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Lose your teeth but keep your nerve! Lessons from sea cows

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Sirenians (extant and extinct sea cows) are a well-known example of morphological adaptation to a shallow-water grazing diet characterized by a modified feeding apparatus and orofacial morphology. They are notably characterized by a tooth reduction associated with the development of keratinized pads. These keratinized structures were especially pronounced in the recently extinct Steller's sea cows, *Hydrodamalis gigas*, which was completely toothless. In an opposite evolutionary trend, manatees have developed a long row of six to eight molars that exhibit a constant addition of supernumerary teeth at the back of the jaw, which then migrate anteriorly (known as continuous dental replacement). We used a comparative framework of ontogenetic, paleontological, and genetic evidence to trace the evolutionary history of tooth loss in sirenians. We first used μ -CT scans of sirenian skulls to understand how motor-sensor systems associated with tooth innervation responded to innovations such as keratinized pads and continuous dental replacement. To further explore the degree of dental regression in sirenians, we determined the functionality of genes whose proteins are tied to tooth development and maintenance. We obtained nine core dental genes from *Trichechus manatus*, *Dugong dugon*, and *Hydrodamalis gigas*. Our results reveal how patterns of innervation changed with modifications of the dental formula, especially continuous replacement in manatees. Both our morphological and genomic data suggest that the tooth

developmental pathway was not completely lost in the edentulous Steller's sea cows. We then argue that the dental neurovascular anatomy was co-opted for innervating and supplying blood to the keratinized pads. Using a long and slow developmental process such as tooth development might constitute a simple way for maintaining the dorsal innervation of keratinous structures in order to preserve sensorial functions of the alveolar region. Such a case of evolutionary tinkering is similar to that observed in other toothless tetrapods, and suggests that the tooth developmental pathway has been recycled multiple times to improve the neurovascularisation of disparate neomorphic keratinized structures, from baleen of mysticetes to beaks of non-avian dinosaurs and keratinized pads of sirenians.