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What exactly is a nuchal ligament and who exactly has one?

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Abstract: Nuchal ligaments are relatively well understood and have venerable histories of recognition in extant euungulates, canids, elephants, and humans. However, whether any anatomical structures in other taxa, both extant and extinct, qualify as nuchal ligaments is unclear because the term 'nuchal ligament' lacks a clear, narrow, consistently applied definition. Possible definitions of the term could be etymological, taxonomic, compositional, or morphological/topological, or a combination thereof. Currently, a de facto morphological/topological definition of 'nuchal ligament' *sensu stricto* seems most common: a nuchal ligament is an epaxial, cervical ligament with a funiculus that is elevated above the cervical spinous processes and connected to them only via laminae. However, many references to 'nuchal ligaments' in both extant and extinct taxa instead seem to employ a broader, etymological definition that encompasses numerous different compositions, morphologies and topologies. Several largely untested assumptions have been made about quantifiable correlates of a nuchal ligament, such as possessing a 'large' or 'heavy' head and/or a 'long' neck, and osteological correlates of a nuchal ligament, such as possessing specific features on the occipital region of the skull and possessing specific morphologies or dimensions of the cervical and cranial thoracic spinous processes. These assumptions have led to corollary assumptions that many extinct tetrapods—particularly those phylogenetically far removed from taxa known to possess them—had nuchal ligaments, but until these presumed correlates are tested and demonstrated in extant taxa, such assumptions remain purely speculative, and alternative cranio-cervical support mechanisms also must be considered. Depending on the definition applied, attributions of nuchal ligaments to extinct taxa, and even to some extant taxa (including humans), may be references to other sorts of morphologically and topologically distinct epaxial structures such as supraspinous ligaments and fibrous septa/raphes that occupy similar anatomical positions as nuchal ligaments *sensu stricto*. 'Nuchal ligament' requires a narrow definition to understand what, if any, features correlate with the presence of the ligament, as well as what taxa have convergently evolved the structure.

INTRODUCTION

The term 'nuchal ligament', along with its formal equivalent, 'ligamentum nuchae', seems a straightforward one, with a clear definition—after all, a structure bearing this name is regularly taught and identified in both human and veterinary anatomy courses. However, application of the term has varied widely across anatomical and palaeontological literature, suggesting that the term lacks a clear, narrow definition, or at least one that is widely understood and consistently applied. Consequently, understandings of which taxa possess(ed) a nuchal ligament, the phylogenetic distribution(s) of the structure, and how often the structure has convergently evolved are also lacking.

The word 'nuchal' in nuchal ligament stems from the Arabic *nukha*, meaning '(upper end of the) spinal cord' (Singer 1959). The term *nukha* was more broadly adopted into Latin (*nucha*) in the 11th century (Green 2005), and seems to have retained its meaning of 'spinal cord' until around the 16th century (Norri 2016). It spread to the Romance languages (e.g., the French *nuque* [Singer 1959]) and by at least the 16th century, came to mean either 'neck' as a whole or, more typically, 'nape (dorsal surface) of the neck' (Coles 1679; Corbett and Chandler 1732; Barrow 1749; Norri 2016). 'Nuchal ligament', then, could broadly describe any epaxial cervical ligament (contra Woodruff [2014] and Woodruff et al. [2016], who considered 'nuchal ligaments' to extend into at least the sacrum), although

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in most taxa that have one, the nuchal ligament complex includes anchoring components in the cranial thoracic region (see below). Historically the term generally has had a more restricted usage: a nuchal ligament is a sagittally (if singular) or parasagittally (if paired) positioned, cervical extension/continuation of the thoracic supraspinous ligament, or, alternatively, the supraspinous ligament in the thoracic region is a continuation of the cervical nuchal ligament (e.g., Butcher 1853; Gray 1858; Gamgee and Law 1862; Leidy 1889; Slijper 1946). Furthermore, the nuchal ligament generally has been recognized as the structure lying between, and often serving as a point of origin for, left and right epaxial cervical muscle pairs, including (but not limited to) the *mm. trapezius*, *rhomboideus*, and *splenius* (e.g., Douglas 1707; Mischel 1744; Innes 1776; Cheselden 1792; Pétrequin 1845). In humans, the whitish structure generally has been described as fibrous (e.g., Gray 1858) because it comprises primarily collagen, but in other mammals well understood to possess one, the structure has been described as elastic because in addition to collagen, it has a high elastin content (Morocutti et al. 1991) that has long been remarkable for giving the structure a yellowish hue (e.g., Vesalius 1543; Crooke 1631; Table 1[1]). Despite these ambiguous, not-quite definitions, the nuchal-ligament structure is morphologically and topologically distinct from the thoracic supraspinous ligament and thus could be more narrowly defined.

MATERIALS AND METHODS

Osteological Specimens

Numerous mammalian osteological specimens in the collection of the Academy of Natural Sciences of Drexel University (ANSP) in Philadelphia, PA, USA, were examined visually for sites of nuchal ligament attachment. Numerous avian osteological specimens also in the collections of the ANSP were likewise examined for sites of sagittal, epaxial ligament attachment; additional avian and 'reptilian' specimens were loaned by the University of Florida (*Crocodylus porosus* and *Varanus komodoensis*), the National Museum of Natural History (*Dromaius novaehollendae*), and the Field Museum of Natural History (*Rhea americana*).

Dissections

Several dissections of mammalian specimens were performed to examine the sagittal, epaxial ligament systems, including nuchal ligaments or the absences thereof, and their attachments to the skulls and cervical and thoracic vertebrae. All dissected specimens either died of natural causes, were the victims of automobile accidents, or were euthanized for reasons having nothing to do with this research. Except for dissections performed at the University of Pennsylvania, I was notified of specimen availability by the appropriate Association of Zoos and Aquariums (AZA) Taxon Advisory Groups. Dissections were performed with IACUC approval at the University of Pennsylvania School of Veterinary Medicine (Philadelphia, PA) on *Canis familiaris*, *Felis catus*, and *Equus ferus caballus*. Other dissections performed were at the State of New Jersey Division of Fish, Game & Wildlife (Trenton, NJ) on *Ursus americanus*, the State University of New York at Buffalo (Buffalo, NY) on *Panthera tigris*, the Cleveland Metroparks Zoo (Cleveland, OH) on *Tragulus napu* and *Hydrochoerus hydrochoerus*, and the Zoological Society of Buffalo, Inc. (Buffalo, NY) on *Giraffa camelopardis*. In each of these cases, the dissections were performed at the housing institution under the supervision of the animal care staff or, in the case of *Panthera tigris*, institutional faculty. The Cleveland Metroparks Zoo and the Zoological Society of Buffalo, Inc. both are AZA accredited institutions.

ANATOMY

In general, a nuchal ligament *sensu stricto* consists of one or more of two anatomical components (Fig. 1). Of these, the nuchal funiculus (funiculus nuchae per the International Committees on Veterinary Gross Anatomical Nomenclature [ICVGAN] 2017; referred to as the dorsal raphe in humans (Vital 2020; Standring 2021)) is the only ubiquitous component and the focus of the aforementioned ambiguous 'definitions'. The funiculus usually consists of a pair of closely appressed or fused, strap- or cord-like structures (funiculi[2]) that originate on the distal ends of the spinous processes of either the last cervical vertebra or the first thoracic vertebra, where it joins with the thoracic supraspinous ligament. Some have considered the funiculus to originate from multiple cranial thoracic spinous processes (up to the fifth in some bovids; Moskoff 1933–1934), but where the cord- or strap-like ligament is in direct contact with sequential spinous process tips, it is most appropriately called a supraspinous ligament, not a nuchal ligament (Fig. 1; see below). Nevertheless, from that origin, in most taxa it extends without directly contacting the intervening cervical spinous processes to the occipital region of the skull (Fig. 1C–G) where it inserts either on

[1]Tables are appended at the end of the paper

[2]Funiculi can be distinctly separate in the cervico-thoracic region (Woodruff 2014; Gunji 2023), but because funiculi in the cervical region typically are closely appressed and often fused, the funiculus generally is referred to in the singular form and is so herein unless specifically stated otherwise.

an external occipital protuberance or in two small, sometimes deep fossae immediately on either side of a narrow, sagittal crest ventral to the (transverse) nuchal crest (Fig. 2). In many instances, the insertion points comprise rugose eminences, which may be created or enhanced by (possibly pathological) ossification of the funiculus at the insertion point(s) in response to loading (e.g., Bendrey 2008; Shahar and Sayers 2018; Lazarczyk et al. 2020). In many taxa, also perhaps variably within a species, these insertion sites overlap medially and conjoin (pers. obs.). In canids, the funiculus does not insert on the skull, but instead extends to the caudodorsal margin of the spinous process of the axis (Fig. 1B). Also in many taxa, the paired funiculi can be discerned in dorsal view and in cross-section (Fig. 3) but cannot be physically separated. Such discernment despite fusion may be responsible for contradictory descriptions in veterinary texts of the condition in *Canis*, in which the funiculus has been reported as a singular (e.g., Pasquini and

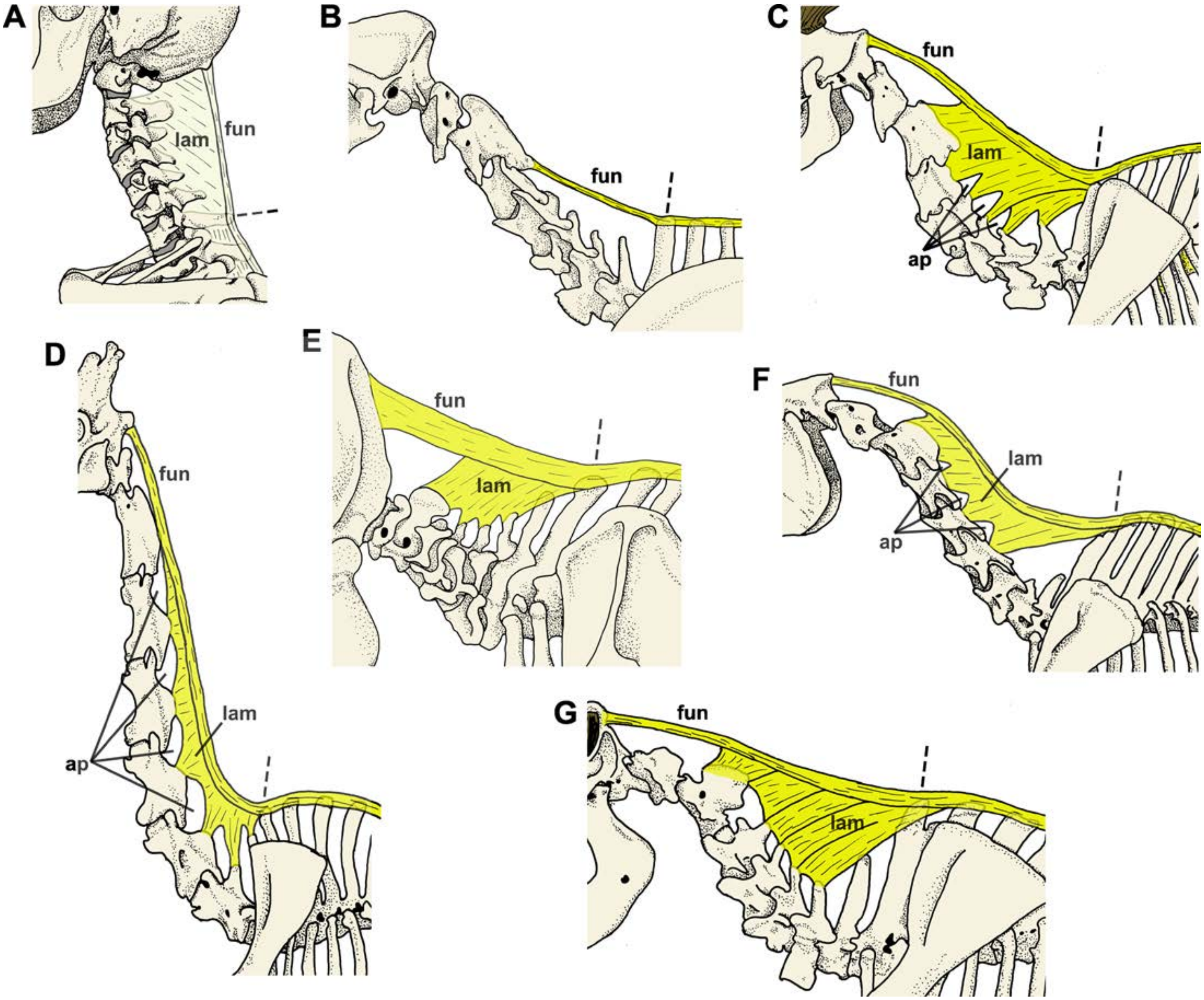


Figure 1. Schematic diagrams of the generalized morphologies and topologies of nuchal ligament complexes of various mammals in left lateral view. Ligaments shown spanning the occipital region of the skull to the cranial thoracic spinous processes. A, *Homo sapiens* (after Vital 2020); B, *Canis familiaris* (after Singh 2018); C, *Cervus elaphus* (after Pianel 2020). Note the distinct spinous laminae that originate on the cranial margin of the spinous process of the first thoracic vertebra and insert on cervical vertebrae 6 and 7; D, *Giraffa camelopardalis* (after Jouffroy 1968); E, ?*Loxodonta* sp. (after Owen 1868); F, *Equus ferus caballus* (after Budras et al. 2011); G, *Bos taurus* (after Singh 2018). Yellower color indicates a high proportion of elastin to collagen; lighter yellow-grey color indicates a low proportion of elastin to collagen. Abbreviations: ap, aperture; fun, funiculus (dorsal raphe in *Homo*); lam, lamina (median septum in *Homo*). Dashed lines demarcate the division between the nuchal ligament (cranial to the line) and the supraspinous ligament (caudal to the line).

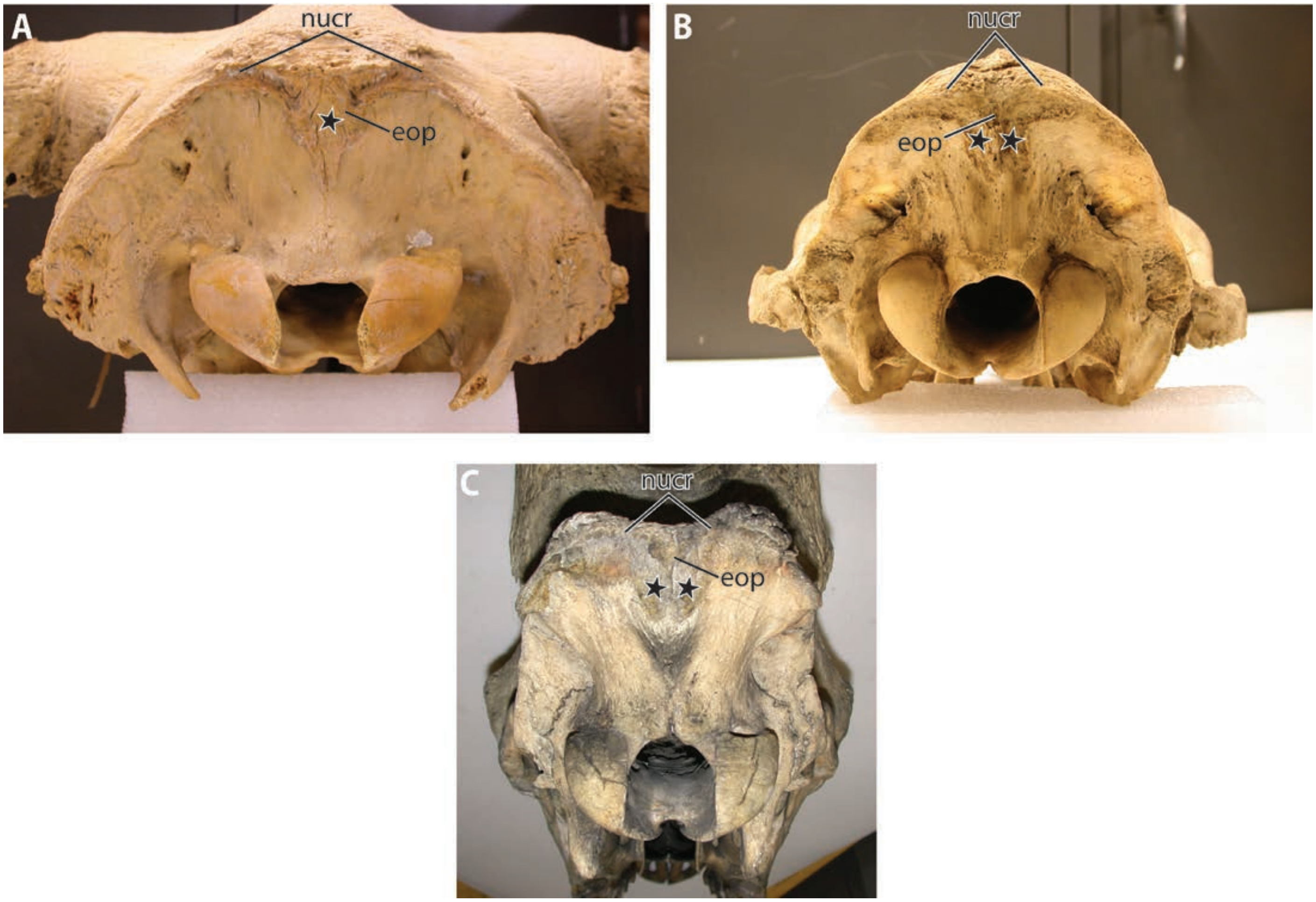


Figure 2. Examples of nuchal ligament insertion sites (stars) on the occipital regions of the skulls of euungulate mammals (seen in caudal view). A, *Bison bison* (ANSP 11960); B, *Camelus dromedarius* (ANSP 3331); C, *Giraffa camelopardalis* (ANSP 2966). Abbreviations: ANSP, Academy of Natural Sciences of Drexel University, Philadelphia, PA, USA; eop, external occipital protuberance; nucr, nuchal crest.

Spurgeon 1989) or a paired (e.g., Nickel et al. 1986) structure. Funiculi across taxa have a range of morphologies in coronal section, ranging from circular or ovoid to triangular to more elaborate shapes (Fig. 3), and the cross-sectional morphology can change along the length of the funiculus within a single taxon (e.g., May 1970). Bianchi (1989) analyzed ontogenetic change in elastic fibres of the (presumably funicular) nuchal ligaments in several mammals.

In addition to the funiculus, most taxa also possess one or more nuchal laminae (laminae nuchae per ICVGAN 2017); these also have been referred to as nuchal lamellae (e.g., Walsh 1866; Slijper 1946; Fielding et al. 1976; May-Davis and Kleine 2014; May-Davis et al. 2020a; Ismail et al. 2021). The laminae consist of fibrous sheets that extend from the funiculus and/or the bodies of the cranialmost thoracic spinous processes to a subset of cervical vertebrae, excluding the atlas except in *Homo* (Fig. 1A) and possibly other primates in which the comparable structure comprises a single contiguous sheet referred to as the nuchal septum (Vital 2020) or median septum (Standring 2021). *Homo* aside, laminae insert on the distal tips of the cervical spinous processes by means of thick, cartilaginous caps (Slijper 1946) that often ossify and fuse to their associated spinous processes (pers. obs.). Laminae are thus distinct from interspinous ligaments, which lie between and connect individual spinous processes—interspinous ligaments are thus located ventral to the laminae and constitute a distinct ligamentous system from the nuchal ligament.

