**Evolution of dental anatomy**

Evolution is the process that creates differences in the heritable features of natural populations (MacCord, 2018). These changes are driven by evolutionary processes, e.g., physical selection (including sexual variety), hereditary recombination, and gene stream, resulting in genetic variation in the species. This includes genetic differences that give rise to phenotypic variation in teeth (MacCord, 2018). In the mid-19th century, Charles Darwin developed the concept of speciation by natural selection, where species were able to pass on traits that were favored by selection. Natural selection favoured toothed organisms because teeth helped in survival by passing on favourable traits to the next generations (Huysseune et al., 2010). Natural selection has also affected how human teeth development has been shaped throughout our lifespan (Huysseune et al., 2010). How and when tooth-like units (odontoids) arose within vertebrates remain questions raised among paleontologists and evolutionary developmental biologists (Ortiz et al., 2018). These question can only be answered by understanding dental anatomy which is the examination of the dental development, variation, and structure of modern and old human populations, is also a critical field of investigation as it contributes and makes great fossils to be studied (Teaford et al., 2000). Through dental anatomy, paleontologists can identify the species' size, locomotor style, environment, and even shed light on behavioral issues, e.g., set size and social organization (MacCord, 2018). The fossil record aids in studying the development of teeth (Teaford et al., 2000). This data serves a useful purpose for scientists interested in the evolution of teeth, enabling them to easily recognize teeth anatomy and the initiation of tooth vertebrates (Witten et al., 2014). In this essay, I will discuss evolutionary changes in teeth development, turning them into different sizes and shapes and why it is important to study tooth regeneration.

**The origins of teeth**

One theory on the origin of teeth suggests that skin denticles evolved first and odontoid-inductive surface ectoderm merged with the inside of the oral cavity to form teeth calling this theory the 'outside-in' theory (Stephanie et al., 2011). Another theory suggests that the patterned odontoids evolved first from endoderm deep inside the pharyngeal cavity, drawing this theory the 'inside-out' hypothesis (Jheon et al., 2013). Another hypothesis states that the evolution of dental anatomy arose from cynodonts, species of reptiles with molars that help with digestion (Donoghue et al., 2016). Those are *Romundina stellina*, a species of small, armored fish that are older than sharks (Brazeau & Friedman, 2015).

Researchers have long studied the origin of teeth and how it evolved within sharks (Brazeau & Friedman, 2015). Research indicated that fish and sharks were found to be the origin of teeth because they still pass some primitive characteristics, including the small and spiky scales called dermal denticles (Haridy et al., 2019). These were found to have originated from neural crest cells, much like in human teeth (Haridy et al., 2019) Teeth cells first originated from scales of fish found in human teeth, as well as thorny scales of skate fish which are composed of the same type of neural crest cells found in human teeth (Haridy et al., 2019). Sharks are more than 420 million years old and have the same biological process of developing teeth as they grow in age-similar humans and other species (Brazeau & Friedman, 2015). Therefore the outside, in theory, is the most supported theory.

Changes among primate life histories have mainly been attributed to differential morbidity rates and ecological niches, lifestyles, cultural quality, cognitive development, or the combination of these factors (Teaford et al., 2000). *Sahelanthropus tchadensis* is believed to possess one of the earliest varieties of skeletal pieces that reveal dental characteristics, including the U-shaped palate and canines smaller than those of the chimps (Brazeau & Friedman, 2015). Some theories have been proposed to explain the origin and development of the tooth comb found in strepsirrhine primates (Donoghue et al., 2016). A tooth comb, also known as Dental comb, found in some mammals, is a group of front teeth arranged like a comb used for grooming. It is known to be found usually in strepsirrhine primates (collectively, lemuriformes). It often includes incisors and canine teeth, which are rolled forward, located at the front of the lower jaw, and followed by a canine-shaped 1st premolar (Fraser et al., 2010). It was proposed that the dietary shift from xxxxxx towards exudate-eating would have been involved in these ante molar morphological transformations, which led to the growth of the tooth comb seen in crown strepsirrhines (Donoghue et al., 2016).

**Teeth development:**

Teeth development begins with the initiation stage, where the dental lamina connects the developing tooth bud to the epithelial layer of the mouth (Murdock et al., 2013). First to root is the central incisor (middle front tooth) in the lower jaw, followed by a second incisor on the lower jaw. Next are four upper incisors, then the first four molar's and then the remaining lateral incisors (beside central incisors) (Soukup et al., 2008). Next are the cuspids/canines followed by the 2nd molars, and lastly, wisdom teeth erupt (Soukup et al., 2008). This is followed by the bud stage where a tooth bud emerges but without a clear arrangement of cells. Later, the cap stage begins where cells begin to arrange themselves in the tooth bud (Murdock et al., 2013). The bell stage follows, and here, the enamel starts to develop and slowly begins to mature, leading to the increased size of the bud (Murdock et al., 2013). Genetics determines how large or smaller the teeth can be if they are rounded or squared-off in structure (Ortiz et al., 2018). Dental eruption ages are generally correlated with different living outcomes and personal attributes (e.g., body and brain mass) (Brazeau & Friedman, 2015).

