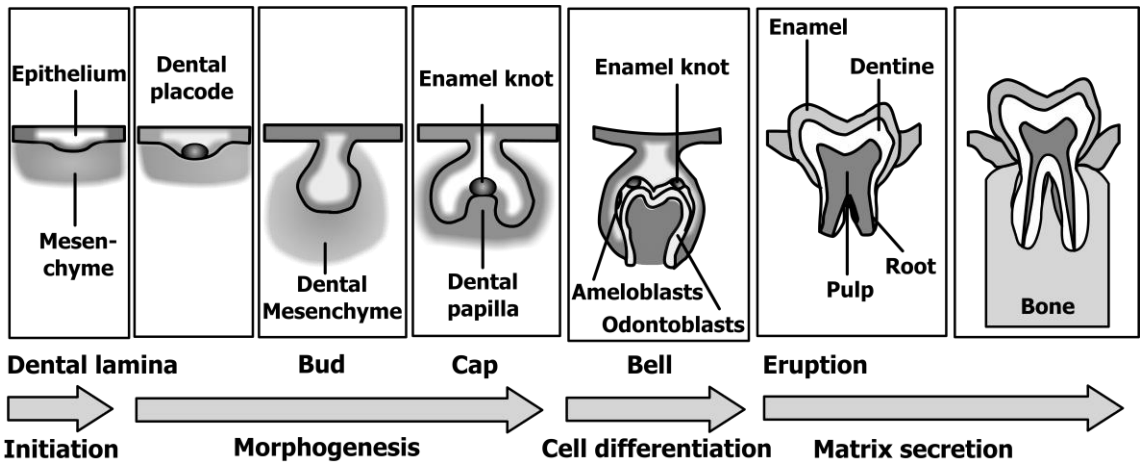


Fig.3: Stages of tooth development

Bud stage- It is a rounded localized growth of epithelial cells surrounded by proliferating mesenchymal cells.

Cap stage – In this stage it is observed that the rounded epithelial bud enlarges and it gains a concave surface and become enamel organ and Mesenchyme forms the dental papilla whereas the tissues which surrounding these two structures is the dental follicle.

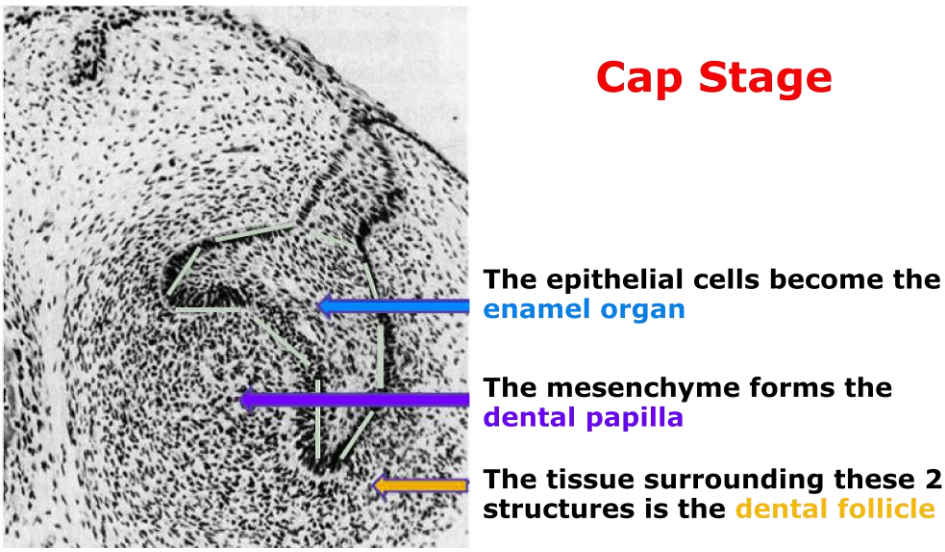


Fig.4: Cap stage of tooth development

Bell stage - After the growth of the papilla and the enamel organ the tooth reached the morpho-differentiation and histo-differentiation stage also known as the bell stage. In this stage the inner enamel epithelial cells are described by the shape of the tooth they form. The cells of the enamel organ have differentiated into the outer enamel epithelial cells which cover the enamel organ, and inner enamel epithelial cells which become the ameloblast that form the enamel of the tooth crown. Between the two cell layers are the stellate reticulum cells, which are star shaped with process attached to each other.