In *Homo*, the median septum merges with (or replaces) the interspinal ligaments (Mercer and Bogduk 2003), but only occasional, less extensive interdigitations between laminae and interspinous ligaments have been reported in other animals (May-Davis et al. 2020a). Laminae that stem directly from the funiculus, as in the majority of such structures in *Giraffa* (Fig. 1D) and some other taxa, may be called funicular laminae; laminae that instead originate on the bodies of one or more cranial thoracic spinous process(es) may be called spinous laminae (Fig. 1C). Often,

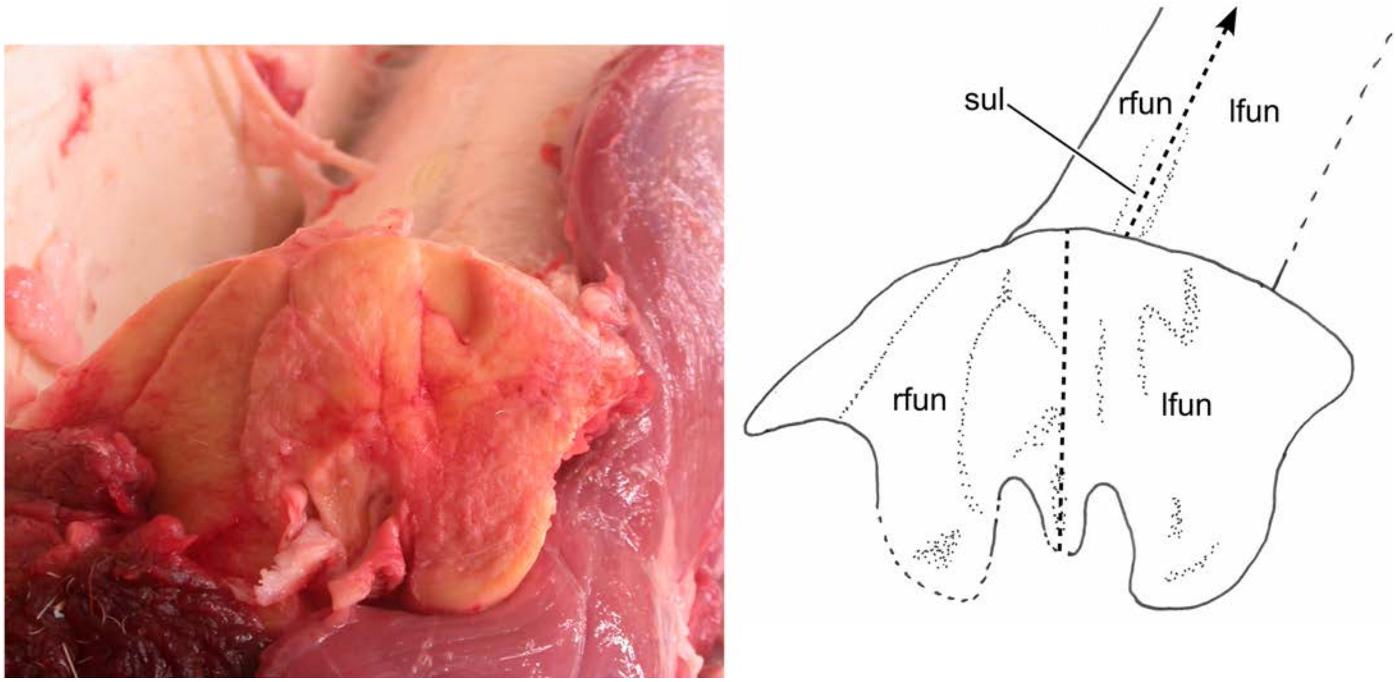


Figure 3. Photograph (left) and schematic (right) of a coronal cross-sectional view of the nuchal funiculus of *Giraffa camelopardalis.* Note both the complex cross-sectional shape and that the right (rfun) and left (lfun) funiculi can be discerned on the dorsal surface separated by a shallow sulcus (sul), though they could not be physically separated. Dashed lines along the sagittal plane mark division between right and left sides. Arrow points caudally.

funicular laminae insert on more cranial cervical vertebrae and spinous laminae insert on the caudalmost cervical vertebrae (e.g., Pianel 2020; Fig. 1C). Distinction between funicular and spinous laminae is not always clear: some laminae appear to stem from both the funiculus and from the cranial thoracic spinous process(es) (e.g., Fig. 1G). Mariappa (1986) reconstructed all the laminae in *Elephas* as spinous, but Owen (1868) reconstructed all laminae in (presumably) *Loxodonta* as funicular. Additionally, to which cervical vertebrae laminae insert is not uniform across taxa: a lone funicular lamina inserts on cervical 7 of *Tragulus* (Fig. 4), but laminae insert on cervicals 2–5, 6, or 7 in other euungulates (e.g., Moskoff 1933–1934; Getty 1975; Mobarak and Fouad 1977; Dimery et al. 1985; Smallwood 1992; Constantinescu 2001; May-Davis et al. 2020a, b; Pianel 2020) and elephants (Owen 1868; Mariappa 1986). Furthermore, the number (typically from zero to six in mammals) of laminae can vary, even within a species (e.g., May-Davis et al. 2020c; Ismail et al. 2021), so rigid descriptions of configurations in any species may not be possible. Where multiple laminae are present, regional subsets may be more strongly developed than others: cranial laminae tend to be thicker and better developed than caudal ones (Dimery et al. 1985; May-Davis et al. 2020c). Laminae prevent the cervical vertebral column from sagging (Fielding et al. 1976; Dimery et al. 1985) and allow the funiculus to follow a curved, rather than linear, path en route to the occiput (Dimery et al. 1985).

Camelus (Mobarak and Fouad 1977) and *Giraffa* (Fig. 5) also possess a structure that has been associated with the nuchal ligament termed the 'pars cucullaris' (from the Latin *cucullus*, meaning 'hood') by Mobarak and Fouad (1977) and the 'plate-like sagittal portion' by Smuts and Bezuidenhout (1987). This structure is not recognized or officially named by ICVGAN (2017), possibly because it has not been recognized in classical veterinary taxa. The pars cucullaris (Fig. 5) comprises a sheet of thin, tough tissue over much of the cranial–mid thoracic spinous processes and muscles that merges with the dorsoscapular ligament (Smuts and Bezuidenhout 1987), the thoracolumbar fascia, and/or tendons of the *m. spinalis thoracis* (Slijper 1946). Although it has been discussed in the context of the nuchal ligament, the pars cucullaris is contiguous with the thoracic supraspinous ligament rather than the nuchal ligament *sensu stricto*, though it may serve functionally as a broader anchor for forces transmitted from the latter. Considering it anatomically as part of the nuchal ligament when it is not in the cervical region is of questionable utility.

PHYLOGENETIC DISTRIBUTION

As the term 'nuchal ligament' generally is used, especially among extant taxa, the structure is exclusively mammalian. Amphisbaenians have a morphologically similar but non-homologous nuchal tendon that aids in moving the head and vertebrae during burrowing (Gans 1974). The

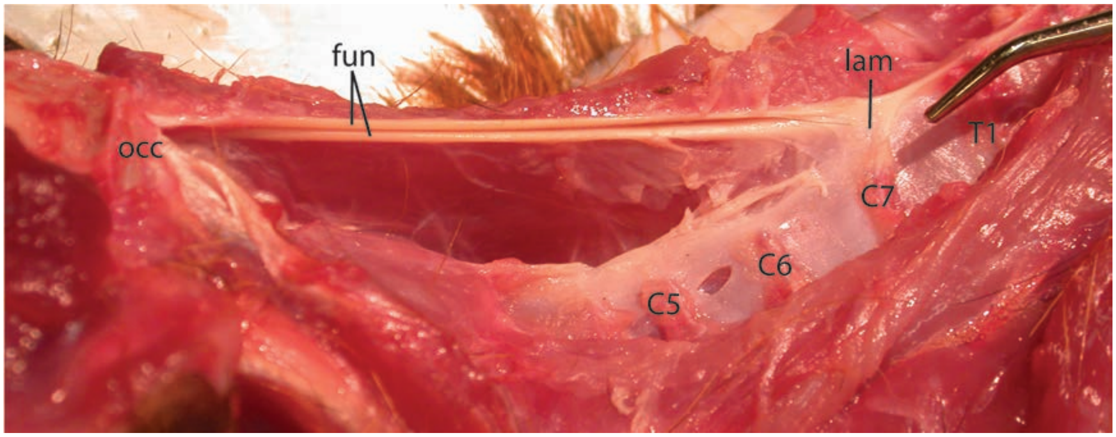


Figure 4. Nuchal ligament of *Tragulus napu* in left lateral view. Abbreviations: fun, funiculus; lam, lamina; occ, occiput of skull. Spinous processes of cervical (C) and thoracic (T) vertebrae numbered by serial position.

palaeognath bird *Rhea* has an elaborate version of the avian interspinal elastic ligament (Boas 1929; Tsuihiji 2004) that bears some morphological resemblance to the funicular and laminar parts of a typical mammalian nuchal ligament, but it is certainly not homologous. Supposed nuchal ligaments occasionally have been reported in non-synapsid sauropsids (e.g., Bojanus 1819), particularly in extinct taxa (e.g., Tschanz 1986; Stevens and Parrish 1999; Woodruff 2016; Fig. 6A–H, Tables 1 and 2). The reasons for this are unclear, but at least in extant taxa, such citations may either be simple mislabelings of supraspinous ligaments, interspinous ligaments, interspinal elastic ligaments, or ligamentous sheaths (Tsuihiji 2004), or be references to sagittal fibrous raphes/septa between epaxial muscles that, depending on the definition applied, do or do not constitute 'nuchal ligaments' (see below).

Within Mammalia, most reports of nuchal ligaments are within Placentalia. However, distribution therein is sporadic (Fig. 6J; Table 2). Nuchal ligaments are most common, and best known, within Euungulata, occurring broadly in perissodactyls and cetartiodactyls except suinans and, possibly, crown cetaceans (e.g., Murie 1871; Chauveau and Arloing 1908; Jouffroy 1968; Nickel et al. 1986; Smuts and Bezuidenhout 1987; Smallwood 1992; May-Davis et al. 2020a, b, c; Gunji 2023; Table 2) (Fig. 6J). The ligament has been best studied in various cetartiodactyls, especially bovids (particularly bovines and caprines), camelids, cervids, and giraffids (e.g., Queckett 1852; Moskoff 1933–1934; Jouffroy 1968; May 1970; Mobarak and Fouad 1977; Dimery et al. 1985; Mbassa and Mgasa 1988; Table 2), and in perissodactyls, especially equids (e.g., Percivall 1832; Blaine 1841; May-Davis et al. 2020a, b, c). Elephants (Afrotheria) also reportedly possess the structure (Mullen 1682; Owen 1868; Mariappa 1986; Table 2), although it has been less well studied, likely because of obvious problems in obtaining and dissecting specimens.

Outside Euungulata, documented, definitive nuchal ligaments are uncommon within Mammalia. They certainly are present in Canidae, again well documented for veterinary purposes (e.g., Evans and deLahunta 2000; Done et al. 2009; Singh 2018). Veterinary texts invariably discuss and illustrate the structure in *Canis familiaris* as consisting of a funiculus spanning the spinous process of the first thoracic vertebrae to the axis, rather than the occiput, and lacking any laminae (Fig. 1B), but some individuals possess diffuse laminae (Ismail et al. 2021). Reports of nuchal ligaments

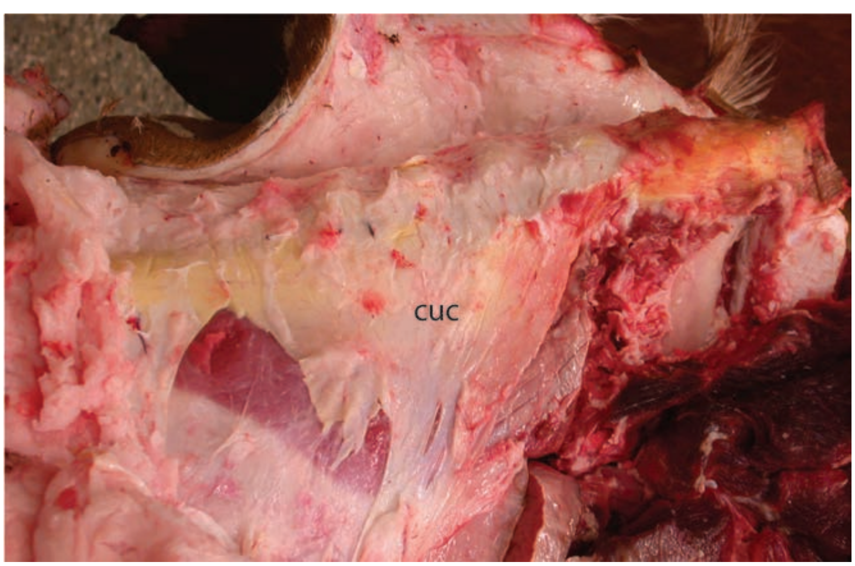


Figure 4. Pars cucullaris (cuc) of *Giraffa camelopardalis* (partially removed to show thinness and underlying musculature).

in non-canid carnivorans are sporadic (Fig. 6J; Table 2). In veterinary texts, *Felis catus* generally has been considered to lack the structure, but depending on how the structure is defined, this may not be correct (Osborn and Homberger 2020), and nuchal ligaments have been reported in several other felid taxa (Table 2). In my own dissections of *Felis catus* and *Panthera tigris*, I was unable to discern any gross-scale nuchal-ligament-like structures.

Among Primates, humans typically are described as possessing a nuchal ligament (e.g., Swindler and Wood 1973; Fielding et al. 1976; Netter 2019; Vital 2020; see below), but whether or not *Pan*, the closest extant relative of *Homo*, has one is unclear: Virchow (1909) and Hofer (1974) reported that *Pan* has one, but Owen (1830–1831), Sonntag (1924), Swindler and Wood (1973), and Diogo et al. (2017) reported that the structure was indistinct or absent. Elsewhere in Hominoidea, australopithecines apparently lacked the structure (Bramble and Lieberman 2004), but *Hylobates* apparently possesses one (Diogo et al. 2012). More basally within Catarrhini, Swindler and Wood (1973) implied that *Papio* has one. Elsewhere within Primates, *Callithrix* (Ohara 1943), Alouatta (Miranda et al. 2022), *Macaca* (Patterson 1942; Casteleyn and Bakker 2021), and *Rhinopithecus* (Patterson 1942) were all noted as possessing nuchal ligaments, though mostly in passing and without any compositional or morphological/topological description.

The mole *Talpa europaea* (Eulipotyphla: Talpidae) reportedly possesses a partly ossified nuchal ligament (Owen 1854, 1868; Table 2). The bony element thus referenced has been illustrated as elevated above the cervical spinous processes and in contact with the caudodorsal margin of the spinous process of that axis (Owen 1854: fig. 41); if this structure is an ossification of or within a funiculus, then the possible nuchal ligament in *Talpa* appears morphologically and topologically similar to that of canids. A similar osseous element also was reported in *Scalopus aquaticus* (Gaughran 1954), so the element appears to be a characteristic, rather than pathological, feature of Talpidae or perhaps a broader clade within Eulipotyphla. Pathological ossification within a nuchal funiculus has been documented in humans (Tsai et al. 2012; Kim et al. 2015; Gokce and Beyhan 2018), though the resulting, short ossifications are unlike the long, rod-like ones of talpids.

Non-placental mammals occasionally have been reported to possess nuchal ligaments as well (Fig. 6I; Table 2), but the natures of the structures thus identified and their relationships to the well-documented nuchal ligaments *sensu stricto* of euungulates, elephantids, and canids are unclear (but see below).

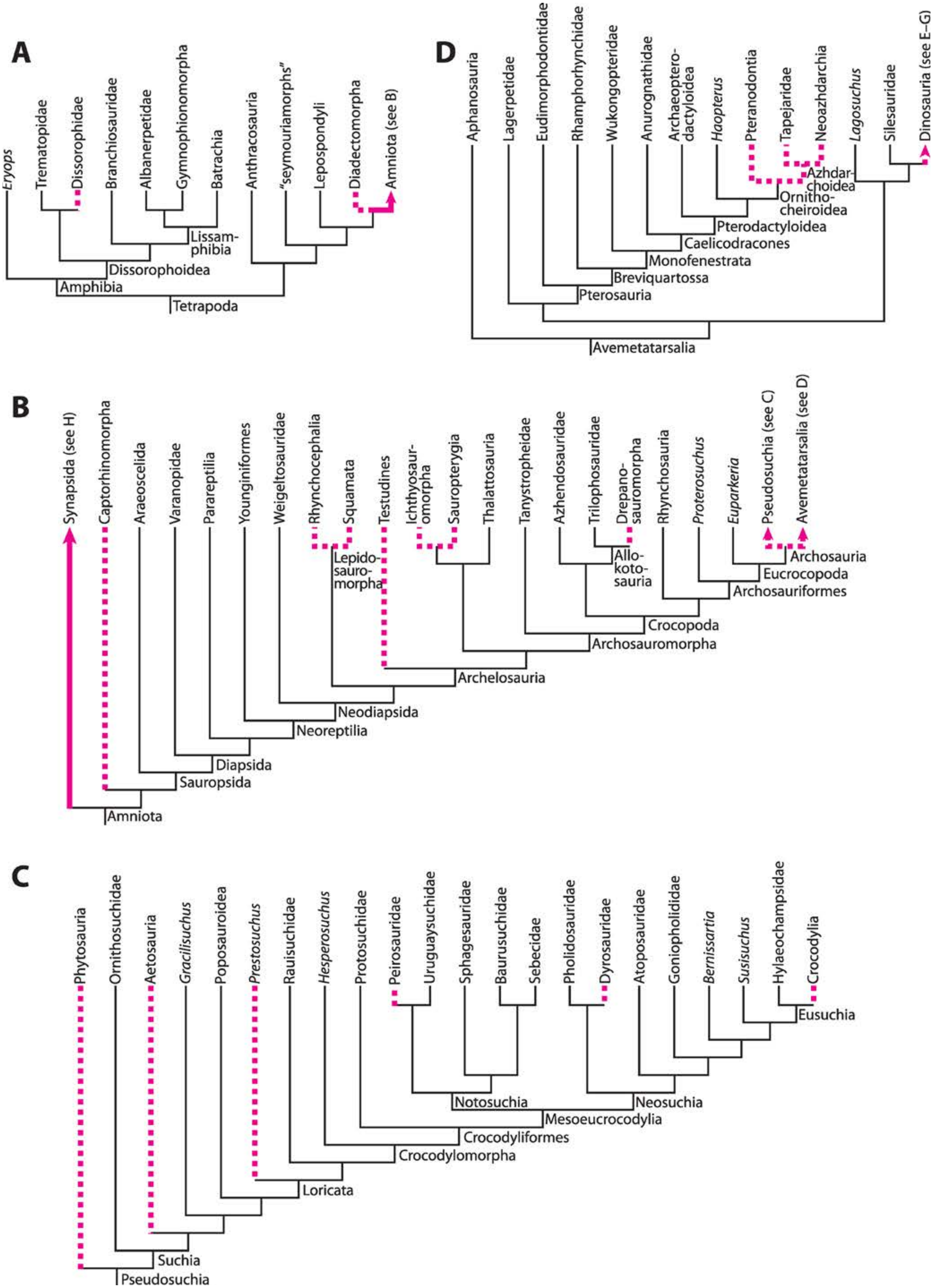
FUNCTION(S)

As above, animals traditionally recognized as possessing a nuchal ligament include various euungulates, proboscideans, canids, and humans, which implies several instances of convergent evolution. Despite this, the function(s) of the ligament across taxa does not seem to have any historical agreement, and several hypotheses have been proposed—or, more correctly, several *a priori* assumptions long have been made without much testing. Most prominent among these are: to support a ‘large’ or ‘heavy’ head and/or a ‘heavy’ or ‘long’ neck (e.g., Mullen 1682; Blumenbach 1786; Brougham and Bell 1836; Wagner 1843), and to store elastic energy to passively raise the head and support a ‘long’ neck (e.g., Vesalius 1543; Linnaeus 1766; Richerand and Kerrison 1803; Owen 1839). In a rare but important instance of testing the supportive function of the nuchal ligament, Dimery et al. (1985) measured strains in the nuchal ligaments of deer, sheep, and camel carcasses during ventral and dorsal flexion, and ascertained that in the deer and sheep, the ligament alone was not capable of raising the heads and necks, whereas it was capable in the camel. So a nuchal ligament indeed may aid in, but not necessarily be entirely responsible for, supporting the weights of heads and necks and for passively raising the head and neck from a ventroflexed position in at least some taxa. Additionally, Gellman and Bertram (2002a) found that the nuchal ligament stores elastic energy and sustains head movement during walking in *Equus*. How broadly applicable these data are in taxa with ‘nuchal ligaments’ unlike those of euungulates, such as dogs and humans, and especially outside of Mammalia, is unknown.

HISTORY OF TERMINOLOGY AND APPLICATION

The structure presently called ‘nuchal ligament’ was not always thus named. The earliest documented references to the structure, in the 14th and 15th centuries, were colloquial rather than scientific and predate systematic and formal attempts to name anatomical structures (Sawai 2018). The structure therefore had more ‘folksy’—and alliterative—names such as faxwax, fixfax, packwax, paxwax, taxwax, and vixvax (Table 1); even today, it is sometimes colloquially called the paddywhack (e.g., Lautenschlaeger and Upmann 2017). Already by the 14th and 15th centuries, the structure was clearly recognized in humans and euungulates that were commonly used as food, such as deer, goats, and sheep (Table 1).