Wisdom teeth erupt later during the lifespan, causing them to be one of the most present time features to be affected by natural selection changes in the human body (Teaford et al., 2000). Wisdom teeth are considered "evolutionary relics" and were useful to our remote ancestors who consumed diets that consisted of rough foods like woody plants containing cellulose and ( raw meat before discovering fire and making it softer (Rücklin et al., 2012; Teaford et al., 2000). It is hypothesized that our human ancestors had stronger skulls with more teeth, which allowed them to grind foliage to settle for the stomach's inability to digest cell walls in plants (Rücklin et al., 2012). After the arrival of farming around 10,000 years ago, "softer" human diets turned into the norm, including sugar and high protein foods (Rücklin et al., 2012). Such diets typically lead to teeth growing with less forward development than our Paleolithic ancestors and insufficient room for wisdom teeth (Perkins, 2015). With contemporary advances in oral medicine and even softer diets, natural selection is slowly removing wisdom teeth from the human mouth, but they still grow, causing pain and infection (Perkins, 2015). This is also shown when wisdom teeth erupt, as they are often impacted or developing under the gums (Bharathi et al., 2018). According to (Bharathi et al., 2018), scientists were able to use genetic drift, a phenomenon where DNA changes can accumulate at an expected rate. When such changes occur faster than expected, it can be inferred that the genes are under positive selection, which gives the organisms an advantage (Bharathi et al., 2018).

Infants that develop thumb-sucking habits can disturb the teeth' alignment, which can xxxxxxxxxxx (MacCord, 2018). Thumb-sucking is a response to natural rooting developed by infants. Sucking reflexes can often lead to misalignment of the permanent teeth and affects the shape of the jaw or roof of the mouth. Teeth growth is a process by which teeth shape from embryonic cells, produce, and burst into the mouth (Vaškaninová et al. 2020). Tooth formation begins in the embryo between the 6th and eighth weeks, and permanent teeth start to be formed in the twentieth week. If teeth do not begin to produce in or near these moments, they cannot produce at all (Vaškaninová et al., 2020).

**Wisdom teeth and evolution:**

Wisdom teeth are being removed by natural selection as they have been impacted when they grow, which was not the case before. Wisdom teeth are believed to have evolved due to the early diets of ancestors such as high cellulose plants, roots, nuts, and uncooked meats, which requires the need for increased chewing power (Burrows et al., 2020). However, at present, humans are more accustomed to eating softer foods, wisdom teeth were rendered functionless (Burrows et al., 2020). As wisdom teeth start to burst through the gums' surface, that allows bacteria to enter through the gaps of the teeth created, which will result in gum disease (Burrows et al., 2020). Oral Infections have been shown to impact the overall well-being, too (Perkins, 2015). The infection can lead to pain and bacteria, which spreads, leading to the gums' inflammation and leading the bacteria within the infection to transfer into the bloodstream affecting the heart valves. Other symptoms induced by wisdom teeth include feeling, redness, pain, and/or swelling and teeth overcrowding (Perkins, 2015).

**Human Diets and teeth:**

Teeth are important because they are the source of information in the interpretation of past human diet, activity, and species variation (Teaford et al., 2000). Ancestors of humans have smaller incisors with molars (australopithecines) likely due to adaptation to terrestrial seed-eating (Louise et al., 2008). Anthropoids were also examined where a discovery about the incisor row length was made about the type of food they consume (Louise et al., 2008). It was determined that large incisors belong to the group of anthropoids consuming harder to chew food or more solid food (Louise et al., 2008). Seeds and hard plant tissues were also found to be the diet of ancient humans as ancestors moved from one habitat to another, progressively (Louise et al., 2008). These sources of food are broken down by blunt molars adapted to types of food sources (Louise et al., 2008). As the diet became more omnivorous, humans then were using incisors and canines to tear off meat and chew them with the molars (Louise et al., 2008).

**Tooth Regeneration:**

Regeneration of teeth cells is a common interest among researchers; however, reconstructing the process of human development from a severely restricted fossil record is a fundamental challenge (Burrow, 2003). Since teeth are composed of enamel, which is the toughest long-lasting resistance to biodegradation, it's easy to consider them fossil records and help with forensic and many future teeth development discoveries (Teaford et al., 2000). The union of DESCs and DMSCs organizations provides a study of tooth germs that will be transplanted into the alveolar white, where these genes can finally become functional teeth (Balic, 2018). This is to help teeth regeneration, which consists of an exchange of signals between mesenchymal and epithelial cells to regulate the stages of teeth development stages. Tooth regeneration is vital to help tooth loss problems, which leaves bone loss since the bone area no longer receives stimulation. Cell regeneration relies upon stem cells' presence, a populace of self-renewing cells that can reproduce the new organ's cellular heterogeneity in the life cycle (Kamate et al., 2019). Humans gradually lose their enamel stem cells early in a lifetime.

For this reason, their ability to repair detrimental adjustments that occur at some stage in life is almost absent (Davit-Béal et al., 2009). Odontoblast cells present within teeth mesenchyme produce dentin mineralized matrix (Davit-Béal et al., 2009). Following an injury, the non-stop mineral deposition as secondary or tertiary dentin increases the mineral with age (Davit-Béal et al., 2009).

The evolution of human teeth is strongly related to understanding teeth development. The teeth have changed into a variety of shapes and sizes, including the jaws of humans, which are smaller than the apes today; this was shown by the investigation of teeth fossils, which showed the difference between modern humans to *H. sapiens*. And this reduction is attributed to changes in the dietary habits of the species. Oral disease poses a significant health burden in many countries. It affects individuals throughout their lifetime, causing discomfort, pain, disfigurement, and even death, this proves that our teeth are essential for our overall health. Losing a tooth may make us look unhealthy, but it could also be a sign of an underlying, more serious health problem. Research in teeth regeneration is based on understanding the underlying mechanisms of tooth development and the biological processes of healing and repair. It creates a solid knowledge of principles that could be applied in harnessing the natural healing potential of the dental tissues or regenerating the damaged tissue or organ. Dental research is encouraged to continue in regenerative dentistry for improving the natural healing abilities of dental tissues via biological repair in future generations.

You need a conclusion section

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