TEETH, JAWS AND DIGESTION: The evolution of mammals

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It's no surprise that teeth are very well preserved in the fossil record; they are hardest part of the body and are resistant to degradation. They provide a roadmap to the evolution of vertebrates and help determine the animal's diet (e.g. carnivore versus herbivore). Indeed, George Cuvier, the 17th century French naturalist and zoologist, suggested he could reconstruct an animal's entire skeleton from a single tooth!

Teeth, and the jaw in which they are embedded, have played an important role in the evolution of animals. As Neil Shubin notes 'Teeth make bigger creatures into smaller pieces. Attached to a moving jaw, teeth slice, dice and macerate; they enable creatures to eat things bigger than their mouths'. While there are early examples of teeth-like structures in cephalopods such as squid and octopus, the first real jaws and teeth were evident in fish that evolved about 420 million years ago. Like fish, reptilian teeth are all similar in shape—the only variation is size. Early mammalian development about 200m years ago coincided with the development of specialised teeth. Unlike reptiles, the mammalian jaw increased in complexity to have different types of teeth set in it—incisors in the front to cut food, canines to rip food, and further back molars to grind and mash it. Such an array of teeth provided early mammals with a much more diverse diet than their reptilian or avian competitors and helped set in place the explosion in new mammalian species.

A reptilian jaw (left) has teeth of similar shape and moderate occlusion. Mammals (right) have incisors, canines and molars, and precise occlusion increasing the efficiency of food processing.

At the same time as mammals were evolving more specialised teeth, the anatomy of the mammalian jaw was also changing[1]. These changes allowed the jaws to move both vertically but to also include lateral (sideways) movement. This contrasts with reptilian and amphibian jaws which only move vertically. Importantly, the upper and lower mammalian jaw ensures that teeth from the upper and lower jaw fit closely together when closed (occlusion). This resulted in a unique and efficient way of chewing that allowed the food to be ground into finer segments. Chewing is specific to mammals; no other vertebrates use elaborate repeated jaw movements to process food before swallowing. Chewing reduces the size of food to facilitate access to nutrients. The smaller the particles, the larger the surface available to gut microbiota, and acquiring the ability to digest a new diet is a fundamental driver for the evolution of new species.

Finally, I can hear the twitching class say 'It's all very well to describe the evolution of teeth in reptiles and mammals but what about our birds?' Well, birds lost their teeth (yes they are as scarce as hen's teeth!)[2]. Evolving from dinosaurs, the oldest birds had reptilian-like teeth, but they lost their teeth to evolve beaks. Without teeth, birds would get less energy than mammals out of their food—however they use gizzards to replace their teeth. The gizzard is an organ in the digestive tract that helps grind up food, often aided by particles of stone or grit. Reptiles and a number of other animal families also possess a gizzard to improve their digestive efficiency.

References: Shubin, N. Your inner fish, Penguin, 2009.

Schultz, J. A. Science 367, 244-245, 2020.

https://quatr.us/biology/digestive-system-evolution.htm

[1] As part of the evolution of the mammalian lower jaw, three of the smaller bones found in the reptilian jaw migrated to form the ossicles of the middle ear which improved the hearing sensitivity of mammals. The presence of three middle ear bones is a mammalian trait.

[2] During hatching a single 'egg tooth' is used to break the egg shell in some avian species. A similar structure is present in other egg-laying animals including monotremes