Innes (1776) noted synonymy between the terms ‘ligamentum nuchae’ and ‘ligamentum colli’; the earliest semi-scientific references to the ‘ligamentum colli’ (meaning simply, but vaguely, ‘neck ligament’) predate Innes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Eryops
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Albanerpetidae
Gymnophionomorpha
Batrachia
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Lepospondyli
Diadectomorpha
Amniota (see B)
Lissamphibia
Dissorophoidea
Amphibia
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Aphanosauria
Lagerpetidae
Eudimorphodontidae
Rhamphorhynchidae
Wukongopteridae
Anurognathidae
Archaeopterodactyloidea
Haopterus
Pteranodontia
Tapejaridae
Neoazhdarchia
Lagosuchus
Silesauridae
Dinosauria (see E–G)
Azhdarchoidea
Ornithocheiroidea
Pterodactyloidea
Caelicodracones
Monofenestrata
Breviquartossa
Pterosauria
Avemetatarsalia
B
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Captorhinomorpha
Araeoscelida
Varanopidae
Parareptilia
Younginiformes
Weigeltosauridae
Rhynchocephalia
Squamata
Testudines
Ichthyosauromorpha
Sauropterygia
Thalattosauria
Tanystropheidae
Azhendosauridae
Trilophosauridae
Drepanosauromorpha
Rhynchosauria
Proterosuchus
Euparkeria
Pseudosuchia (see C)
Avemetatarsalia (see D)
Lepidosauromorpha
Allokotosauria
Archosauria
Eucrocopoda
Archosauriformes
Crocopoda
Archosauromorpha
Archelosauria
Neodiapsida
Neoreptilia
Diapsida
Sauropsida
Amniota
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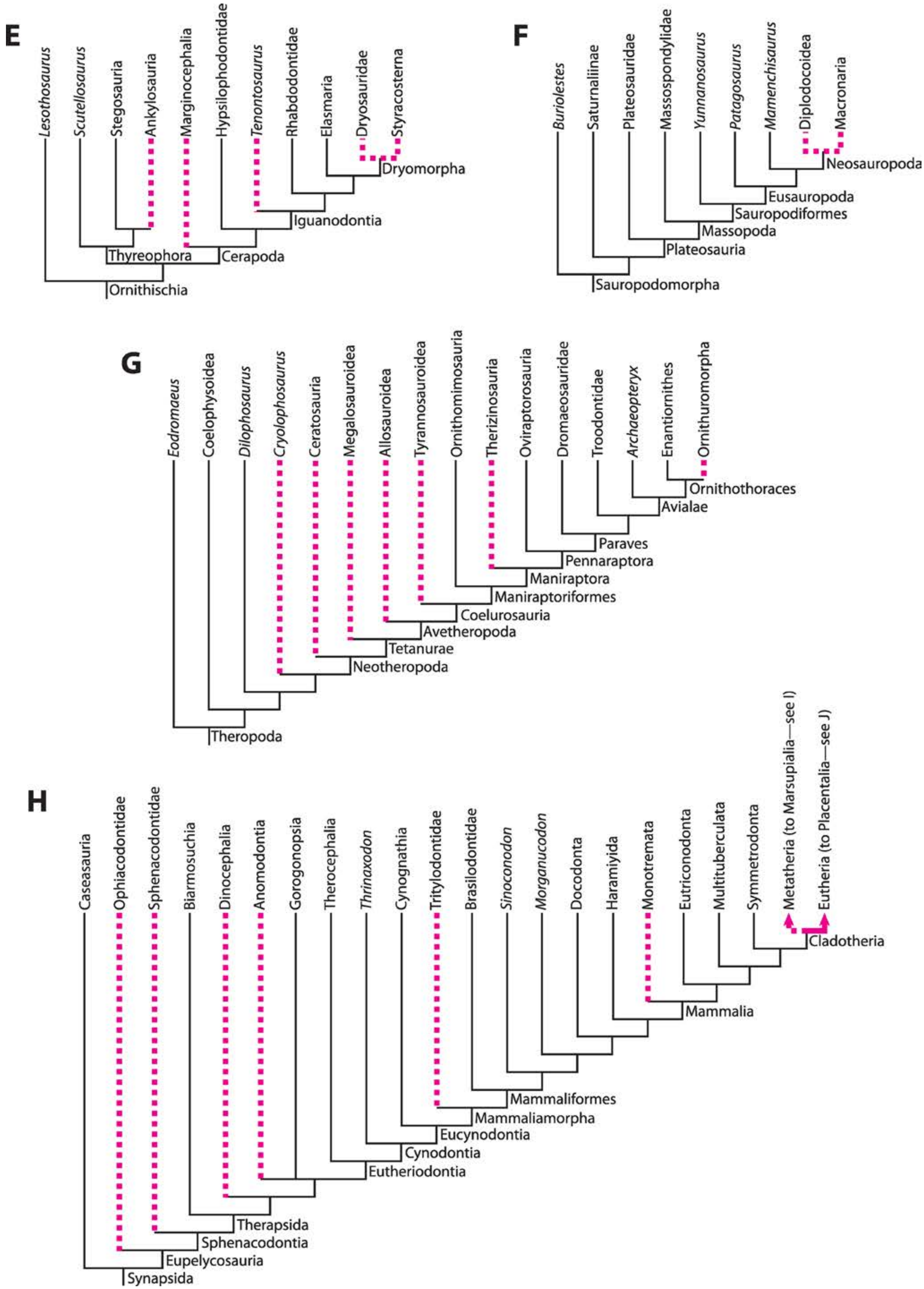
Ornithosuchidae
Aetosauria
Gracilisuchus
Poposauroidea
Prestosuchus
Rauisuchidae
Hesperosuchus
Protosuchidae
Peirosauridae
Uruguaysuchidae
Sphagesauridae
Baurusuchidae
Sebecidae
Pholidosauridae
Dyrosauridae
Atoposauridae
Goniopholididae
Bernissartia
Susisuchus
Hylaeochampsidae
Crocodylia
Eusuchia
Notosuchia
Neosuchia
Mesoeucrocodylia
Crocodyliformes
Crocodylomorpha
Loricata
Suchia
Pseudosuchia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Stegosauria
Ankylosauria
Marginocephalia
Hypsilophodontidae
Tenontosaurus
Rhabdodontidae
Elasmaria
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Styracosterna
Dryomorpha
Iguanodontia
Thyreophora
Cerapoda
Ornithischia
F
Buriolestes
Saturnaliinae
Plateosauridae
Massospondylidae
Yunnanosaurus
Patagosaurus
Mamenchisaurus
Diplodocoidea
Macronaria
Neosauropoda
Eusauropoda
Sauropodiformes
Massopoda
Plateosauria
Sauropodomorpha
G
Eodromaeus
Coelophysoidea
Dilophosaurus
Cryolophosaurus
Ceratosauria
Megalosauroidea
Allosauroidea
Tyrannosauroidea
Ornithomimosauria
Therizinosauria
Oviraptorosauria
Dromaeosauridae
Troodontidae
Archaeopteryx
Enantiornithes
Ornithuromorpha
Ornithothoraces
Avialae
Paraves
Pennaraptora
Maniraptora
Maniraptoriformes
Coelurosauria
Avetheropoda
Tetanurae
Neotheropoda
Theropoda
H
Caseasauria
Ophiacodontidae
Sphenacodontidae
Biarmosuchia
Dinocephalia
Anomodontia
Gorgonopsia
Therocephalia
Thrinaxodon
Cynognathia
Tritylodontidae
Brasilodontidae
Sinoconodon
Morganucodon
Docodonta
Haramiyida
Monotremata
Eutriconodonta
Multituberculata
Symmetrodonta
Metatheria (to Marsupialia—see I)
Eutheria (to Placentalia—see J)
Cladotheria
Mammalia
Mammaliformes
Mammaliamorpha
Eucynodontia
Cynodontia
Eutheriodontia
Therapsida
Sphenacodontia
Eupelycosauria
Synapsida

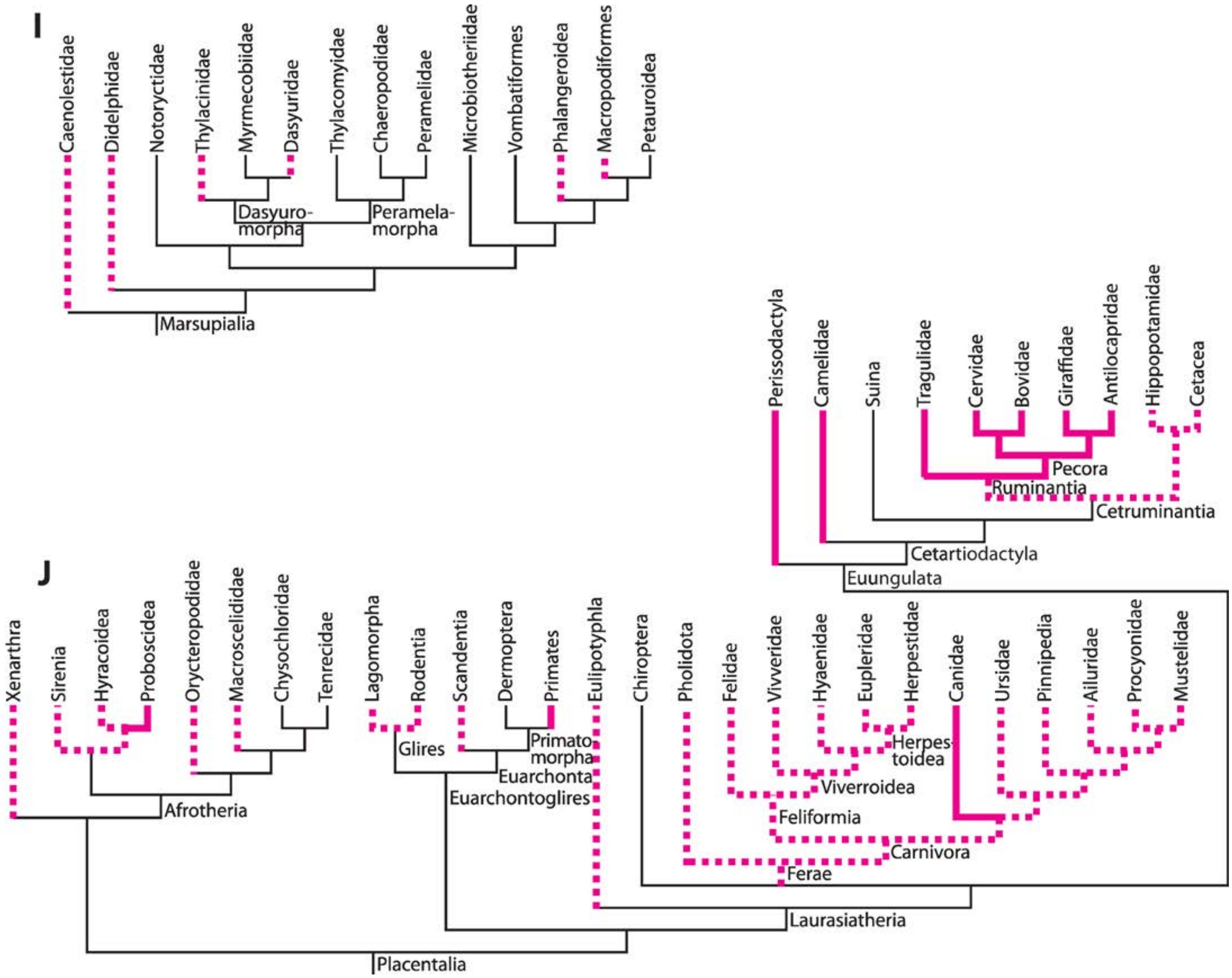

Figure 6 (including previous 2 pages). Phylogeny of Tetrapoda showing the distribution of 'nuchal ligaments' as reported in the literature. Heavy magenta lines indicate lineages within which at least one genus or species has been reported to have or have had a nuchal ligament; dashed magenta lines indicate dubious or poorly justified reports and solid magenta lines indicate well-documented occurrences. For a detailed list of specific taxa, see Table 2. Magenta arrowheads indicate that the indicated clade is expanded in subsequent diagrams. A, Phylogeny of basal tetrapods to Amniota modified and simplified from Marjanović and Laurin (2019); B, Phylogeny of Amniota to Synapsida and Archosauria modified and simplified from Wolniewicz et al. (2022) and Buffa et al. (2024); C, Phylogeny of Pseudosuchia modified and simplified from Pol et al. (2014), Bronzati et al. (2015), and Nesbitt et al. (2020); D, Phylogeny of Avemetatarsalia to Dinosauria modified and simplified from Andres and Myers (2013) and Nesbitt et al. (2023); E, Phylogeny of Ornithischia (Dinosauria) modified and simplified from Dieudonné et al. (2020); F, Phylogeny of Sauropodomorpha (Dinosauria) modified and simplified from Müller (2019); G, Phylogeny of Theropoda (Dinosauria) modified and simplified from Hendrickx et al. (2015); H, Phylogeny of Synapsida to Cladotheria modified and simplified from Luo et al. (2015) and Angielczyk and Kammerer (2018); I, Phylogeny of extant Marsupialia modified and simplified from May-Collado et al. (2015); J, Phylogeny of extant Placentalia modified and simplified from Esselstyn et al. (2017).

(1776) by a substantial margin (Pictor 1562; Welsh 1676; Table 1), although such earlier references to 'ligamentum colli' appear to have been in the context of the throat, not the nape of the neck (Table 1), so whether or not these earlier references are to the same anatomical structure is unclear. Regardless of the name, the nuchal-ligament structure continued to be recognized in humans and 'beasts of burden' (presumably meaning select, domesticated euungulates), but also now in dogs and elephants (Table 1). Douglas (1707) referred frequently to the 'ligamentum colli' with respect to the origin of various epaxial cervical muscles in *Canis*, reporting specifically the origin of the *m. splenius* on a thin membrane (likely the fibrous raphe; Done et al. 2009) that itself connects to 'all the *Ligamentum colli*' (Douglas 1707: 79)—this may constitute the first attempt to formally name the structure. Winslow (1732) clearly described the nuchal-ligament structure in *Homo*, but called it the 'posterior cervical ligament'. Subsequently through the 18th century, both 'ligamentum colli' and 'posterior cervical ligament' (often as 'ligamentum cervicale posterius') were used by various authors; other terms used include simply 'ligamentum cervicale' ('cervical ligament'), and, for humans, 'linea alba colli' ('white line of the neck'; Table 1). Most anatomical treatises from this time focused on human anatomy.

The earliest instance I could find of the term 'ligamentum nuchae' is Schaarschmidt (1749), though whether or not this is the true origin of the term is uncertain. As mentioned earlier, the term 'nucha' had already been in use to mean 'nape of the neck' by the 16th century, so the application of the term to the ligament in question is appropriate, perhaps more so than broader-scope terms such as 'colli'. If Schaarschmidt (1749) indeed originated the term 'ligamentum nuchae', why he opted to create a new name after an established history of other terms being applied to the structure is not explained. Even after 1749, 'ligamentum colli' and other terms continued to be used by numerous authors through the 19th century (Table 1). The term 'ligamentum nuchae' appears in other German texts shortly after 1749 (e.g., Böhmer 1751), but whether the term was not adopted more widely after 1749 was because most subsequent workers were unaware of Schaarschmidt (1749) and the expanding German nomenclature or because they perceived that previously established terms had priority also is unknown. Nevertheless, after 1749, the structure continued to be documented in humans and various euungulates, including horses, camels, rhinoceros, giraffes, and even moles (Table 1). More widespread settlement on the name 'ligamentum nuchae' seems to have occurred only following the standardization of anatomical nomenclature by His (1895), though some other terms still persisted into the early 20th century (e.g., Ballou 1907; Chauveau and Arloing 1908).

NEED FOR A NARROW DEFINITION

Two reasons exist for narrowly defining 'nuchal ligament':

1) To determine the evolutionary origin(s) of the structure—As currently broadly recognized, a nuchal ligament *sensu stricto* has evolved convergently a minimum of four times: once at some point in Primates (which explains its presence in humans, but see below), once in Canidae (which explains its presence in dogs), once at some point in Proboscidea (which explains its presence in elephants), and once in Euungulata (which explains its presence in various cetartiodactyls and perissodactyls); a fifth instance may include Talpidae or a larger clade within Eulipotyphla. If this is correct, then the structure also has been lost multiple times (e.g., in suinans and possibly crown cetaceans). The nuchal ligament in each of these clades differs compositionally and morphologically, however, so an anatomical definition would have to be either broad enough to encompass this diversity, or narrow and explicit enough to exclude some compositions and/or morphologies. Furthermore, a structure called 'nuchal ligament' has been hypothesized—or, again more appropriately, assumed *a priori* based on either phylogenetic relationships (see below) or the presence of one or more untested correlates (see below)—in various extinct tetrapod clades, both mammalian and non-mammalian (Fig. 6; Table 2). If these assumptions are correct, and depending on how 'nuchal ligament' is defined, then the structure either evolved convergently dozens of times within Tetrapoda, attesting to remarkable degrees of evolutionary flexibility and biomechanical constraint, or else it evolved in a basal tetrapod and was lost dozens of times subsequently.

2) To identify correlates in extant and extinct taxa—Presumed correlates of the presence of a nuchal ligament fall into two categories:

a) *Quantifiable correlates*—As mentioned previously, little effort has been made to establish the function of a nuchal ligament. Its presence in a taxon has most often been assumed to correlate with quantifiable criteria, such as having a 'large' and/or 'heavy' head, or with having a 'long' and/or 'heavy' neck, or some combination thereof. Such assumptions have never been tested, however: no studies have examined whether or not animals that possess nuchal ligaments also possess heads and/or necks above a certain weight value or of a certain proportion to some other body size parameter(s). The closest such study I could find was that of Slijper (1946), who examined ratios of neck length to trunk length in various mammal clades and indicated that canids and some euungulates have longer necks in proportion to trunk length than most, but not all, other mammals, but that was not a statistical analysis and the exact taxa examined were not specified. Some taxa reported to have nuchal ligaments, such as humans, moles, and even dogs, appear to lack obviously 'large/heavy' heads and necks or 'long' necks. More broadly, many extinct taxa also have been declared as having possessed 'nuchal ligaments' that likewise have dubiously 'large/heavy' heads or 'long' necks (e.g., the dissorophid 'amphibian' *Anakamacops* [Liu 2018], the sphenacodontid synapsid *Dimetrodon* [Olson 1936], and the ophiacodontid synapsid *Archaeothyris* [Reisz 1971]; Table 2). Conversely, whether or not other 'large/heavy'-headed (e.g., ceratopsid dinosaurs) or 'long'-necked (e.g., sauropod dinosaurs) extinct taxa had euungulate-like nuchal ligaments remains entirely speculative.

What qualifies as 'large', 'heavy', and 'long' has never been defined or statistically bounded, nor has correlation of any of these parameters specifically to nuchal ligaments, and not to any other means of cranio-cervical support, been demonstrated. This means that whether or not evolving a mammal-style nuchal ligament is a necessary, and even the only possible, biomechanical consequence of evolving a 'large', 'heavy', or 'long' head and/or neck has never been determined. Yet 'nuchal ligament' usually has been the default assumption across Tetrapoda for taxa with 'large' and 'heavy' heads and/or 'long' necks rather than support by any other means. As one example, reconstructions of the notoriously 'long'-necked sauropod dinosaurs often have defaulted to euungulate-style nuchal ligaments *sensu stricto* (e.g., Janensch 1929; Preuschoft and Klein 2013), typically called by the mammalian name even though such a structure would be analogous rather than homologous (Martin et al. 1998). Only occasionally have other ligamentous means of cervical support been considered, such as avian-style interspinal elastic ligaments and/or 'reptilian'-style supraspinous ligaments (e.g., Schwarz et al. 2007; Schwarz-Wings and Frey 2008) that are phylogenetically more parsimonious. [Others (e.g., Alexander 1985; Woodruff 2016) have hypothesized sauropods to have had nuchal ligaments, but their reconstructions illustrate structures that are not nuchal ligaments *sensu stricto*.] This is not to say that euungulate-style nuchal ligaments *sensu stricto*, or nuchal-ligament-like interspinal elastic ligaments (as in *Rhea*), in sauropod necks are impossible; merely that appropriate testing for correlates of such ligaments has not yet been conducted to support such hypotheses. Assumptions that 'large', 'heavy', and 'long' heads and/or necks correlate with nuchal ligaments have been pervasive over time and across taxa (e.g., Hildebrand 1974; Alexander 1989; Bray and Burbidge 1998; Gellman and Bertram 2002b; Stevens and Parrish 2005; Mitchell et al. 2013; Haussler 2016; Arnold et al. 2017; Noè et al. 2017; Titov et al. 2021; Domning 2022). I emphasize, however, that while these assumptions remain largely untested, they are not necessarily incorrect. They merely must be acknowledged as *a priori* assumptions until data that support them have been demonstrated.

b) *Osteological correlates*—Several osteological features have been cited, especially in extinct taxa, as indicating the presence of a nuchal ligament. Most prevalently, these are: the presence and/or sizes of depressions, crests, or eminences on the occipital surface of the skull in the vicinity of the nuchal crest; and the relative dimensions and/or morphologies of spinous processes on the axis, post-axial cervical vertebrae, and/or cranial thoracic vertebrae (Table 2). For the latter, the presence of 'withers'—tall spinous processes on the cranial thoracic vertebrae, especially in proportion to short spinous processes on the preceding cervical vertebrae—sometimes has been cited as indicating the presence of a nuchal ligament (e.g., Paul 1988, 2017), but the relationship between the morphology of a spinous process, the forces acting on it, habitual neck posture, overall body size, and phylogeny is complex. Some results suggest that elongate cranial thoracic spinous processes, at least in some taxa, do not correlate with having at least a 'large' or 'heavy' head (Roskosz and Empel 1961; Austin 2005; Schüler et al. 2024). Nevertheless, as with quantifiable correlates, correlation between the presence of a nuchal ligament and any particular skull features, or morphologies or dimensions of cervical or cranial thoracic vertebrae, has never been tested for veracity, either statistically or even with basic comparative anatomical studies. Again, though, such hypotheses are not necessarily incorrect—they, too, are presently *a priori* assumptions.