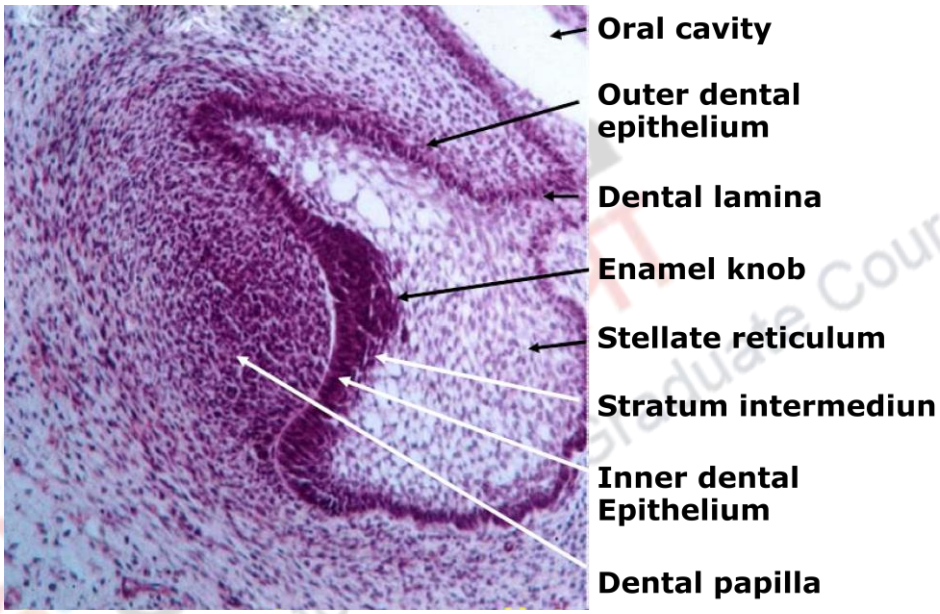


Fig 5: Bell stage in tooth development

A fourth layer which is found in the enamel organ is composed of stratum intermedium cells, which lie next to to the inner enamel epithelial cells. They provide assistance to the ameloblast in the formation of enamel. The main role of the outer enamel epithelial cells is to organize a network of capillaries that will bring nutrition to the ameloblast.

When mesenchymal cells differentiate the cells in the periphery of the dental papilla become odontoblast. Then, these cells elongate and become columnar and form a matrix of collagen fibers identified as pre-dentin which become dentin.

The next differentiation of ameloblast after several increments of dentin have formed the enamel matrix. And, after the enamel organ is differentiated the dental lamina begins to degenerate by undergoing lysis. Cells interact through a system of effectors, modulators and receptors called cell signaling.

Initiation of tooth development

Teeth develop from two types of cells:

1. Oral epithelial cells from the enamel organ
2. Mesenchymal cells from the dental papilla.
3. Sometimes neural crest cells also contribute in development.

The first sign of tooth formation is the development of dental lamina rising from the oral epithelium. It grows into a sheet of epithelial cells that pushes into the underlying mesenchyme around the perimeter of both the maxillary and mandibular jaws. At the leading edge of the lamina 20 areas of expansion appear which form tooth buds for the 20 primary teeth. When primary teeth are developed they form buds for the leading edge of the lamina that continues to grow to develop the permanent teeth, which succeed the 20 primary teeth. Now, this portion of the lamina is called the successional lamina which continues posteriorly into the elongating jaw and from it come the posterior teeth, which form behind the primary teeth. In this way, 20 of the permanent teeth replace the 20 primary teeth and 12 posterior permanent molar develop behind the primary dentition. The last teeth to develop are the third molars, which develops about 15 years after birth. The originating dental lamina makes both the successional and general lamina which initiate to play role in the 6^{th} prenatal week and remains to functional up to the 15^{th} year producing all 32 teeth.

Development of the dental papilla

Papilla cells are important in further enamel organ bud formation into the cap and bell stages. In appearance they are densely packed cells characterize the dental papilla and it is evident in the early bud stage during which cells proliferate around the enlarging tooth buds at the leading edge of the dental lamina.

Blood vessels and nerve fibers appear early in the dental papilla which provide the source of nutrition. And with cellular changes there is formation of hard shell around the central papilla, as this occurs in the papilla becomes the dental pulp.

Dentinogenisis

The process of formation of dentin is called dentinogenisis. Process starts when the odontoblast elongates in dentinal tubules, they develop at the proximal end of the cell adjacent to the dentin enamel junction. Gradually the cell moves pulp ward and the cell process known as the odontoblast process. Increment lines of the dentin are characteristic feature of the dentine which are formed along the dentin enamel junction.