Bone histology and/or micro-computed tomography (micro-CT) scanning at presumed ligament enthesis sites has potential to support or refute hypotheses of nuchal ligament presence in extinct taxa. At the site of presumed nuchal ligament enthesis, such as at the tips of cervical spinous processes, bone—more specifically, calcified fibrocartilage at the bone–ligament interface (Apostolakos et al. 2014)—should be orientated parallel to the direction of the tensional force of the ligament that attached to it because bone is strongest when the grain of the bone is orientated with the forces acting on it and because bone is strongest under compression and tension (McGowan 1999). Such studies in both extant and extinct taxa are, thus far, rare (Woodruff 2016). Comparative histological and/or micro-CT studies of enthesis sites in extant taxa should form the basis for understanding comparable sites in extinct taxa (Woodruff 2016).

In addition to these presumed correlates, hypotheses that any particular extinct taxa possessed nuchal ligaments can be bolstered by phylogenetic proximity to extant taxa that have nuchal ligaments. For example, the extinct equid *Dinohippus*, which is phylogenetically close to extant *Equus*, may reasonably be considered likely to have possessed a nuchal ligament. But how far phylogenetically such hypotheses can be pushed is unclear. For example, is hypothesizing that small, 'short'-necked and 'small'-headed basal equids such as '*Hyracotherium*' ('*Eohippus*') possessed nuchal ligaments reasonable simply because the phylogenetically more distant *Equus* does (Wood et al. 2010; May-Davis et al. 2021)? What about even more basal taxa, such as *Protungulatum*? Even among extant taxa, phylogenetic proximity does not always mean a taxon has a nuchal ligament—for example and as outlined above, *Homo* appears to have one, but *Pan* may not. Without statistical and/or comparative support that any particular quantifiable and/or osteological features truly correlate with the presence of a nuchal ligament, all such hypotheses or assumptions must be viewed with caution.

OPTIONS FOR A DEFINITION

Several options exist to define the term 'nuchal ligament':

1) Broad etymological definition—Essentially, anything goes: any epaxial, sagittal or parasagittal ligamentous structure lying dorsal to the spinous processes in the cervical region could be called a nuchal ligament. Etymologically, this definition meets the generally accepted meaning of 'nuchal' as 'dorsal surface (nape) of the neck'—any ligament in the dorsal region of the neck is, etymologically, a nuchal ligament *sensu lato*. This could include structures currently recognized as nuchal ligaments *sensu stricto* (e.g., in euungulates, proboscideans, and canids), supraspinous ligaments, atlanto-occipital ligaments, fibrous raphes/septa, ligamentous sheaths, and hypothetical novel structures. Similarly, any ligamentous structure that inserts on or near the nuchal crest of the skull could be called a nuchal ligament *sensu lato*—a ligamentous structure associated with the nuchal crest perforce would be a nuchal ligament etymologically, although this would exclude the structure in canids because the canid nuchal ligament does not insert on the skull. While either of these example etymological definitions is possible, neither accords with much current usage. For example, the dorsally situated cervical interspinal elastic ligaments of birds, including the nuchal-ligament-like variation in *Rhea* (Tsuihiji 2004), generally are not considered nuchal ligaments and indeed have their own, separate nomenclature (ligamentum elasticum interspinale; Baumel et al. 1993; Tsuihiji 2004), even if their function is similar. This is perhaps because of their morphological and topological distinction from mammal-style nuchal ligaments *sensu stricto*: typical (excluding *Rhea*) avian interspinal elastic ligaments comprise discontinuous segments between the bases of the cervical spinous processes rather than comprising a continuous structure located dorsal to the distal ends of the cervical spinous processes. Similarly, dorsally situated, sagittal, cord- or strap-like ligamentous structures lying in direct contact with the distal tips of the cervical spinous processes in *Varanus komodoensis* (Surahya 1989) and *Alligator mississippiensis* (Frey 1988) were called supraspinous ligaments rather than nuchal ligaments, likely because of their morphological and topological similarities to the supraspinous ligament of the thoracic region. These examples suggest that anatomists often already employ more restricted taxonomic and/or morphological/topological (or both) definitions for 'nuchal ligament'. Thus, an etymological definition for 'nuchal ligament' seems untenable and undesirable.

2) Restricted taxonomic definition—Conceivably, 'nuchal ligament' could be defined as being present only in specific taxa (e.g., Mammalia broadly, or Euungulata, Proboscidea, Canidae, and Hominoidea more narrowly); any supportive, epaxial, cervical structure outside these taxa, morphologically similar or not, could not be a nuchal ligament. This option would obviate possible instances of convergent evolution, particularly in extinct taxa (e.g., hadrosaurid dinosaurs [Bertozzo et al. 2020]), or at least would require that morphologically and topologically and/or functionally similar structures in taxa outside the definitional group(s) be given different names to reflect non-homology, as has been done with *Rhea* (Tsuihiji 2004) and other avians. That avians have an alternative terminology for such cervical structures suggests that anatomists already apply some degree of taxonomic consideration in defining 'nuchal ligament'.

3) Restricted compositional definition—'Nuchal ligament' could be defined based on composition as an elastic vs. an inelastic structure. For example, the yellowish, elastin-rich structures in euungulates, proboscideans, and canids could be considered nuchal ligaments, but the white, elastin-poor structures in *Homo* (Fielding et al. 1976) and perhaps some other tetrapods (e.g., Osborn and Homberger 2020) would not (or vice versa). Such a compositional definition would require establishing a percentage threshold of elastin, or a particular ratio of elastin to collagen, present for a structure to qualify as a nuchal ligament. For example, dry-weight quantities of elastin in the acknowledged elastic nuchal ligaments of bovines (50–70% [varying ontogenetically; Halvorsen et al. 2023]) and equines (80% [Gellman and Bertram 2002b]) are greater than the unspecified but minority quantity of elastin in the human nuchal ligament (Fielding et al. 1976)—a specified percentage (e.g., 50%) of elastin could serve as the threshold. Such a definition is attractive because of its ready quantifiability, but it is perhaps undesirable for two reasons: (a) because it would make determining whether or not extinct taxa for which no unaltered soft tissues are preserved had nuchal ligaments virtually impossible, and (b) because it defies centuries of recognizing a nuchal ligament in taxa with the opposing composition. In the current example, if a nuchal ligament is defined as possessing a high elastin content, then the structure in *Homo* would not qualify despite a centuries-long history of recognizing the structure in humans. Notably, however, some have argued that the structure in *Homo* is not a true ligament (see below), suggesting that composition is, to some degree, already an important anatomical consideration in defining 'nuchal ligament'.

4) Restricted morphological/topological definition—Various aspects of the morphology and topology of a nuchal ligament itself and/or its relationship to surrounding muscles could constitute the basis for a definition. For example, the lone common aspect of nuchal ligaments across extant taxa well documented to possess one is the position of the funiculus (dorsal raphe in humans) with respect to the cervical spinous processes: the funiculus itself does not make contact with cervical spinous processes; it merely spans the distance between cervical 7 (in *Homo*) or the cranialmost thoracic spinous process (in other taxa) and either the occipital region of the skull or, in canids and possibly talpids, the caudodorsal margin of the spinous process of the axis[3]. Connections to individual cervical vertebrae are made via laminae, if present. In this example, a hypothetical definition of 'nuchal ligament' would hinge on the distinctive separation of the funiculus from the tips of the cervical spinous processes; the presence of laminae would not need to be part of the definition. Sagittal or parasagittal, cord- or strap-like ligaments in direct contact with each cervical spinous process instead would be supraspinous ligaments, continuations of the structure from the thoracic region, as has been recognized in *Varanus komodoensis* (Surahya 1989) and *Alligator mississippiensis* (Frey 1988). Such a morphological/topological definition encompasses most, if not all, reports of nuchal ligaments across extant taxa well documented to possess one (including *Homo*) and therefore constitutes a *de facto* but unofficial definition of nuchal ligament *sensu stricto*, but would exclude reports of 'nuchal ligaments' in several extinct taxa (e.g., Woodruff 2016; Table 2). Nevertheless, this definition seems most broadly applicable and flexible and so perhaps is the most desirable option.

5) Restricted, combined definitions—Definitions combining aspects of the above are also conceivable. For example, 'nuchal ligament' could be defined using a combination of morphological/topological and taxonomic criteria as a ligamentous structure comprising a funiculus elevated above the distal tips of the cervical spinous processes in any member of Mammalia (or some other taxon or subset of taxa). As above, such a definition would necessitate giving analogous but morphologically and topologically nuchal-ligament-like structures outside of Mammalia distinct names, the benefits of which for understanding convergent evolution are debatable. Likewise, 'nuchal ligament' could be defined using a combination of morphological/topological and compositional criteria: for example, as a ligamentous structure comprising a funiculus elevated above the distal tips of the cervical spinous processes that is composed of a specific quantity of elastin or proportion of elastin to collagen. Such a combined definition again could exclude the structures in certain taxa, such as the inelastic structure in *Homo*. However, as noted above, composition already appears to be a factor in the understanding of the term 'nuchal ligament' *sensu stricto*, so this type of combined definition is a distinct possibility, although the problem of applying it to extinct taxa remains.

Until a narrow definition of 'nuchal ligament' is established, anatomical studies of either extant and (perhaps especially) extinct taxa that apply the term should (1) explicitly state what definition of the structure is intended by the term, and (2) describe the morphology and topology of the structure intended by the term, taking care to ensure that the described structure is not better accommodated by another name, such as 'supraspinous ligament', 'dorsal raphe', or 'median septum'.

WHAT IS AND IS NOT A NUCHAL LIGAMENT

Once a solid, narrow definition of 'nuchal ligament' is adopted, extant taxa that have nuchal ligaments can be identified as such properly. Then research can begin into what, if any, quantifiable and osteological features truly correlate with the presence of a nuchal ligament; only after such correlates have been solidly identified can extinct taxa with those features be understood to have had nuchal ligaments. That understanding, in turn, would lead to a better understanding of the phylogenetic distribution of the structure and how often it (or a collective of analogous structures) has convergently evolved, as well as the range of anatomical configurations that the structure can adopt. In the meantime, however, the general usage of the term 'nuchal ligament' *sensu stricto* seems to include taxa with elevated funiculi unconnected to the cervical spinous processes and exclude taxa that possess supraspinous ligaments that are in contact with sequential cervical spinous processes, such as lepidosaurs (e.g., Surahya 1989; Tsuihiji 2004) and crocodylians (e.g., Frey 1988). Some extinct taxa (e.g., sauropod dinosaurs) also have been reconstructed with cervical supraspinous ligaments (e.g., Woodruff 2016) that would etymologically, but not morphologically or topologically, be nuchal ligaments *sensu stricto*. Such confusing applications of nomenclature attest to the need for a narrow definition of 'nuchal ligament'.

[3]In taxa in which the funiculus reaches the occiput, the funiculus may contact the distal surface of the enlarged spinous process of the axis, but whether or not actual insertion is made at this site is unclear.

DOES *HOMO* POSSESS A NUCHAL LIGAMENT?

While a nuchal ligament has long been identified in *Homo sapiens* (Table 1), some have argued that the structure in question is not properly a ligament. Virchow (1909) and Slijper (1946) noted that a structure that Slijper (1946: 28) termed a 'fibrous, median septum', which separates right and left epaxial muscles dorsal to the distal ends of the cervical spinous processes, often has been called a 'nuchal ligament' in many mammals, including kangaroos, bears, and humans. Similar identifications may explain at least some reports of 'nuchal ligaments' in other mammals (e.g., Minkoff et al. 1979; Gambaryan et al. 2015; Osborn and Homberger 2020) and beyond (e.g., Werneburg 2011; Young 2022). Paraskevas (2011) outrightly called the human nuchal ligament a membrane rather than a ligament. Standring (2021: 843) explicitly stated that the human nuchal ligament is not truly a ligament, being instead 'a unique arrangement of tendons and fascia between the posterior muscles of the neck', although no basis (e.g., histological) for this statement was provided. Nevertheless, it parallels the position taken by Mercer and Bogduk (2003; see also Alimi and Tubbs 2019; Vital 2020). As noted above, the so-called nuchal ligament in *Homo* is composed largely of collagen, with variable but minority quantities of elastin (Fielding et al. 1976), in stark contrast to the structures in euungulates. The evolutionary interpretation of these data is difficult. Two possible explanations arise:

1) The dorsal raphe plus fibrous septum in *Homo* (and, by extension, possibly other mammals that have been perfunctorily labeled as having 'nuchal ligaments') is a nuchal ligament *sensu stricto*, but has secondarily lost its predominance of elastin during the evolution of bipedalism (Fielding et al. 1976). This was suggested by Gray (1901) and Virchow (1909) and could be indicated by the shared enervation pattern, morphology, and topology of the structures in *Homo* and other taxa. For example, both (a) consist of a cord- or strap-like funiculus (unpaired in *Homo*) that is contiguous with the supraspinous ligament of the thoracic vertebrae, as well as sheet-like laminae (Mercer and Bogduk 2003); and (b) lie sagittally and insert on or near the sagittal nuchal crest of the skull (Fielding et al. 1976). Humans, as rather unusual bipeds with approximately vertical spines, may have lost elastin in their nuchal ligaments because the force of the weight of the head and neck is transmitted directly through the vertebral bodies, requiring minimal muscular or other effort to keep the head erect (Jouffroy 1968; Fielding et al. 1976). This is not to say that the human nuchal ligament is functionless; it is important in restraining cervical flexion and preventing vertebral misalignment (Takeshita et al. 2004) and in head stabilization (Bramble and Lieberman 2004; Yegian et al. 2020). The report of a nuchal ligament in the quadrupedal *Papio* (Swindler and Wood 1973) would, superficially, support the idea that the transition to bipedality may have induced compositional modification (from elastin-rich to elastin-poor) in the homologous structure in *Homo* as well as possible loss of the structure in *Pan*. However, although the ratio of elastin to collagen in the nuchal ligament of *Papio* is unknown, D. Swindler (pers. comm. 2004) reported that its structure is grossly similar to that of humans, suggesting that the inelastic composition and structure in *Homo* is typical of catarrhines and that the structure in humans did not lose elastin during the course of hominoid evolution. Descriptions of nuchal ligament compositions among more basal primates are rare: the only description I could find was for *Callithrix* ('*Hapale*') *jacchus*, in which the nuchal ligament was described as largely inelastic despite having some quantity of elastin (Ohara 1943). Perhaps no primate possesses a nuchal ligament dominated by elastin as it is in euungulates. Clearly much work is needed across Primates to better document the presence, morphologies/topologies, and compositions of 'nuchal ligaments' through the clade, though of course a narrow definition of 'nuchal ligament' is needed first.

2) The dorsal raphe and fibrous median septum (Mercer and Bogduk 2003; Vital 2020; Standring 2021) evolved parallel to, but independently from, the elastic nuchal ligament funiculi and laminae *sensu stricto* of other mammals. Several distinctive features of the nuchal ligament in *Homo* may indicate this: (a) the funicular (dorsal raphe) portion in *Homo* is composed of a triangular arrangement of fascial fibres, created by interdigitations with the surrounding *mm. trapezius* (Johnson et al. 2000; Mercer and Bogduk 2003; Alimi and Tubbs 2019), unlike the more unidirectional fibre orientations in the nuchal ligament funiculi *sensu stricto* of other mammals; (b) the laminar sheet in *Homo* also does not contain directionally orientated laminae as in other taxa; instead, it is composed of non-uniformly orientated fascial fibres (Mercer and Bogduk 2003; Vital 2020); (c) the laminar portion (median or nuchal septum) merges with (or replaces) the interspinous ligaments (Mercer and Bogduk 2003); (d) the laminar portion in *Homo* inserts on the atlas and interdigitates with the spinal dura mater at the atlanto-occipital and atlanto-axial joints (Dean and Mitchell 2002), unlike the nuchal laminae *sensu stricto* of euungulates; and (e) human nuchal laminae form a continuous sheet (midline septum) rather than being composed of distinct branches that are separated near their cervical vertebral insertions by apertures (*sensu* May-Davis et al. 2020a; Fig. 1) as they often are in other mammals. As suggested by Jouffroy (1968) and Fielding et al. (1976), the

human structures only coincidentally have a morphological and topological resemblance to the nuchal ligaments *sensu stricto* of, for example, euungulates. Chauveau and Arloing (1908:185–6) referred to a similar structure 'replacing' the nuchal ligament in Suidae and Felidae as a 'fibrous raphe', recalling the 'median' or 'fibrous raphe' seen in *Canis* (Evans and deLahunta 2000; Done et al. 2009), *Bos* (Heath 1979), *Giraffa* (Endo et al. 1997), and other animals that almost certainly is the fused fascia surrounding epaxial muscles along the dorsal sagittal plane. This seems to be identical to the 'septum nuchae' of Mercer and Bogduk (2003) and the 'fibrous, median septum' of Slijper (1946), and harkens back to the 'linea alba colli' of Cheselden (1750). Many reports of nuchal ligaments across Tetrapoda (Slijper 1946; Table 2) may actually be references to such fibrous septa/raphes that, depending on the type of definition applied, do or do not constitute 'nuchal ligaments'.

If this is correct, the configuration of the structure in *Homo*, and perhaps other primates, may morphologically and topologically resemble, but not be, a nuchal ligament *sensu stricto* solely because of the physical constraints of the region in which it exists rather than because of evolutionary homology or because *Homo* needs an equivalent, supportive function as euungulates. A fascial, fibrous structure evolving along the sagittal plane between epaxial muscle masses must necessarily be sheet-like (laminar), and the only space for expansion into a thickened, cord-like (funicular) structure would be along the dorsal margins of those muscles (and the structure at that location, as in *Homo*, need not be paired; see also Slijper 1946). Similarly, lack of expansion space created by the epaxial muscles and their insertion sites on the occipital region of the skull necessitates insertion on the external occipital protuberance. Possibly the positions of the muscles surrounding the dorsal raphe and median septum in *Homo* force them to mimic the morphology of a nuchal ligament *sensu stricto*.

Ultimately, the anatomical differences between the 'nuchal ligament' in *Homo* and those of other mammals could be considered substantial enough to warrant calling the structure in *Homo* (and possibly other primates) a name distinct from the nuchal ligaments *sensu stricto* in other mammals. This position was advocated by Mercer and Bogduk (2003), who tacitly suggested simply eliminating the term 'nuchal ligament' in *Homo* and using instead 'dorsal raphe' and 'midline (or nuchal) septum' for the two parts. Or, conversely, the structure in *Homo* could retain the term 'nuchal ligament'—despite the feature lacking key ligamentous structural features (Mercer and Bogduk 2003; Standring 2021)—and the distinctive structures in euungulates, elephantids, and canids should be called by a different term to emphasize their morphological, topological, and/or compositional differences. Schaarschmidt (1749) first applied the term 'ligamentum nuchae' to *Homo*, which argues that the latter solution makes the most sense. However, a nuchal-ligament structure historically has been recognized by various names equally in both *Homo* and other mammals (Table 1); which taxon and which composition and/or morphology was the first to receive distinct recognition and a name, even a 'folksy', non-scientific one, whatever that name was, is lost to history. Both could lay claim to the name equally.

The long-standing use of 'nuchal ligament' in both human and non-human mammal anatomy for anatomically different structures could force the term to be retained in both simply to avoid historical confusion—in other words, the terminology would be identical between humans and non-human mammals (and possibly other tetrapods), but the term would refer to structurally distinctive entities in each. This is more or less the current and problematic status quo, somewhat equivalent to the aforementioned etymological definition for 'nuchal ligament'. But even if this undesirable status quo is maintained, such breadth of use would not, however, then imply that the term 'nuchal ligament' could broadly be used for any epaxial cervical ligament system: for example, cervical supraspinous ligaments would not therefore automatically be nuchal ligaments. Regardless, further comparative work (histological, innervational, vascular, etc.) on the nuchal ligaments in both *Homo* and mammals that have elastic nuchal ligaments *sensu stricto* to determine the natures of their respective evolutionary, developmental, and anatomical origins would be useful.

CONCLUSIONS

Clearly, a firm, narrow definition of 'nuchal ligament' is needed to begin to understand the evolutionary history or histories of any structure(s) bearing the name. A restricted morphological/topological definition seems most ideal and applicable, but the topic warrants broader debate among anatomists. Once a narrow definition is in place, statistical research into quantifiable and/or osteological (including histological) correlates of a nuchal ligament in extant animals that possess the structure can progress. Correlates, once identified, would enable the identification of which extinct taxa also had nuchal ligaments. These multiple avenues of research necessary to enable such anatomical reconstructions of extinct taxa would, in turn, enable better functional interpretations of those extinct taxa, replacing often *a priori* assumptions that such ligaments must have existed in any given taxon for poorly defined, quantifiable reasons (such as 'having a heavy head' or 'having a long neck') and osteological reasons (such as the presence of specific depressions, rugosities, and/or eminences on the occipital region of the skull, or proportions of spinous process lengths between the cervical and cranial thoracic vertebrae). Additionally, extinct taxa possessing 'large/heavy' heads and necks or 'long' necks that may be determined by whatever means to not have possessed nuchal ligaments *sensu stricto* can be better explored for what type(s) of alternative supportive mechanisms they evolved instead. Nuchal ligament and related anatomy is a veritable untapped resource, in both extant and extinct taxa, with multiple potential avenues of research (statistical, osteological, histological/micro-CT, developmental, biomechanical, etc.), but research on extant taxa should form the basis for hypothesizing the presence of a nuchal ligament in any extinct taxon.

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Table 1: Select Chronological and Taxonomic History of Terminology Used for the Nuchal Ligament Prior to 1900 *(translations via Google Translate except as noted)*

Text highlighted in mauve is either unclear in the original text or the translation, or both.

YEAR	AUTHOR	TITLE	TERMINOLOGY	ORGANISM(S)	NOTES
before 1300	Walter of Bibbesworth	*Le Tretiz (The Treatise)*	fax-wax	human	'Le col, la gorge, e le mentoun,/Dunt le frainceis est commun./The throte-bolle/Dedens la gorge est le gargate,/mide-rede/E pluis parfunt si gist rate;/fax-wax/E si ad derere le wen au col,/A chescune sage e au fol.' —see *Le Traite de Walter de Bibbesworth* —from Rothwell (1990), pp. 4–5 (The neck, the throat and the chin, for which the French is well known:/In the throat is the larynx and lower down lies the spleen,/And at the back of the neck is a ligament (every wise man and fool has one).) —translation from Dalby (2012), pp. 44–45
c. 1340	unknown	unknown (possibly a rehashing of *Le Tretiz*)	faxwax	cow(?) ('calf' and 'cove' [cow] are mentioned on the same page, but so is 'man')	'Corps teste et hanapel/Body heuede and heuedpanne/Et peil cresceant sur la p[e]il/And here growe[n]de on the skyn/Toup canel et cervel/Toppe tey and the brayne/Greue fountayne et haterel/Sched molde and sculle/Col venoun et fossolet/Nekke faxwax and nekkehole/Lapet oraile et molet/Dewelappe here and herehole' —see Skeat (1906) here
c. 1378	Henry Daniel	*Liber Uricrisiarum*	faxwax, paxwax	human (particularly the second reference from 3.20)	3.12: 'And vnderstond þat, whan *pili* apperen in the vryn, or it is wiþ a febre or elles wiþouten febre. If wiþ a febre, *pili* comen of al the body; if wiþouten febre, onely of þe reynes. Þus seiþ þe Coment vpon Giles. Gilbert seiþ þat *pili* come night of þe teyns, but onely of members þat ar synowy and skinny, os is faxwax and os synowes ar and the rens and þe arteries and swich maner members in the body.' —see Harvey et al. (2020), p. 247; Norri (2016), p. 386; 3.16: '*Attome* ar caused & gendred þrogh continuel distillacioun, i. þrogh euery fote fallyng & course & rennyng of humores vpon sad members, as vpon þe bones & on oþer members þat ar hard & sadde, os paxwax, synowes, & swich oþer.' —see Harvey et al. (2020), p. 251; '3.20: '*Rubea* and stykand & wiþ a blak *ypostasis* &* drubly and wiþ bodyes like heres or elles lik thynges muselynges of paxwax: ful wik tokne & deth.' —see Harvey et al. (2020), p. 275; also 'Vryn sandarik, i. rede os mader: sekenesse & peyne in þyee stomac & in þe hede & in þe brawne & in þe paxwax and in þe schuldres.' —see Harvey et al. (2020), p. 281
c. 1470	John Russell	*Boke of Nurture*	fyxfax	deer, goat, sheep	(Under the heading 'How to Carve the Crane, Fawn, Vension, &c.') 'Off Fowen/kid/lambe,/þe kidney furst it lay,/þan lift vp the shuldur, do as y yow say,/ȝiff he wille þerof ete/a rybbe to hym convey;/but in þe nek þe fyxfax þat þow do away.' —see Furnivall (1894), p. 28 here
c. 1475	unknown (anonymous)	unknown surgical treatise	vixvax, 'yellow hair'	? (not human)	p. uncertain: 'The secunde principal part of þe necke beþ ij seruices, þe whiche ben certeyn longitudinel fleisch ligginge in þe myddil vp þe tweie sidis of þese aforseid spondilis...And þis maner of fleisch is callid in sum cuntre in Ynglisch vixvax, and of summe ȝonge children it is callid ȝolowȝ heer.' (from here; q.v. Norri 2016)
1490	listed as Galen, but clearly a translation by unknown author(s)	*Opera Plurima: De Sectis, etc.*	ligamentum colli	? (not human)	p. unnumbered: 'Similiter ligamentum colli I gule torius non solum vocem amputate: sed etiam suffocationem parit: artaria vero divisae vocem quidem nocer: respiranonem vero non aufert animali.' (In the same way, the ligament of the neck is not only amputated by the gule torus, but it also gives birth to suffocation.) (from here)
1523	Leonardus Legius	*Propositiones et Flosculi ex Galeni Libris (Propositions and Florets [the best things] from the Books of Galen)*	ligamentum colli	? (likely not human because Galen never dissected humans)	p. 37: 'Ligamentum colli i gulle totins no solum vocem amputat: sed etiam suffocationem parit.' (The ligament of the neck and of the throat not only cuts off the voice, but also gives rise to suffocation.) (from here)
1543	Andreas Vesalius	*De Humani Corporis Fabrica (On the Fabric of the Human Body)*	none (described only)	dogs (cow/ox, pig, goat)	pp. 300–302: 'Dogs and those animals that can without difficulty bite their own back have much looser joints than man between the cervical vertebrae and also have longer cervical vertebrae. In them we see a ligament whose nature I shall not hesitate to describe here for Galen's sake. In dogs, after you have dissected the second pair of muscles moving the head, you will find in the neck a ligament that is woven in texture and unlike any other in the whole body except perhaps the vertebral ligaments that I have just described; it is harder than the others and yellow in color and can be resolved into a large number of fibers. It grows forth from the sides of the apex of the spine of the seventh cervical vertebra and proceeds upward; it is not attached to any vertebra until it reaches the second cervical, into which it inserts at the sides of the spine at the very tip. In some animals, such as sheep, it inserts into the occipital bone. This ligament is enveloped in its own individual membrane and appears double because of an impression extending lengthwise along it. You will be able to examine the nature of this ligament whenever the neck of a calf, a piglet, a kid, or an older ox is placed upon the dinner table: this ligament is the yellow object that we normally separate from the meat and give· to the dogs, for among the other ligaments it alone is rejected as unfit for consumption. Because it is so strong the people of Brussels call it 'the grapes' and tell young girls that if they eat it their hair will grow thicker; this joke is, I imagine, based on the pale yellow color of the ligament and the fact that among other parts of the body it <alone> can be resolved into the likeness of a head of hair. Its prime

					function is to prevent the cervical vertebrae from dislocating, for they are very loosely articulated and have a greater degree of oblique movement than the rest of the vertebrae. Similarly in oxen along the entire length of the spinal column we see on each side passing along the spines a single broad ligament of this type hidden among the muscles moving the back; it is just such a thing as Galen attributed to humans in *On the Function of the Parts*.' (translation from Richardson & Carman (1999), pp. 320–321)
1562	Georgius Pictor	*Separati Sermones, Aphoristica Brevitate in Omnes Ferme Praeter Naturam Affectus ex Summis Medicae Professionis Auctoribus in Unum Conscripti (Separate Sermons, Aphoristic Brevity on All Fermes Apart from Nature's Affections from the Highest Authors of the Medical Profession Composed into One)*	ligamentum colli	human(?)	p. 85–86: 'Separati Sermones Galeni, guttur concernentes: Instrumentu uocis, sibreuiter definiatur, no est aliud nisi guttur totu.lib.de interiorib.cap. 6. Gutture paciente, materia uocum ad illud uenire prohibetur, loco praeallegato. Ligamentum colli & gulae totius, non solum uocem amputate, sed & suffocationem parit. Eodem loco.' (Separate sermons of Galen, concerning the throat: The instrument of the voice, to be defined differently, is nothing but the whole throat. book of the interior chap. 6. With the patient's throat, the material of the callus is prevented from coming to it, in the pre-alleged place. The ligament of the neck and the entire throat, not only amputate the voice, but also gives birth to suffocation. In the same place.)
1589	Juan Valverde de Hamusco	*Anatome Corporis Humani (Anatomy of the Human Body)*	ligamentum processus vertebrarum colli deuinciens (ligament of the vertebral processes of the neck)	human	Index; ostensibly on p. 15, but name not used there—unclear if this refers to the nuchal ligament or some other set of cervical vertebral ligaments. p. 15: 'Verum enimuero vertebrae hae omnes a capite Appendice donantur, praecipue autem septima, cui ea, quam caeteris omnibus longior multo contigit; vnde posterioribus thoracis vertebrarum prcessibus nonnihil assimilatur, quamuis hi paullo acutiores existant. Verum tam ij, quam illi inferius excauantur, superius vero prominent eminente linea, quam in medio superioris partis obtinent, quae alteri excauatae lineae respondet, eandemmet in inferiori regione stucturam seruanti: ita vt processus triangulares videantur. Ex superiore alterius linea ligamentum educitur, quod in inferiorem processus altioris vertebrae lineam inseritur, cuius medio processis hi coligantur, dexteris musculis vti dicemus, a sinistris per illud diremptis.' (But I think that all these vertebrae are given by the head of the appendix, but especially the seventh, to which it happens to be much longer than all the others; whence it is somewhat likened to the posterior processes of the thoracic vertebrae, although these exist a little sharper. It is true that, as they are hollowed out below, a protruding line stands out above, which they obtain in the middle of the upper part, which corresponds to the other hollowed out line, which serves the same structure in the lower region: thus they appear to be triangular processes. From the superior line of the other, a ligament is brought out, which is inserted into the inferior process of the superior vertebra, in the middle of which these processes are gathered, so to speak, of the muscles of the right, having been separated from the left by it.)
1598	Carlo Ruini	*Anatomia del Cavallo, Infermita, er Suoi Rimedii (Anatomy of the Horse, Infirmity, and Its Remedies)*	Il nervo grande, ò ligamento soprail quale nascono le crine. (The great nerve, or the ligament above which the hair arises.)	horse	Fig. 10, p. 98–99, labeled 'E'; Fig. Tavola Prima, p. 226–227, labeled 'I' (funicular part only)
1605	Caspard Bauhin & Theodor de Bry	*Theatrum Anatomicum*	none (described only)	dog, other non-human animals(?)	p. 1081–1082: 'Musculos quoque, qui vertebris adnascuntur, sustinent, & interuallis processuum vertebrarum inferuntur, tam transuersoru, quae membranea sunt, quam psteriorum inter ipsorum spinas & radices, quae in spinarum apicibus adeo crassescunt, vt ad apices simul coeuntes, velut vnum ligamentum per spinarum longitudinem ductum forment. / Insuper ligamentum quoddam priuatum, subflauum ex vertebrae foramine sede interna, ad radicem processus posterioris, inter duos ascendentes aut descendentes processus exoritur, quod in vertebrae subsequentis sedem eandem inseritur. / Verum in canum ceruice ligamentum occurrit, rarum, robustum tamen & flauum, quod in fibras nullas dissolui potest, quod ex apice spinae septimae vertebrae ceruicis enascitur, & ascendens nullique connatu secundae ceruicis spinae apici infigitur; in ouibus vero occipiti connascitur. Quod in animalibus oners dorso ferentibus crassissimu est: ad dorsi firmitudinem, & solum inter corporis ligamenta, tanquam esui ineptum reiicitur, & a nostris Baldenwachs dicitur. Hoc prompe in fibras dissoluitur, ne vertebrae ceruicis suo loco excidant, cum laxe admondum articulentur, & processes oblique agantur: in quibusdam animalibus secundum dorsi longitudinem vtrinq; vnum secundum spinas intermusculos, dorsum mouentes, occultatum.' (The muscles, too, which are attached to the vertebrae, support them, and are brought into the intervals of the processes of the vertebrae, both transversely, which are membranes, and of the posterior ones between their own spines and roots, which are so thick at the tips of the spines, that they come together at the tips, as if one ligament

					led through the length of the spines form. / In addition, a certain ligament, subfluous, arises from the foramen of the internal seat of the vertebra, at the root of the posterior process, between the two ascending or descending processes, which is inserted into the same seat of the subsequent vertebra. / It is true that in dogs there is a cervical ligament, rare, yet strong and weak, which cannot be broken up into any fibers, which arises from the apex of the seventh cervical vertebra, and when it ascends, it is attached to the apex of the second cervical spine by no effort. On the other hand, it is connected to the back of the head. That in animals which bear burdens on the back is the thickest: for the stability of the back, and only between the ligaments of the body, it is rejected as unfit for itself, and is said by our Baldenwachs. This is promptly dissolved into fibers, so that the cervical vertebrae do not fall out of their place, since they are very loosely articulated, and the processes are carried obliquely: in some animals, according to the length of the back, in the opposite direction; one according to the spines between the muscles, moving the back, hidden.)
1631	Helkiah Crooke	*Mikrokosmographia: A Description of the Body of Man, 2nd Ed.*	none (described only)	'beasts of burden'	p. 916: 'In the necke of a Dogge wee meete with a Ligament which is rare indeede but strong and yellow, and cannot be parted into fibres. It groweth out of the very top of the spine of the seauenth Racke of the necke, and ascending vpward free and at liberty is fastned in|to the top of the second spine of the necke. In sheep it groweth to the Nowle-bone. In beastes of burthen it is very thicke for more strength, and of all the Ligaments of the bo|dy is refused for meat; yet sayth Vesalius some commend it to be eaten to make the haire grow long. It may be (sayth he) because it is easily dissolued as it were into yellow haire. In some creatures throughout the length of the backe runneth a Ligament on each side betweene the muscles that moue the backe, which sayeth Vesalius, Galen also attributes to men in his bookes de vsu partium.'—See Palmer (1890), p. 269
1676	George Hieronymus Welsh	*Curationum Exotericarum Chiliades. 2. et Consiliorum Medicinalium Centuriae (Exoteric Cures Chiliades. 2. and the Medicinal Councils of the Centuries)*	ligamenti colli	human(?)	p. 44: 'Pulsum parvum, frequentem, inaequalem & formicantem cum animi languor persentiri: Vellicationes scapularum: flatus in hypochondriis: sudores in toto vapidos: Inflationem tumidam labiorum: horrorem & tremorem: perfrigerationes extremorum: tensionem ligamenti colli in jugulum inserti: dispnoeam: Urinam variam: non abseque supicione veneni, & tenerioris animi corporisq; constitutionis, nihil omnino asperi ferentis.' (A small, frequent, uneven, and tingling pulse is felt with languor of the mind: twitching of the shoulders: flatulence in the hypochondria: profuse sweats all over: swollen inflation of the lips: shudder and trembling: chills of the extremities: tension of the ligament of the neck inserted in the throat: dyspnoea: colored urine: not abstinent with the supposition of poison, and of a more tender mind of the body; constitution, bearing nothing at all rough.)
1682	Allan Mullen (Moulen, Moulin)	*An Anatomical Account of the Elephant Accidentally Burnt in Dublin, on Fryday, June 17. In the Year 1681.*	taxwax	elephant	p. 14: 'The Ligament, commonly call'd Taxwax, reach'd from the Head, to which it grew, to about the 13th *vertebra* of the *dorsum*; it was double, one on each side of the *Spinae vertebrarum colli & dorsi*; it was both very thick, and very broad, and consequently very strong; its use doubtless was to assist the Muscles and other parts of the Neck, to bear the extraordinary weight of the Head, being placed not flat, but edgewise, like planks used as Joices to bear up Floors. And this piece of Architecture is found in most, if not all Quadruped's, for the very same purpose; but being needless, it's wanting in men.'
1707	James Douglas	*Myographiae Comparatae Specimen: or a Comparative Description of All the Muscles in a Man and in a Quadruped*	ligamentum colli	dog	p. 70: 'In a Dog, its [the 'Trapezius seu Cucullaris'] superior Origin comes from all the *Ligamentum colli* that's below the rise of the *Levator humeri proprius*; that part of it which resembles the *Cuculla* springs from about the middle of the *Vertebrae* of the Back; that Series of Fibres which pulls the *Scapula* directly backwards unites with the upper triangular part of this Muscle by a thin Tendon.'; p. 75: 'In a Dog the *Serratus superior posticus* arises by a thin Tendon from the lower part of the *Ligamentum colli*, its last acute Process, and from the eight superior Processes of the Back.'; p. 79: 'In a Dog it [the Splenius] terminates in the transverse process of the first *Vertebra colli*, and into the posterior and lateral part of the *Occipital Bone*. Backwards it's intimately conjoined with its fellow of the other side, from the sharp Process of the last *Vertebra colli* to the *Occiput*, from which commissure or joining there runs down a thin transparent Membrane to all the *Ligamentum colli*.'
1710–1712	Patrick Blair	*Osteographia Elephantina (Philosophical Transactions 27)*	tax wax	elephant	p. 78: 'Afterwards the Body being turn'd over, I had opportunity to see the *Tax Wax* mention'd by Dr. *Moulins*, which arises from a *Spina* in the back part of the Scull (cc.) whence running backward along the Sides of the seven *Vertebra* of the Neck, it terminated betwixt the 6th and 7th *Vertebra* of the Back, becoming still thinner in its Progress. It was about six Inches broad, pretty thick, and descended obliquely from the Top of the *Spina Vertebrarum* to above the Ribs, and cover'd all the Muscles which arise from the Neck, and support the Head; assisting them, (as Dr. *Moulins* rightly observes) because the Head of Quadrupeds, especially of this Animal, being more pendent, have more need of Supporters than the Head of a Man, where this Contrivance is wanting. Dr. *Moulins* tells us, that it was plac'd edgewise; the Reason of which may be, because of the *Spines* of the four first *Vertebrae* of the Back, which are 4 inches broad; whence the *Tax Wax*, running forward (where the Spines are narrow, or where there are no spines at all, as in the three first *Vertebrae* of the Neck) in a streight [sic] Line to the Scull, the space below it for the Muscles to move in, must be the same at the Neck as at the *Spina*, where the *Epiphyses* keep their Upper Sides at such a distance. From above this *Tax Wax* in the Neck, do arise two Muscles, thinner and narrower at first, but thicker and broader as they go to the Scull, where they firmly adhere to the Sides of a large *Sinus* in its back part (bb.) whence ascending, being lodg'd in the Depression upon the top of the Head, and betwixt the Eminencies (dd.) they descend till they come over against the Hole for the Root of the Trunk (a.) and become thicker and round, and in their whole Descent make up the forepart of the Trunk with extremity.'