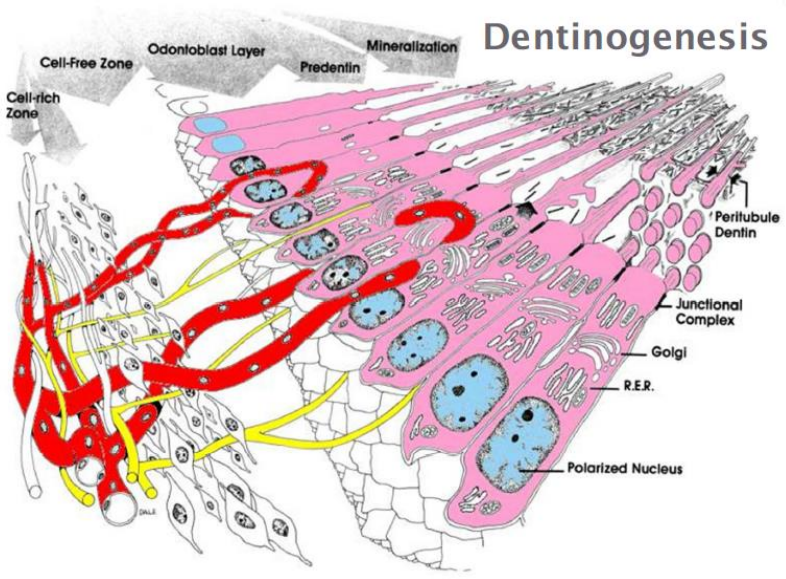


Fig 6: Dentinogenesis

The first meshwork of collagen fibers, is dentinal matrix and it becomes calcified within 24 hours whereas it is called predentin before calcification and dentin after calcification. The collagenous dentinal matrix is laid down in increments like bone or enamel, which is indicative of a daily rhythm for hard tissue formation. The site of initial formation is at the cusp tips. As the odontoblastic process elongates a tubule is maintained in the dentin, and the matrix is formed around this tubule. Dentinogenisis takes place in two phases. First is the collagen matrix formation, followed by the deposition of calcium phosphate (hydroxyapatite) crystals in the matrix.

Calcification: On the surface and in the collagen fiber there is appearance of crystal in small vesicles that is the initiation of calcification. The crystals grows, then spreads and coalesce up until the matrix is totally and completely calcified. It is seen that only the newly formed band of dentinal matrix along the pulpal border is uncalcified. Mineralization occurs due to an increase in mineral density of the dentin. As each daily increment of predentin forms along the pulpal boundary the adjacent peripheral increment of predentin formed the previous day calcifies and become dentin.

Amelogenesis: when ameloblasts starts deposition of enamel just after a few micrometers of dentin, than they get deposited at the dentinoenamel junction is known as amelogenesis. At the bell stage cell of the inner enamel epithelium differentiate, they elongate and are ready to become active secretory ameloblasts. The ameloblast exhibit changes as they differentiate in five functional stage:

1. Morphogenesis
2. Organization and differentiation
3. Secretion
4. Maturation
5. Protection

Short conical process (tomes' processes) develop at the apical end of the ameloblasts during the secretory stage. Junctional complexes which are known as the terminal bar apparatus appears at the junction of the cell bodies and tomes' processes and maintain contact between adjacent cells. The first enamel deposited on the surface of the dentin establishes the dentinoenamel junction. As the enamel matrix develops, it forms in continuous rods from the dentinoenamel junction to the surface of the enamel. When ameloblasts begin secretion, the overlying cells of the stratum intermedium change in shape from spindle to pyramidal. Substances that are needed for production of the enamel arrives via the blood vessels and then it passes through the stellate reticulum to the stratum intermedium and ameloblast. In this manner the protein amelogenin is produced. Only a few ameloblast at the tip of the cusps begin to function initially. As the process proceeds more ameloblast become active and the increments of enamel matrix become more prominent.

4. Structure of Non-human teeth

- **Dogs:**

A Dog has 42 permanent teeth, which are distributed over the dental arches not equally, and so the upper dentition consists of 20, and the lower of 22 teeth. The largest are considered upper fourth premolar and lower first molars, which are called discordant teeth. It is observed that between the discordant teeth and fangs a dog has an open bite, which is limited to the top and bottom conical crown premolar teeth. Thus, in the closed position of the jaws, behind this occlusion is limited by discordant teeth, just in contact are smaller in size two molars. Only large dog's molars in a valid comparison can be likened to human molars.