1732	Jacques-Bénigne Winslow	*Exposition Anatomique de la Structure du Corps Humain (Anatomical Exhibition of the Structure of the Human Body)*	posterior cervical ligament	human	p. 119: '53. Les Ligamens Interosseux de l'Avant-Bras & de la Jambe appartiennent à cette espece, de même que le Ligament Obturateur, les Ligamens qui regnent tout le long de chaque côté de l'Os du Bras, depuis son Col jusqu'aux Condyles; le Ligament Cervical posterieur; les Ligamens lateraux du Col; les Membranes Ligamenteuses des Trous posterieurs de l'Os Sacrum.' (53. The Interosseous Ligaments of the Forearm & Leg belong to this species, as well as the Obturator Ligament, the Ligaments which run along each side of the Bone of the Arm, from its Neck to the Condyles; the Posterior Cervical Ligament; the Lateral Ligaments of the Collar; the Ligamentous Membranes of the Posterior Holes of the Sacrum.); p. 154: 'Outre tous ces Ligamens de l'Epine du Dos, il y en a un qui s'étend comme une Membrane depuis l'Occiput jusqu'aux dues dernieres Vertebres du Col. Il est large en haut, & sa largeur diminuë à mesure qu'il descend. Il est attaché par son Extrémité superieure & large le long de l'Epine Occipital, & par un de ses bords au Tubercule posterieur de la premiere Vertebre, au milieu des Fourches Epineuses des Vertebres suivantes, & à la Pointe ou Extrémité posterieure des dernieres Vertebres. L'autre bord de ce Ligament est comme en l'air. C'est aussi un Ligament Inter-Musculaire. Je l'appelle Ligament Cervical posterieur.' (Besides all these Ligaments of the Spine of the Back, there is one which extends like a Membrane from the Occiput to the last due Vertebrae of the Neck. It is wide at the top, and its width diminishes as it descends. It is attached by its superior & wide extremity along the Occipital spine, & by one of its edges to the posterior tubercle of the first vertebra, in the middle of the spiny forks of the following vertebrae, & to the tip or posterior extremity of the last vertebrae . The other edge of this Ligament is like in the air. It is also an Inter-Muscular Ligament. I call it [the] Posterior Cervical Ligament.)
1740	Johann H. Zedler	*Grosses vollständiges Universal-Lexicon aller Wissenschaften und Künste (Large Complete Universal Lexicon of All Sciences and Arts)*	ligamentum cervicale posterius	human(?)	pp. 2190–2191: (under heading 'Ossium Ligamenta') 'Die Bander zwischen den Knochen (interossea) am Unterarme und am Schienbeine gehoren zu dieser Urt; wie auch das verstovffende Band, (Ligamentum obturatorium;) die Bander, welche die gantze Lange an jeglicher Seite des Oberarmbeins von seinem Halse an, bis zu den Knopffen einnelzmen, das hintere Nackenband, (Ligamentum cervicale posterius) die Bander zum Seiten des Halses; die sennigten Haute der hintern Lucher des heiligen Beins.' (The ligaments between the bones (interossea) on the forearm and tibia belong to this type; as also the occlusive ligament, (ligamentum obturatorium;) the ligaments enclosing the whole length on each side of the humerus from its neck to the button-feet, the posterior nuchal ligament, (ligamentum cervicale posterius) the ligaments to the sides of the neck; the sennigten skin of the buttocks of the holy leg.)
1744	Johannes A. Mischel	*Institutio Anatomica, Erster Theil*	ligamentum cervicale posterius	human(?)	pp. 285–286: 'Bedachter musculus hat gar seine unmittelbare Befestigung an denen spinis vertebrarum superiorum colli, sondern nur an einem membranosen ligament, welches am osse occipitis und an denen spinis aller vertebrarum colli fest sitzet, allow es seine Endschafft erreichet; es wird dasselbige ligamentum, cervicale posterius genennet. Besagtes ligamentum wird durch seine Bereinigung mit denen fibris tendineis des musculi trapezii und splenii sher verstarctet. (Considered muscle even has its direct attachment to the spinis vertebrarum superiorum colli, but only to a membranous ligament, which is firmly attached to the occipital bone and to the spines of all neck vertebrae, allowing it to reach its end. It is called the same ligamentum, cervicale posterius. Said ligament is greatly strengthened by its joining with the tendinous fibers of the trapezius and splenius muscles.)
1745	Robert James	*A Medical Dictionary; Including Physic, Surgery, Anatomy, Chymistry, and Botany, in All Their Branches Relative to Medicine, Vol. 2*	posterior cervical ligament	human	page unnumbered: 'Of this Kind are the Supercilium of the Cotyloide Quality, the Ligaments which tie the Os Hyoides to the Styloide Apophyses, the posterior Cervical Ligament; the Ligaments which connect the sharp Edges of the spinal Processes of the Vertebrae to one another, and those seared at the Bases of these Apophyses, next the great Canal of the Vertebrae, especially in those of the Loins.' —references '*Winslow's Anatomy*' = Winslow (1732)?
1746	Frank Nicholls	*Compendium Anatomico-Oeconomicum*	ligamentum colli	'brutes' ('brutis')	p. 6 (in a table of 'Ligamentum Elasticum')
1747	Burchard D. Mauchart & Heinrich G. Rumelin	*Capitis Articulatio cum Prima et Secunda Colli Vertebra [Articulation of the Head with the First and Second Cervical Vertebrae]*	ligamentum cervicale	human(?)	p. 11: 'Variae appellationis, a situ, origine, insertione, usu, e.g. ligamentum cervicale, interspinale, suspensorium, obturans, etc.' (Various appeals, by location, origin, insertion, use, e.g. cervical, interspinal, suspensory, obturator, etc. ligaments)
1749	John Barrow	*Dictionarium Medicum Universale: or, a New Medical Dictionary*	cervical ligament	human	p. unnumbered: 'INTERSPINALES *colli*, certain muscles of the neck. They lie between the six spinal *Apophyses* of the neck, and between the last of the neck, and the first of the back; being inserted in those *Apophyses*, by both extremities on one side of the posterior, cervical ligament, which parts them from those of the other side.'; p. unnumbered: 'SERRATUS *posticus superior*. This is

					a flat thin muscle, situated on the upper part of the back. It is fixed on one side by a broad *Aponeurosis* to the lower part of the posterior cervical ligament, and to the spinal *Apophyses* of the two last *Vertebrae* of the neck, and the two first of the back.'
1749	August Schaarschmidt	*Osteologische Tabellen (Osteological Tables)*	ligamentum nuchae	human	p. 24 (pertaining to the os occipital): 'Die aufferliche Zervorragungen, und groar (a) In der Mitte ein tuberculum, Protuberantia occipitalis s. tuberculum occipitale genennt, moran fich das ligamentum nuchae attachirt.' (The prominent projections, and large (a) In the middle a tuberculum, called Protuberantia occipitalis s. tuberculum occipitale, to which the ligamentum nuchae is attached.) —earliest use of 'nuchal ligament'; possibly so called because of association with the processes nuchae on the skull…?
1750	William Cheselden	*The Anatomy of the Human Body*	linea alba colli	human	p. 84: 'TRAPEZIUS arises from the os occipitis, and from a linea alba colli, from the spinal process of the last vertebra of the neck, and the ten upper most of the back, and from a linea alba between all these processes…'
1751	Philipp A. Böhmer	*Institutiones Osteologicae in Usum Praelectionum Academicarum cum Iconibus Anatomicis (Osteological Institutions for the Use of Academic Lectures with Anatomical Icons)*	ligamentum nuchae	human	p. 66: 'Quatuor ibidem eminent processus, e quibus in nuchae asperiusculus producitur, aliquando bifidus, ligamentum nuchae firmans.' (There stand out four processes, from which the asperiusculus is produced in the neck, sometimes bifid, strengthening the nuchal ligament.)
1753	Claude Bourgelat	*Elémens d'Hippiatrique, ou Nouveaux Principes sur la Connoissance et sur la Médecine des Chevaux, Tome 2, Part 1 (Elements of Hippiatrics, or New Principles on the Knowledge and Medicine of Horses, Vol. 2, Part 1)*	cervical ligament	horse	p. 236: 'Quoique la tête & l'encolure soient l'une & l'autre très-affermies dans leurs articulations au moïen des ligamens particuliers & de ce nombre de muscles dont je vous ai fait l'exposition, il est néanmoins encore un ligament dont l'usage est de foûtenir l'encolure & la tête, indépendamment même de tous ces muscles, sur tout lorsque cette dernière partie est basse, & que conséquemment il faut une plus grande force pour la retenir. / Ce ligament, que j'ai nommé le ligament cervical, est très-fort lui-même: il est double dans son principe & simple dans le reste de son étenduë. Il commence aux prémières vertébres du dos, c'est-à-dire que son attache la plus solide est aux apophises épineuses des six prémières vertébres dorsales, après quoi il se partage en deux lames plus larges, qui remplissent cet intervalle triangulaire qui résulte de la situation élevée de l'encolure & du garot.' (Although the head and the neck are both very firm in their articulations by means of the particular ligaments and of this number of muscles which I have explained to you, there is nevertheless still a ligament whose the custom is to brace the neck and the head, independently even of all these muscles, especially when this last part is low, and when consequently a greater force is needed to retain it. This ligament, which I have named the cervical ligament, is very strong itself: it is double in its principle & simple in the rest of its extent. It begins at the first vertebrae of the back, i.e. its strongest attachment is at the spinous processes of the first six dorsal vertebrae, after which it divides into two broader blades, which fill this triangular interval which results from the elevated situation of the neckline and the withers.)
1753	Pierre Tarin	*Dictionnaire Anatomique, Suivi d'une Bibliotheque Anatomique et Physiologique (Anatomical Dictionary, Followed by an Anatomical and Physiological Bibliography)*	none	human?	p. 50: 'Les *Cordons ligamenteux* (*Funiculi ligamentosi*) viennent de chacune des extrêmités des apophyses épineuses.' (The ligamentous cords (*Funiculi ligamentosi*) come from each of the ends of the spinous processes.) †
1754	August Schaarschmidt	*Syndesmologische Tabellen (Syndesmological Tables)*	ligamentum nuchae s. cervicale	human	p. 58: 'Zweischen dem occipite und den ubrigen vertebris colli ist das ligamentum nuchae s. cervicale, welches sich sehr breit an der proterubantia occipitali anfanft, immer enger zugehet, und fish mit seinen Enden an den apophysibus spinosis vertebrarum colli befestiget.' (Between the occiput and the remaining vertebris colli is the ligamentum nuchae s. cervicale, which begins very broadly at the proterubantia occipitali, narrows more and more, and attaches with its ends to the apophysis spinosis vertebrarum colli.)
1759	John Bartlet	*The Gentleman's Farriery Or a Practical Treatise on the Diseases of Horses*	cervical ligament	horse	p. 92: 'The red hot iron so frequently run through the foretop and mane, near the occipital bone, for this purpose, has often been found to have destroyed the cervical ligament.'

1766	Caroli Linnaeus	*Systema Naturae, Tome I, 12th Ed.*	paxwax, ligamentum album	'quadrupeds'	p. 48: 'Paxwax, Ligamentum album, ad Caput elevandum & Collum sustinendum, commune ast quadrupedibus; at deest Homini & Simiis, cum erecti plerumque sedeans & ineedent, nec co indigeant, Rajus.' (A white ligament, for raising the head and supporting the neck, is common to all quadrupeds; but man and apes, when they are generally awake, sit down and eat, and do not need food.)
1766	George Stubbs	*The Anatomy of the Horse, Including a Particular Description of the Bones, Cartilages, Muscles, Fascias, Ligaments, Nerves, Arteries, Veins and Glands*	ligamentum nuchae	horse	p. 1: 'The occipital crest, which is very strong in the horse. Behind and below this crest is the nuchal crest to which the ligamentum nuchae is attached.'
1769	Peter S. Pallas	*Spicilegia zoologica quibus novae imprimis et obscurae animalium species, Fasc. Decimus Tertius (Zoological Spicules Containing New and Obscure Species of Animals, Vol. 13)*	ligamentum cervicale	Siberian musk deer	p. 35: 'Dorsum, psoades & artus postici maxime carnosa, robustissimis faltibus comparata. Ligamentum cervicale exile, utpote in excorni animalculo, inter musculos ferme latens.' (The back, psoades, and hindquarters are particularly fleshy, compared with the most robust fronds. A slender cervical ligament, as if in the horn of an animal, lying firmly between the muscles.)
1776	John Innes	*Eight Anatomical Tables of the Human Body*	ligamentum nuchae, seu colli	human	p. 34: 'Its [Trapezius, seu cucularis] tendinous joining with its fellow in the nape of the neck, which is called *ligamentum nuchae*, seu *colli*.'
1779	Johann G. Essich	*Bildung eines Wundarztes nach dem Muster der beßten und neuesten chirurgischen Schriftsteller. Von der Anatomie. Physiologie. Mechanischen, und medicinischen Wundarzeneykunst, Vol. 1*	ligamentum cervicale	human	p. 38: 'Zwischen dem Hinterhauptbeine und den ubrigen Halswirbelbeinen ist das Ligamentum cervicale, welches an der Protuberantia occipitali sehr breit anfangt, immer enger zugeht, und sich mit seinen Enden an den Apophysibus spinosis Vertebrarum colli befestiget.' (Between the occipital bone and the other cervical vertebrae is the cervical ligament, which begins very broadly at the protuberantia occipitalis, becomes narrower and fastens with its ends to the apophysibus spinosis vertebrarum colli.)
1780	Samuel F. Simmons	*The Anatomy of the Human Body*	ligamentum colli; cervical ligament	human	p. 319: 'It [the 'Trapezius, or Cucullaris'] arises, by a thick, round, and short tendon, from the lower part of a protuberance in the middle of the occipital bone backwards, and from the rough line that is extended from thence towards the mastoid process of the os temporis, and by a thin membranous tendon, which covers part of the complexus and splenius. It then runs downwards along the nape of the neck, and rises tendinous from the spinous processes of the two lowermost vertebrae of the neck, and from the spinous processes of all the vertebrae of the back, being inseparably united to its fellow, the whole length of its origin, by tendinous fibers, which, in the nape of the neck, form what is called *ligamentum colli*, or the *cervical ligament*.'
1782	Ferdinand Joseph von Leber	*'Ferdinand Leber's' Vorlesungen über die Zergliederungskunst ('Ferdinand Leber's' Lectures on the Art of Dissection)*	Nackenband (ligamentum cervicale s. nuchae)	human	p. 27: 'In seiner duszeren Flache kommen folgende Erhohungen vor: 1) in der Mitte eine Hervorragung, die man den Buckel des Hinterhaupts nennt, an welchen fich das Nackenband anhanget; von dieser Hervorragung entspringt 2) eine scharfe Linle, die den Kamen Hinterhauptbeinstachel hat.' (In its upper surface the following elevations occur: 1) in the middle, a prominence called the hump of the occiput, to which the nuchal ligament is attached; from this prominence arises 2) a sharp line having the occipital spine.); Register (index?): 'Das Nackenband (Lig. Cervicale s. Nuchae)'
1783	Johann C.A. Mayer	*Beschreibung des ganzen menschlichen Körpers, mit den wichtigsten neueren anatomischen Entdeckungen bereichert (Description of the Whole Human Body, Enriched with the Most*	Nackenband (ligamentum nuchae)	human	p. 122–123: 'Durch die Bander de Spitzen an den Stachelfortsatzen (Ligamenta apicum processuum spinosorum). Ich wurde die Bander wegen ihrer Uetzulichfeit mit den vielen hier anligenden Sehnen der Rucfenmusfeln lieber sehnigte Bander de Stachelfortsatze (Ligamenta tendinea processuum spinosorum) nennen. Sie fullen die Zwischenrdume der Spitzen mit senfreche herablaufenden Fasern aus, und sind oft von jenen Sehuen, die sich mit ihnen verbinden, schwer zu unterschefden. Unten am Rucfgrat sind sie weit fester wie oben, weil unten die Starte der Musfeln zuninmt, und ihre vormehmste Bestimmung ohne Zweifel diese ist, in den Zwischenraumen jener Spitzen den Musfeln zur Hulage zu dienen. Ueberdem unterstutzen sie auch die aufrachte Stellung des Stammes, und helfen ihn durch thre Elasticitat weiherum etheben, wenn er nach vormdrts gebugt war. Un den Halswirbelbeinen, wo diese Bander mehrentheils fehlen, ersetzt das Nackenband (Ligamentum nuchae), von dem ich ben den

		Important Recent Anatomical Discoveries)			Nackfenmusfeln reden werde, ihre Stelle.' (Through the bands de tips on the spinous processes (Ligamenta apicum processuum spinosorum). I would prefer to call the ligaments tendinous ligaments of the spinous processes (Ligamenta tendinea processuum spinosorum) because of their convenience with the many tendons of the back muscles lying here. They fill the interstices of the tips with mustard-like descending fibers, and are often difficult to distinguish from the tissues which connect with them. Down at the ridge they are much firmer than above, because the beginnings of the muscles increase below, and their chief purpose is undoubtedly to serve as a hump for the muscles in the spaces between those peaks. In addition, they also support the erect position of the trunk, and help it to rise further by its elasticity when it is bent forward. In the cervical vertebrae, where these ligaments are mostly absent, the nuchal ligament (ligamentum nuchae), of which I shall speak in connection with the cervical muscles, takes their place.)
1784	Charles Elliot (ed.)	*A System of Anatomy. From Monro, Winslow, Innes, and the Latest Authors, Vol. I*	ligamentum nuchae, ligamentum colli	human	p. 321: 'Where it [Trapezius, seu Cucullaris] is inseparably united to its fellow in the nape of the neck, it is named *Ligamentum Nuchae* or *Colli*.'
1785	Frederick Treves	*Surgical Applied Anatomy*	none	human	p. 540: 'In all cases there is more or less laceration of the intervertebral discs, the supraspinous, interspinous, and capsular ligaments are torn, as are also the ligamenta subflava.' ††
1786	Johann F. Blumenbach	*Geschichte und Beschreibung der Knochen des menschlichen Körpers (History and Description of the Bones of the Human Body)*	ligamentum suspensorium colli	'quadrupeds'	p. 289: 'Ben manchen vierfuszigen Thieren die fein so starfes ligamentum suspensorium colli haben, das ben andern den vorhangenben Kopf tragen hilft, zeigt sich dagegen eine uberdus sonderbare Eintichtung in den Nacfenwitbeln, deren Korper vorn nach unten einen schuppenformigen Fortsatz bildet, der als Stutze die Last des Kopfs erleichtert.' (In some four-footed animals, which have such a strong ligamentum suspensorium colli, which helps others to support the hanging head, there is, on the other hand, an extremely strange indentation in the nape of the neck, the body of which forms a scaly process in front downwards, which supports the load of the head relieved.)
1788	Philippe Etienne Lafosse	*Lehrbegriff der Pferdearzney. Aus dem Französischen übers. durch Johann Knobloch, Vol. 3 (Teaching concept of horse medicine. Translated from the French. by Johann Knobloch, Vol. 3)*	Nackenband (= ligamentum nuchae)	horse	p. 21–22: 'Ich begreife nicht, wie Herr Bougelat von einem woblgestellten Kopfe eine sentrechte Lage verlangen fann. Diese Stellung ist fehr felten ben Pferden anzutreffen, die sich schon tragen, man findet sie hingegen nur ben solchen, welche den Kopf herunter hangen lassen; denn ben diesen sind die Ausstrectmuteln des Kopfes, wie auch das Nackenband gleichsaht erschlapt, und dann musz der Kopf nothwendig in eine sentrechte Richtung fallen, auf eine andere Art aber ware es nicht moglich.' (I do not understand how M. Bougelat could demand a perpendicular position from a well-positioned head. This position is rarely found on horses that are already carrying themselves, but it is found only on those that let their heads hang down; for with these the stretching straps of the head, as well as the neck band, are exhausted, and then the head must necessarily fall in a perpendicular direction, but it would not be possible in any other way.); p. 113: 'Benn aber die Bunde nach dieser Zeit noch eitert, so ift es ein Zeichen, dasz das Nackenband Schaden gelitten.' (But if the bands still fester after this time, it is a sign that the nuchal ligament has suffered damage.); p. 114: 'Nach dieser Methode heilt die Senickbeule, die man sonst fur so gefahrlich halt, sicher und leicht. Nur dann wird sie gefahrlich, wenn der Eiter hohle Gange macht, das Nackenband angreist, das Hinterhauptsbein anfriszt, das Kapfelband, welches dieses Bein mit dem ersten Halswirbelbeine verbindet, oder das Birbelbein selbst zernagt, und sich in die Hohle des Ruckgrads ergeiszt.' (According to this method, the senile bump, which is otherwise thought to be so dangerous, heals safely and easily. It becomes dangerous only when the pus makes hollow ducts, attacks the nuchal ligament, gnaws the occipital bone, the capsular ligament that connects this leg to the first cervical vertebra, or the pear bone itself, and gnaws itself into the cavity of the dorsal bone.)
1789	Friederich Hildebrandt	*Lehrbuch der Anatomie des Menschen, Vol. 1*	Nackenband (ligamentum nuchae)	human	p. 316: 'Die fascia longitudinalis posterior ist am Halse breiter, die anterior ist dunner und schwmacher, als in der Brust. Die intertransversalia fahlen weist ganz. Uuch die ligg. Intercruralia, und interspinalia, sind am Halse dunner und schwacher. Dagegen ist an den spinis des Halses das lange starte Nackenband (*ligamentum nuchae*) ausgespannt, das von den proterberantia occipitali eterna und der spina externa occipitis anfangt, sich an den zwiefachen Enden der spinarum der Halswirbel befestigt, auf der obern Flache der siehenten spinae sich endigt, und sowohl zur Befestigung des Kopfes, als zur Unlage gemisser Musckeln dient.' (The fascia longitudinalis posterior is broader at the neck, the anterior is thinner and weaker than in the chest. The intertransversalia pale has entirely. Also the ligg. Intercruralia, and interspinalia, are thinner and weaker on the neck. On the other hand, the long neck ligament (ligamentum nuchae) is stretched out on the spinis of the neck, which begins from the proterberantia occipitali eterna and the spina externa occipitis, attaches itself to the double ends of the spinarum of the cervical vertebrae, and ends on the upper surface of the seventh spinae, and serves both to fasten the head and to support missing muscles.)
1792	William Cheselden	*The Anatomy of the Human Body*	linea alba colli	human	p. 84: 'Trapezius arises from the os occipitis, and from a linea alba colli, from the spinal process of the last vertebra of the neck, and the ten uppermost of the back, and from a linea alba between all these processes…'
1795	Johann G. Walter	*Myologisches Handbuch*	ligamentum nuchae, Nackenband	human(?)	p. 19: 'Er befestiget sich an die lineam semicircularem superiorem osfis occipitis (obere halbzirtelformige Linie des Hinterhauptbeins), und an das ligamentum nuchae von der ersten bis zur siebenten vertebra colli (Nackenband vom ersten bis zum

					siebenten Halswurbelbein).' (It [the trapezius] attaches to the lineam semicircularem superiorem osfis occipitis (upper semicircular line of the occipital bone), and to the ligamentum nuchae from the first to the seventh vertebra colli (neck ligament from the first to the seventh cervical bone).); p. 21: 'Befestiget sich an den untern Theil des ligamenti nuchae (Nackenbandes), an den funften, fechsten und siebenten processum spinosum (Grathenfortsatz) der vertebrarum colli (Hals: Wurbelbeine), und an das labium externum baseos scapulae (der auszern Lefze der Grundflache des Schulterblatts), unter dem levatore anguli scapulae (Heber des Schulterblattminfels), bis an die faciem triangularem baseos scapulae (drenminflichte Flache der Grundflache des Schulterblatts).' ([Rhomboideus superior] Attaches to the lower part of the ligamenti nuchae (neck ligament), to the fifth, sixth and seventh processum spinosum (spinal process) of the vertebrarum colli (neck: spinal bones), and to the labium externum baseos scapulae (the outer lips of the base of the shoulder blade), below the levatore anguli scapulae (lifter of the scapula), up to the faciem triangularem baseos scapulae (surface of the base of the scapula).)
1798	Hyacinthe Gavard, Jean Baptist Uytterhoeven, & Alexandre de Broux	*Volledige verhandeling over de botten, volgens de leer van Desault (Complete treatise on the bones, according to the teachings of Desault)*	ligamentum cervicale posterius	human(?)	p. 187: 'By de kinders is hy veel min als by de volwassenen en de gryzaerden uitspringende; hy geeft aen den achtersten nekband, (I) welk een zeer vastgefloten celwyze-weefsel is, geplaetst tusschen de spieren van de eene zyde van het achterste deel van den hals en die van de tegenovergesteide zyde, vasthegting. ((I) Ligamentum cervicale posterius.)' (With the children he is much smaller than with the adults and the gryzards stand out; it gives attachment to the posterior neck ligament, (I) which is a very tight cell-like tissue, placed between the muscles of one side of the posterior part of the neck and those of the opposite side. ((I) Posterior cervical ligament.))
1803	Anthelme Richerand & Robert Kerrison	*Elements of Physiology*	posterior cervical ligament	'quadrupeds'	p. 354: 'The head, therefore, is nearly in equilibrium with the spine that supports it; at least, a smaller degree of power is required to retain it in a natural position; while the head of the quadruped, which is continually inclined towards the earth, presents the necessity of being retained by a cause capable of great and continual resistance. This cause is manifest in the posterior cervical ligament, so remarkable in these animals; it is attached to the spinous apophyses of the vertebrae of the neck, and to the external projection of the occipital bone, more strongly marked in them than in man, in whom the posterior cervical ligament exists by only a simple cellular line, forming an accurate division between both side of the neck.'
1808	M. Cuvier	*Additional memoir upon living and fossil elephants (Philosophical Magazine Ser. 1, v. 30)*	cervical ligament	elephant	pp. 15–16: 'If we next view them laterally, what is very striking is, that the summit of the head is almost round in the African elephant, and that it rises in the Indian elephant into a kind of double pyramid. / This summit answers to the occipital arcade of man and other animals, and is so high in the elephant merely for the purpose of giving to the occipital face of the cranium a sufficient extent for a cervical ligament and occipital muscles, proportionate to the weight of the enormous mass they have to support.'
1809	Bartholomew Parr	*The London Medical Dictionary Vol. I*	ligamentum colli, or nuchae	human	p. 517: 'Where it [the cucullaris muscle] is inseparably united to its fellow in the nape of the neck, it is named *ligamentum colli*, or *nuchae*. (Innes.)
1814	Charles Bell	*A System of Dissections, Explaining the Anatomy of the Human Body, Vol. II*	ligamentum nuchae	human	p. 165: (pertaining to the 'Trapezius or Cucularis'): '1. The protuberance in the middle of the os occipitis, by a thin membranous tendon, which covers part of the splenius and complexus muscles. 2. From the transverse endge of the occiput which extends from the protuberance towards the mastoid process of the temporal bone. 3. From the ligamentum nuchae, where it seems to arise from its fellow. 4. From the spinous processes of the two inferior vertebrae of the neck, and from the spinous processes of all the vertebrae of the back, (adhering to its fellow.)'; p. 168 (pertaining to the 'Splenius'): '1. The four superior spinous processes of the vertebrae of the back. 2. The five inferior of the neck, (adheres to the ligamentum nuchae…'
1819	L.V. Bojanus	*Anatome Testudinis Europaeae*	ligamentum nuchae	turtle	p. 3 (caption for fig. 3b): 'Ubi *ligamentum nuchae* figitur primis ossibus testae marginalibus (cf. Tab. VI. Fig. 17. ubi ligamentum nuchae siglis *b.b.* indicatur.)' (Where the ligament is attached to the first marginal bones of the skull.); p. 4 (caption for fig. 5): 'Ubi *ligamentum nuchae* inseritur (cf. fig. 5b *** et ipsum ligament. Tab. VI. Fig. 17. *bb*)'
1820	Joseph H. Green	*The Dissector's Manual*	cervical ligament (ligamentum nuchae)	human	p. 140: 'Cervical Ligament (ligamentum nuchae). Arises from the perpendicular spine of the occipital bone, descends on the back part of the neck, and adheres to the spinous processes of the cervical vertebrae.'
1825	John Hart	*Description of the Skeleton of the Fossil Deer of Ireland,* Cervus megaceros	cervical ligament	Irish elk	p. 18: 'The spine consists of twenty-six vertebrae, viz. seven cervical, thirteen dorsal, and six lumbar. The size of the cervical vertebrae greatly exceeds that of the other classes, and the spines of the dorsal rise to a foot in height. The necessity of these bones being so marked is obvious, considering the strong cervical ligament, and powerful muscles, required for supporting and moving a head which, at a moderate calculation, must have sustained a weight of three quarters of a hundred of solid bony matter.'
1826	Delabere Blaine	*The Outlines of the Veterinary Art; or, the Principles of Medicine, as Applied to the Structure, Functions, and Oeconomy of the Horse, 3rd Ed.*	ligamentum colli; cervical ligament; fix fax	horse	p. 334: '*r r* the ligamentum colli, cervical ligament, or fix fax of the neck'; p. 337: 'It [the Trapezius] arises posteriorly from several of the spinous processes of the dorsal vertebrae, and blends with the panniculus carnosus, and latissimus dorsi: anteriorly it arises from the ligamentum colli, or cervical ligament, and then runs down in an angular form to be inserted tendinous into the prominent part of the spine of the scapula…'

1830–1831	Richard Owen	On the Anatomy of the Orang Utan (in *Proceedings of the Committee of Science and Correspondence of the Zoological Society of London, Part I*)	ligamentum nuchae	human, orangutan, chimpanzee	p. 29: 'Neither in the *Orang Utan* nor in the *Chimpanzee* is there any true *ligamentum nuchae.* The part commonly so called in the human subject, consisting also in these animals only of the inelastic commissural tendons of the *trapezii*, the *rhomboidei* and the *serrati postici superiores*.'
1832	William Percivall	*The Anatomy of the Horse, Embracing the Structure of the Foot*	cervical ligament	horse	p. 22 (under 'Occipital Bone. (Os Occipitis)'): 'The External Surface is divided by a transverse mark into two portions, a super-occipital and a sub-occipital portion, which were once two separate bones, and presents, 1st . along its median line, and from above downwards, the occipital crest, bounding the cranium posteriorly, and giving attachment to the complexus; below this, the occipital tuberosity, to which is fixed the cervical ligament, with broad, rugged, posterior occipital depressions marked by the attachments of the recti capitis postici; still lower, the occipital hole, transversely oval, and traversed by the spinal marrow and its membranes, the vertebral artery, and accessory and sub- occipital nerves; below and in front of this hole, the basilar process, articulating with the sphenoid bone, whose under surface shews the basilar fissure, triangular and widening in its course to the occipital hole, where it terminates to this process are attached the recti capitis antici.
1836	Henry Brougham & Charles Bell	*Paley's Natural Theology*	pax-wax	'quadrupeds'	pp. 252–253: 'Along each side of the neck of large *quadrupeds* runs a stiff robust cartilage, which butchers call the pax-wax. No person can carve the upper end of a crop of beef without driving his knife against it. It is a tough, strong, tendinous substance, braced from the head to the middle of the back; its office is to assist in supporting the weight of the head. It is a mechanical provision, of which this is the undisputed use; and it is sufficient, and not more than sufficient for the purpose which it has to execute. The head of an ox or a horse is a heavy weight, acting at the end of a long lever (consequently with a great purchase,) and in a direction nearly perpendicular to the joints of the supporting neck. From such a force, so advantageously applied, the bones of the neck would be in constant danger of dislocation, if they were not fortified by this strong tape. No such organ is found in the human subject, because, from the erect position of the head (the pressure of it acting nearly in the direction of the spine,) the junction of the vertebrae appears to be sufficiently secure without it.'
1836	Julius Heilenbeck	*De Musculis Dorsi et Cervicis Comparatis*	ligamentum nuchae	human	p. 18: 'Praeparandi methodus, quam in musculo nostro indagando secuti sumus, haec est: cute supra processibus spinosis inscisa et ad utrumque latus retracta musculus cucullaris praeparatur, in medio spinarum et scapulae inscisione longitudinali scinditur et ad utrumque latus reflectitur. Mm. rhomboideis, serrato postico superiori, splenioque capitis et colli eadem ratione apatis ligamentum nuchae spinis infixum videmus. Restant M.M. complexus et biventer cervicis, qui aut extrinsecus retrahendi aut in insertionis loco resecandi sunt. Quo facto magna sollertia m. semispinalis cervicis a carne versus tendines praeparandus telaque cellulosa ex angulo inter ligamentum nuchae musculumque semispinalem eliminanda est.' (The preparation method we followed in our muscle research is this: the hooded muscle is prepared by incising the skin above the spinous processes and retracting it on both sides, it is split in the middle of the spine and the scapula with a longitudinal incision and it is reflected on both sides. Mm. rhomboids, serratus posterior superior, and the splenium of the head and neck in the same way we see the apatus ligament embedded in the nuchal spine. The remaining complexus and biventer cervicis, which must either be retracted externally or cut off at the point of insertion. When this was done, the great skill of the semispinalis cervicis is to be prepared from the flesh towards the tendons, and the cellular tissue is to be eliminated from the angle between the nuchal ligament and the semispinal muscle.); p. 20: 'In utroque latere tendinosus oritur a ligamente nuchae supra sextam colli vertebram, mox in carnem abiens in utroque latere adscendit et secundae vertebrae inseritur.' (On each side, the tendon arises from the nuchal ligament above the sixth vertebra of the neck.); etc.
1839	Joseph Beraz	*Lehrbuch der Anatomie des Menschen*	ligamentum nuchae	human	p. 60: 'Die Querfortsatze werden durch Bander verbunden, welche zwischen ihnen liegen (ligamenta intertransversalia). In den Brustwirbeln sind sie nur schmal, und verschwinden an den Halswirbeln ganz. Zwischen den Dornfortsatzen liegen ebenfalls Bander (ligamenta interspinalia), die an den autzersten Zpitzen etwas verstartt find, und als Spitzenbander (ligamenta apicum) bejonders unterschieden werden. Un den Spizen der Halswirbel findet sich statt ihnen das Nadenband (ligamentum nuchae), welches vom duszern Hinterhauptshoder und der Leiste unter ihm herablommt.' (The transverse processes are connected by ligaments that lie between them (ligamenta intertransversalia). They are narrow in the thoracic vertebrae and disappear entirely in the cervical vertebrae. There are also ligaments (ligamenta interspinalia) between the spinous processes, which are somewhat stiffened at the outermost tips, and are particularly distinguished as apical ligaments (ligamenta apicum). At the tips of the cervical vertebrae, instead of them, there is the neck ligament (ligamentum nuchae), which descends from the central occiput and the groin below it.) ¶
1839	Richard Owen	*Notes on the Anatomy of the Nubian Giraffe (Transactions of the*	pax-wax; ligamentum nuchae	giraffe	p. 233: 'The *trapezius* consists of two pretty distinct portions: one arises from the transverse processes of the fifth and sixth cervical vertebrae; its fleshy part is thick and strong, but expands as it passes downwards and backwards, and finally is lost in a strong fascia overspreading the large shoulder-joint. The second portion is thin and broad; it arises from the *ligamentum nuchae*, and is inserted

		Zoological Society of London 2(3))			into the *fascia* covering the *scapula*.'; p. 234: 'The development of elastic ligament is truly extraordinary in the *Giraffe*, as exemplified in the pax-wax or *ligamentum nuchae*. This mechanical stay and support of the long neck and of the head commences from the sacral *vertebrae*, and receives fresh accessions from each lumbar and dorsal vertebra as it advances forwards; the spines of the anterior dorsal *vertebrae* becom [sic] greatly elongated to afford additional surface for the attachment of new portions of the ligament, which appears to be inserted, on a superficial dissection, in one continuous sheet into the longitudinally extended but not elevated spinous processes of the cervical *vertebrae*, as far as the *axis*: the *atlas*, as usual, is left free for the rotatory movements of the head; the termination of the ligament passes over that vertebra to terminate by an expanded insertion into the occipital crest. It consists throughout of two bilateral moieties.'
1841	Hans Barkow	*Syndesmologie*	ligamentum nuchae	human	p. 16: 'Die allgemeineren Bander des hinteren Theiles der Wirbelsaule sind die *ligamenta capsularia processuum obliquorum*, die*ligamenta intercruralia*, *ligamenta interspinalia*, das *ligamentum nuchae*, das *ligamentum longitudinale posterius columnae spinalis* und die *ligamenta intertransveralia*.' (The more general ligaments of the posterior part of the spine are the ligamenta capsularia processuum obliquorum, the ligamenta intercruralia, ligamenta interspinalia, the ligamentum nuchae, the ligamentum longitudinale posterius columnae spinalis and the ligamenta intertransveralia.)
1841	Delabere Blaine	*Outlines of the Veterinary Art, 5th Ed.*	cervical ligament; ligamentum colli	horse	p. 195: 'The *cervical ligament*, or *ligamentum colli*, is a very strong substance, of a rope-like form, placed between the lons a support to the head. The muscles of the neck are very strong : but muscles, if constantly kept in action, tire; Nature has, therefore, given a substance that has great strength, without being liable to fatigue, by which the head remains permanently supported. This substance differs from ligament, in some respects, by being elastic, and thus the motions of the head are much accelerated. It is strongly attached, by its anterior extremity, to the posterior part of the occipital bone; passing over the first cervical vertebra, without attaching itself to it, but being intimately connected with the spinous processes of the second, third, and fourth; the stronger portion of it here passes forward to reach the spinous processes of the dorsal, but it sends down a kind of double lamen of ligament, to unite with the rest of the cervical bones.'
1843	Rudolph Wagner	*Lehrbuch der Zootomie. Erster Theil. Anatomie der Wirbelthiere. (Textbook of Zootomy. Vol 1. Anatomy of the Vertebrates)*	Nackenbande (ligamentum nuchae)	'animals with large heads'	p. 33: 'Ueberall richtet sich die Musculatur bei den einzelnen Ordnungen nach der Bildung des Skelets und der ganzen Oekonomie des Thiers. Bei den Fleischfressern sind die Kaumuskeln mit dem Schläfemuskel sehr entwickelt und füllen als grosses Fleischpolster den ganzen Raumzwischen dem grossen Jochbogen und dem Schädel aus, auf dessen oberer Fläche sie fast zusammenfliessen. Die Rücken-, besonders die Nackenmuskeln sind sehr stark besonders bei den Thieren mit grossen Köpfen, welche oft noch Hörner und Geweihe tragen. Sie entspringen hier vom Widerrust, den sehr hohen Dornfortsätzen der vorderen Rückenwirbel und dem Nackenbande (ligamentum nuchae), welches sich an das Hinterhaupt ansetzt. Bei der Giraffe entspringt das Nackenband schon von den Sacralwirbeln.' (Everywhere the musculature of the individual orders depends on the formation of the skeleton and the entire economy of the animal. In carnivores, the chewing muscles are very developed together with the temporalis muscle and, as a large cushion of flesh, fill the entire space between the large zygomatic arch and the skull, on the upper surface of which they almost flow together. The back muscles, especially the neck muscles, are very strong, especially in animals with large heads, which often also have horns and antlers. Here they arise from the withers, the very high spinous processes of the front vertebrae and the nuchal ligament (ligamentum nuchae), which attaches to the occiput. In the giraffe, the neck band originates already from the sacral vertebrae.)
1845	J. Pétrequin	*Lehrbuch der medicinisch–chirurgischen und topographischen Anatomie (Textbook of Medical–Surgical and Topographical Anatomy)*	Nackenband (= nuchal ligament?)	human	p. 18: 'Die zellig-fibrose Scheide umkleidet alle Musklen; sie ist ausgesprochener am Rucken und an den Lenden, als am Halse, wo man sie nicht vom M. trapezius (Kappenmuskel) zu trennen vermag. In der Mittellinie des Nackens gehy sie in das oberflachliche Nackenband uber.' (The cellular-fibrous sheath covers all muscles; it is more pronounced on the back and loins than on the neck, where it cannot be separated from the trapezius (cap muscle). In the midline of the nape it merges into the superficial nuchal ligament.)
1846	N. Joly and A. Lavocat	*Recherches Historiques, Zoologiques, Anatomiques et Paléontologiques sur la Girafe, (*Camelopardalis giraffa*, Gmelin)*	cervical ligament	giraffe	p. 73–74: 'Quant aux apophyses épineuses, elles se font remarquer par un développement considérable, et tout à fait en rapport avec la longueur du cou de l'animal. Leur extrémité libre se renfle beaucoup, surtout dans les six ou sept premières, afin de donner de plus nombreux joints d'attache au large et robuste ligament cervical, que nous décrirons bientôt. Toutes ces apophyses sont, d'ailleurs, légèrement inclinées en arrière, et diminuent de longueur en avant et en arrière à partir de la quatrième.' (As for the spinous processes [of the dorsal vertebrae], they are remarkable for their considerable development, and quite in keeping with the length of the animal's neck. Their free extremity bulges out much, especially in the first six or seven, in order to give more numerous joints of attachment to the broad and robust cervical ligament, which we shall soon describe. All these apophyses are, moreover, slightly inclined backwards, and diminish in length forwards and backwards from the fourth.); p. 94: 'Fixé par son aponéurose d'origine sur la partie inférieure du ligament cervical et du splénius, il s'insère à la partie antérieure du cartilage de