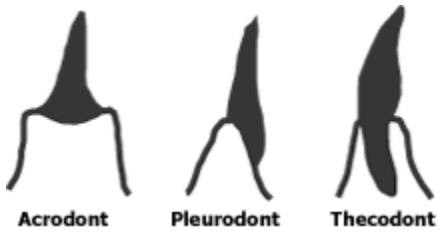
- **Horse:**

An adult horse has between 36 and 44 teeth. Where the enamel and dentin layers are found to be intertwined. In all horses you will observe, that they have 12 premolars, 12 molars, and 12 incisors. Generally, all male equines also have four canine teeth (called tushes) between the molars and incisors.

On the other hand, few female horses (that is less than 28 percent) have canines, and those that do generally have only one or two, which in many cases is seen that are only partly erupted. Very few horses have 1 to 4 wolf teeth, which are basically vestigial premolars, it is seen that mostly horses have only one or two vestigial premolars. This characteristic is equally common in male and female horses and the probability of presence of this teeth is much more likely to be on the upper jaw. If these vestigial premolars are present, they can cause many problems as they can hinder with the horse's bit contact. Therefore, it is common that the wolf teeth are removed. A horse's incisors, premolars, and molars, once fully developed, keeps the eruption in continuation as the grinding surface is worn down through chewing. In a young adult horse you will see that they would have teeth which are 4.5-5 inches long, with the major part of the tooth's crown remaining underneath the gum line in the dental socket. And this rest part of the tooth will slowly emerge from the jaw, i.e. erupting about 1/8" every year, as the stallion ages. As it happens with humans likewise, when the animal reaches a certain age, usually old age, the crowns of the teeth are either very short or the teeth are often lost altogether.

- **Reptiles:**

When we see the case of reptiles, it is usually seen that all turtles lack teeth. Whereas, reptiles like Snakes, lizards, crocodilians, and tuataras all have teeth. These teeth vary from each other in their form, their attachment to the gum, and whether they are shed. Generally, it is seen that the teeth of herbivorous species are broadly flattened with crushing surfaces. Those of most carnivorous reptiles are tapered to sharp points. Often, the teeth in the front of the mouth have recurved tips, which facilitate the puncture of prey during the strike, and reduce the chance of the prey escaping.



Some serpents have fangs that is the source of venom, these fangs could be present on either the anterior part of the snake's mouth or near the temporomandibular joint. Kardong 2002 suggests that reptile teeth may well be joint in sockets (thecodont), either on the alveolar surface of the jaw (acrodont), or on the inner side of the jaws (pleurodont). In few reptiles scientists have found thecodont teeth. These are replaced within the same socket. Whereas, Crocodilian teeth are thecodont in nature. Snakes typically have acrodont teeth; each tooth resides on the occlusional surface of the jaws in a very shallow socket. Replacement teeth rise next to the active teeth. It is seen that the most lizards have pleurodont teeth, though we have also seen numerous exceptions, which consist of chameleons and bearded dragons. Whereas when it comes to tuataras it is seen that they have acrodont tooth attachments. The teeth of reptiles usually are similar throughout the mouth. However, the tuatara, crocodilians, and venomous snakes have heterodont dentition with more than one tooth type per arcade (Romer and Parsons, 1986).

Teeth	Incisors	
Carnivore	Sharp	Pointed
Herbivore	Broad, Flattened	Spade shaped
Omnivore	Short	Pointed
Human	Broad, Flattened	Spade shaped

Teeth		Canines
Carnivores	Long, Sharp	Curved
Herbivore	Dull & short	Or Long or none
Omnivore	Long, sharp	And curved
Human	Short	Blunt

Teeth		Molars
CARNIVORE:	Sharp, jagged	And blade shaped
HERBIVORE:	Flattened with cusps	v/s complex surface
OMNIVORE:	Sharp blades	and/ or flattened
HUMAN:	Flattened	With nodular cusps

5. Summary

- The study of tooth anatomy is important for a forensic investigator or analyst, the knowledge of anatomy and composition leads to the identification in case of mass disaster or unknown deceased.
- The human tooth can be classified according to their parts:
  - The crown
  - The root
- Human Tooth is covered with three different layers which are:
  - The pulp
  - The dentine
  - Enamel
- Human Tooth develops through three successive early stages:
  - Bud stage.
  - Cap stage.
  - Bell stage.