					l'omoplate, sur les faces externe et interne.' (Fixed by its aponeurosis of origin on the lower part of the cervical ligament and the splenius, it [the rhomboideus] is inserted into the anterior part of the cartilage of the scapula, on the external and internal sides.) ¶¶
1849	Person Ferguson	*Efficacy and method of employing chloroform in veterinary practice (The Lancet, 54(1353))*	ligamentum colli	horse	p. 123: 'He continued to inhale it for about fifteen minutes, by which time, he broke into a sweat, and his head was raised to the level of his back, that being just the height at which the elastic 'ligamentum colli' will support it, unaided by muscular action.'
1853	Richard G.H. Butcher	*On dislocation of the cervical vertebrae, without fracture. (Dublin Quarterly Journal of Medical Science 15(2))*	ligamentum nuchae	human	p. 386: 'The supraspinous ligament, derived from the ligamentum nuchae, was torn through between the fifth and sixth cervical vertebrae, as well as the muscular fibres in the same locality, filling the offices of interspinous ligament...'
1854	Richard Owen	*The Principal Forms of the Skeleton and of the Teeth*	nuchal ligament	mole, giraffe	pp. 16: 'Strong membranes, called 'aponeurotic,' and certain leaders or tendons, become bony in some animals; as, e.g., the 'tentorium' in the cat, the temporal fascia in the turtle, the leaders of the leg-muscles in the turkey, the nuchal ligament in the mole, Fig. 41, u, and certain tendons of the abdominal muscles of the kangaroo, which, so ossified, are called the 'marsupial bones,' Fig. 44.'; pp. 195–196: 'The part answering to the nuchal ligament in the giraffe is bony in the mole, u.'
1857	George H. Dadd	*The Anatomy and Physiology of the Horse*	ligamentum nuchae	horse	pp. 79–80: 'There are various ways of removing the skin : the author prefers to commence on the back, and dissect off towards the feet. Supposing the subject to lie on the off-side, we commence an incision at the anterior part of the nasal region, and continue the same upward until we arrive at the occiput; we then incline the scalpel from the superior part of the neck, in order to avoid the mane, and continue the incision along the lateral part of the dorso lumbar spines until the coccyx is reached; the overlapping portion can then be dissected, and turned over to the off-side, so as to expose the tendinous insertions of the panniculus [carnosus muscle] into the ligamentum nuchae, etc., etc.'
1858	Henry Gray	*Anatomy: Descriptive and Surgical*	ligamentum nuchae	human	pp. 20, 203, 218, 220 'The *Ligamentum Nuchae*...is a thin band of condensed cellulo-fibrous membrane, placed in the line of union between the two Trapezii in the neck. It extends from the external occipital protuberance to the spinous process of the seventh cervical vertebra, where it is continuous with the supra-spinous ligament. From its anterior surface a fibrous slip is given off to the spinous processes of each of the cervical vertebra, excepting the atlas, so as to form a septum between the muscles on each side of the neck. In the human subject, it is merely the rudiment of an important elastic ligament, which serves to sustain the weight of the head in some of the lower animals.'
1862	John Gamgee & James Law	*General and Descriptive Anatomy of the Domestic Animals Vol. I, Pt. II*	ligamentum nuchae; cervical ligament	horse, pig	p. 247: 'The *supra-spinous ligament* extends along the summits of the spinous processes of the vertebrae from the sacrum to the occiput. It may be divided into two portions : a *posterior*, or *dorso -lumbar*, and an *anterior*, or cervical, the latter being that described by authors as the ligamentum nuchae.'; p. 248: 'The *cervical portion*, or *ligamentum nuchae*, is composed of yellow elastic tissue, constituting an elastic apparatus, which separates the cervical muscles of the right side from those of the left, and maintains the head in its natural position with little assistances from the muscles, consequently without inducing fatigue. / It is divisible into a funicular and a lamellar portion...' p. 253: 'In the *pig* no proper cervical ligament exists, its short and comparatively immoveable neck being supported by muscles only. There may, however, be noticed a superficial fibrous raphe extending from the first dorsal spine as far as the occiput.'
1866	Henry Wheatley	*A Dictionary of Reduplicated Words*	fax-wax, ligamentum nucha	'quadrupeds'	p. 27: 'FAX-WAX, sb. 'ligamentum nucha.' The strong ligament from the neck, proceeding from one spinous process to another, and inserted into the occipital bone. It is thus called in quadrupeds . See also fick-fack, fig-fag, fix-fax, pack-wack, pax-wax, pease-wease, tax-wax.'
1866	J.H. Walsh	*The Horse, in the Stable and the Field*	ligamentum colli, great cervical ligament, ligamentum nuchae	horse	p. 356–357: 'The Ligamentum Colli, or great cervical ligament, is intended to relieve the muscles of the neck in supporting the head by its natural or inherent elasticity. It is entirely formed of yellow elastic tissue, and occupies the angle formed posteriorly by the anterior dorsal spines, and inferiorly by the cervical spinous processes, thus separating the cervical muscles of the right side from those of the left. It is divided into two parts—a funicular and lamellary portion. The first, designated under the name of the cord of the cervical ligament, is represented by a large band, which extends immediately from the dorsal spinous processes to the top of the head, divided into two lateral lips by a mesian line. The cord is connected posteriorly with the supra-spinous ligament, and is inserted anteriorly into the scabrous pit, situated just below the crest of the occiput. It is covered superiorly by a mass of thick adipo-fibrous tissue, much developed in low-bred animals. Inferiorly it gives off the lamellary portion, which is composed of two muscles, and give off six tongues or slips, which unite with the spines of the six posterior cervical vertebrae, mixing with the fibres of the interspinous ligaments.'; p. 615 (index): 'Ligamentum colli (or nuchae).'
1866	William Youatt & Walker Watson	*The Horse: With a Treatise on Draught*	ligamentum colli	horse	p. 149: 'There are, however, some admirable contrivances connected with the arrangements of the *ligamentum colli*. As it proceeds from the head, it is in the form of a round cord. It is connected with the *atlas*, or first bone of the neck, and then, attaching itself strongly to the second bone, principally supports the head by its union with this bone. The mechanical disadvantage is increased; but

					the head is turned more freely on the first and second bones. The principal stress is on the *dentata*, or second bone, so much so, that, in poll-evil, this ligament may be divided without serious inconvenience to the horse. It then suddenly sinks deeper, and communicates with all the other vertebrae. Each of these communications becomes a separate point of support, and as they approach nearer to the base, the mechanical disadvantage, or the force with which the weight of the head and neck presses and acts, is materially lessened. The head, then, while the animal is in a state of rest, is supported by this ligament, without any aid from muscular energy...The ligament of the neck is inserted into the centre of the back part of the occipital bone, and immediately below the vertex or crest of the bone; and therefore the bone is so thick at this part.'
1868	Richard Owen	*On the Anatomy of Vertebrates, Vol. III: Mammals*	nuchal ligament, ligamentum nuchae	mole, horse, ox, giraffe, camel, elephant, rhinoceros	p. 17 (mole): 'The muscles of the scapula are singularly developed and modified: the trapezius operates upon the short base of the elongate bone with great advantage. The anterior portion, *d*, arising from the occiput, derives further strength from the ossified 'nuchal ligament,' and is inserted at *e* : the part answering to the posterior fibres of the muscle, *f*, arises as far back as the lumbar vertebrae to be similarly inserted into the base of the scapula, antagonising the former.'; p. 28 (horse): 'fig. 11 . The 'spinalis dorsi' repeats closely the characters of that muscle in Man. Its continuation, the 'spinalis cervicis,' is in the Horse of great strength and importance: its origin commences from the second dorsal spine, which origin is continued for about one-third of the way down that spine toward its root: it arises likewise from the third dorsal spine and the ligamentum nuchae; from these origins it runs forward to be implanted by strong and distinct ten dons into the spines of the anterior cervical vertebra.'; pp. 29–31 (horse); p. 42 (ox & giraffe): 'The 'trapezius,' fig. 18, 10, 11, answers to the scapular division of that muscle in Man; it arises in the Ox from the neural spines of the anterior half of the thorax, and from the 'ligamentum nuchae.' In the Giraffe it is in two portions : one arises from the transverse processes of the fifth and sixth cervical vertebrae, its fleshy part is thick and strong but expands as it passes down ward and backward and finally is lost in a strong fascia over spreading the shoulder -joint; the second portion is thin and broad, arises from the ligamentum nuchae, and is inserted into the fascia covering the scapula.'; p.48–9 (camel): 'In the Camel the ligamentum nuchae arises, broad and thin, from the anterior dorsal spines, but gathers substance as it advances and becomes condensed into a pair of cords which receive accessions from the cervical spines, by which the ligaments seem bound down so as to follow the curve of the neck: the insertions are into the superoccipital. Posteriorly a continuation of the ligament may be traced spreading out and losing itself in the base of the single hump of the Dromedary, and as far back as that of the hind hump in the Camel.'; p. 49 (elephant): 'The relative size and insertions (*a* cervical, *b* nuchal) of the ligamentum nuchae of the Elephant are shown in fig. 22. Much of the same kind of yellow elastic tissue is combined with the aponeuroses of the abdominal muscles in the Elephant, Rhinoceros, and Giraffe, in reference to the capacity and heavy contents of parts of the alimentary canal.'
1889	Joseph Leidy	*An Elementary Treatise on Human Anatomy*	nuchal ligament	human, 'quadrupeds'	pp. 75–76: 'The nuchal ligament forms a median, triangular, membranous partition between the muscles at the back of the neck. Below it is continuous with the supraspinous ligament, and extends between the ends of the spinous processes of the cervical vertebrae and the occipital crest and protuberance. It is a loose intertexture of bundles of fibro-connective tissue with elastic tissue. The bundles, for the most part, start from the end of the prominent spinous process of the last cervical vertebra, and thence proceed in a radiant manner to the ends of the spinous processes above and to the occipital crest and protuberance. The bundles to the latter are longitudinal and form the thickened border of the ligament. In quadrupeds the nuchal ligament is composed of elastic tissue, and is adapted to sustain the skull, which in such animals is suspended from the spine. In those with a large head, sometimes loaded with heavy appendages, as in the stag with its antlers and the elephant with its huge tusks, it forms a powerful and most efficient instrument in supporting the weight and in removing all strain from the muscles. The supraspinous ligament[1] is a narrow and not very distinct. cord, composed of longitudinal bundles of fibres connecting the summits of the spinous processes, and extending continuously from the last cervical vertebra to the sacrum. ([1]L. supraspinale; 1. longitudinale posterius; 1. apicum)'
1890	Auguste Chauveau and Saturnin Arloing	*The Comparative Anatomy of the Domesticated Animals, 2nd Ed.*	superspinous cervical ligament, cervical ligament, ligamentum nuchae, ligamenta subflava	human, 'quadrupeds' (especially horse)	pp. 132–133: 'In the cervical ligament there is distinguished a *funicular* and a *lamellar* portion. The first, usually called the *cord* of the cervical ligament, is a wide funiculus which extends directly from the first dorsal spinous processes to the summit of the head. Divided into two lateral lips by a median groove, this cord is continued posteriorly with the dorso-lumbar ligament, and is inserted forwards into the cervical tuberosity of the occipital bone. It is covered above by a mass of fibro-adipose tissue which, in certain commonbred horses, is very abundant. Below, it gives rise, in its posterior two-thirds, to the majority of the fibres belonging to the lamellar portion. On the sides, it receives the insertions of several cervical muscles. The *lamellar portion*, comprised between the funicular portion, the spinous processes of the second dorsal vertebrae, and the cervical stalk, constitutes a vast triangular and vertical septum, which itself results from the apposition of the two lamellae which lie back to back, and are united by cellular tissue ; they are bordered above by the two lateral lips of the cord. The elastic fibres which enter into their composition are given off either from the latter, or from the spinous processes of the second and third dorsal vertebrae ; they are directed downwards or forwards, and reach the spinous processes of the last six cervical vertebrae, into which they are inserted by so many digitations, becoming confounded with the interspinous ligaments of the neck. The fibres of the two last digitations are few in number, widely separated from one another, and united by many anastomosing branches, which make them appear as a kind of wide network. The 1amallae

					of the cervical ligament are in relation, outwardly, with the superior branch of the ilio-spinal ligament, the transverse spinous muscle of the neck, and the great complexus. / (This important structure, which is in reality the mechanical stay and support of the heavy head and neck of quadrupeds, and is usually termed the *ligamentum nuchae*, is all but absent in Man, being represented in him by a thin narrow band, or rather two thin planes of fibres, the *ligamenta subflava*. It is described by Leyh as if there were not two portions, and that excellent anatomist does not appear to insist sufficiently on the difference between the dorso-nuchal and the dorso-lumbar divisions. Percivall, who almost entirely neglects the ligaments, also makes no distinction. The difference in structure, elasticity, and situation, warrants the distinction made by Chauveau. As already indicated, the function· of this ligament, and more particularly of its nuchal division, is to maintain the head and neck in their natural position during repose, and to allow the most extensive movements at other times.)"
1895	Wilhelm His	*Die Anatomische Nomenclatur: Nomina Anatomica*	ligamentum nuchae	human	p. 40: (under heading 'Ligamenta columnae vertebralis et cranii') 'Lig. nuchae'

† This reference marks the earliest attempt found to name the supraspinous ligament (as 'Funiculi ligamentosi'). However, the structure is described as early as the 16th and early 17th centuries (Vesalius, 1543; Platter, 1603; Bauhin & de Bry, 1605).
†† This reference marks the earliest use found of the term 'supraspinous ligament'; q.v., Gavard et al. (1798). Alternative terms, such as 'ligamentum longitudinale posterius' (or 'ligamentum posterius longitudinale') also do not seem to date prior to the late 1700s (Hildebrandt, 1798); also 'ligamentum apicum' (Mayer, 1783; Blumenbach, 1786; Vetter, 1788; Hildebrandt, 1789).
¶ This reference also restricts the term 'colli' (as it pertains to ligaments) to 'ligamentum colli costarum internum' and 'ligamentum colli costarum externum' (p. 65); the use herein of 'ligamentum nuchae,' rather than 'ligamentum colli,' may have been in part to distinguish that structure from the costal ligaments. (q.v., Barkow, 1841: p. 30).
¶¶ This reference (q.v., Gamgee & Law, 1862; Walsh, 1868) appears to mark the beginning of the 'last gasps' of the use of 'ligamentum cervicale/cervical ligament' for the nuchal ligament. Around this time, the term 'cervical ligament' also begins to be used in relation to the femur (e.g., Smith, 1850; Mussey, 1857). Periodic appearances of 'cervical ligament' persist into the early 20th century (e.g., Ballou, 1907), but 'nuchal ligament' largely appears to be standard after His (1895).

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<u>Table 2:</u> Tetrapod Taxa Reported to Have, or Have Had, a Nuchal Ligament

'Assumed' means that the presence of a nuchal ligament (NL) was not documented via detailed description and/or graphical or photographic evidence; the presence of the ligament simply was mentioned in an 'offhand' manner. 'Documented' means that the presence of a NL was documented via detailed description and/or graphical or photographic evidence, typically via first-hand dissection. Many mentions of a NL are of unclear origin: dissection was strongly implied, but a NL was not formally documented. † = extinct taxon.

Higher-Level Taxon	Lower-Level Taxa	Reference(s)	Assumed	Docu-mented	Notes
Tetrapoda (non-synapsid and non-sauropsid)	Temnospondyli†: Dissorophoidea†: Dissorophidae†: Eucacopinae† (*Anakamacops*†)	Liu (2018)	✓		Mentioned as inserting on smooth, concave surface on exoccipital dorsolateral to occipital condyle
	Diadectomorpha† (no species specified†)	Sumida (1997)	✓		Mentioned in relation to enlarged spinous process on axis
Synapsida (non-mammaliamorph)	Eupelycosauria†: Sphenacodontidae† (*Dimetrodon*†)	Olson (1936)	✓		Mentioned in relation to thoracic spine size
	Eupelycosauria†: Ophiacodontidae† (*Archaeothyris*†)	Reisz (1971)	✓		Mentioned as inserting on a caudal projection of the parietals
	Therapsida: Dinocephalia†: Tapinocephalidae† (*Moschops*† and other species†)	Barghusen (1975)	✓		Mentioned in relation to expanded occiput size
	Therapsida: Anomodontia†: Dicynodontia†: Kannemeyeriidae† (*Kannemeyeria*†)	Renaut (2000)	✓		Mentioned as inserting on the occiput
	Therapsida: Anomodontia†: Dicynodontia†: Kingoriidae† (*Dicynodontoides* [*Kingoria*]†)	Cox (1959)	✓		Illustrated as inserting at the dorsal end of the nuchal crest
	Therapsida: Anomodontia†: Dicynodontia†: Shansiodontidae† (*Tetragonias*†)	Cruickshank (1967)	✓		Mentioned in relation to skull size and, indirectly, occipital region morphology

	Therapsida: Anomodontia†: Dicynodontia† (various species†)	Surkov & Benton (2008)	✓		Mentioned as inserting on caudal outgrowth of interparietal and parietals (esp. in large-headed Triassic taxa)
	Therapsida: Cynodontia: Charassognathidae† (*Nshimbodon*†)	Huttenlocker & Sidor (2020)	✓		Mentioned as inserting on nuchal line of occipital
	Therapsida: Cynodontia: Dviniidae† (*Dvinia*†)	Ivankhnenko (2013)	✓		Mentioned in relation to lambdoid suture
	Therapsida: Cynodontia: Eucynodontia: Probainognathia: Tritylodontidae† (*Kayentatherium*†)	Sues & Jenkins (2006)	✓		Mentioned in relation to tall cranial thoracic spinous processes
Therapsida: Mammaliamorpha: Mammalia: Monotremata	Tachyglossidae (*Tachyglossus*)	Gambaryan et al. (2015) (q.v., Howell [1937])		✓	Called 'nuchal ligament' but parenthetically: 'shaped as a sagittal fascia giving rise to the *m. semispinalis capitis* and the *m. splenius*'—almost certainly not a true nuchal ligament
Therapsida: Mammaliamorpha: Mammalia: Theria (non-marsupial and non-placental)	Eutheria: Cimolesta†: Pantolestidae† (*Palaeosinopa*†)	Rose & von Koenigswald (2005)	✓		Mentioned in relation to taphonomic pose of body (contraction of the nuchal ligaments [plural])—almost certainly not intended to convey homology
	Eutheria: Cimolesta†: Coryphodontidae† (*Coryphodon*†)	Osborn (1898)	✓		Mentioned in relation to low spines on cervical vertebrae and shapes of distal spinous processes on cranial thoracic vertebrae
Therapsida: Mammaliamorpha: Mammalia: Marsupialia	Australidelphia: Diprotodontia: Phalangerida: Phalangeridae (*Trichosurus*)	Barbour (1963)	✓		Mentioned as origination point for *m. trapezius*

	Australidelphia: Diprotodontia: Macropodiformes: Balbaridae† (*Nambaroo*†)	Kear et al. (2007)	✓		Mentioned as possibly associated with tall cervical spinous processes
	Australidelphia: Diprotodontia: Macropodiformes: Balbaridae† (no species specified)	Den Boer (2018)	✓		Mentioned as associated with enlarged vertebral canal in the cervical vertebrae
	Australidelphia: Diprotodontia: Macropodiformes: Macropodidae (*Macropus*)	Ohara (1943); Kato & Hopwood (1993)	✓		Mentioned as insertion point for *m. rhomboideus* (Kato & Hopwood); mentioned as collagenous and poorly developed (Ohara)
	Australidelphia: Diprotodontia: Macropodiformes: Macropodidae (*Protemnodon*†)	Den Boer (2018)	✓		Mentioned as associated with enlarged vertebral canal in the cervical vertebrae
	Australidelphia: Dasyuromorphia: Dasyuridae (*Sarcophilus*)	Macalister (1870)	✓		Mentioned as origination point for *m. trapezius*
	Australidelphia: Dasyuromorphia: Thylacinidae† (*Thylacinus*†)	Rabovsky et al. (2015)	✓		Mentioned in relation to opisthotonic posture of some specimens
	Ameridelphia: Paucituberculata: Caenolestidae (*Caenolestes*)	Osgood (1921)	✓		Mentioned as lying between the halves of the *m. semispinalis cervicis*
	Ameridelphia: Didelphimorphia: Didelphidae (*Didelphis*)	Nishi (1919); Minkoff et al. (1979)	✓		Mentioned as origin point for *m. splenius* (Nishi); mentioned as a structure joined to a 'tendinous median raphe' that is an origin point for *m. platysma* (Minkoff et al.)
Therapsida: Mammaliamorpha: Mammalia: Placentalia	Arctocyonia†: Arctocyonidae† (*Arctocyon*†)	Argot (2012)	✓		Mentioned in relation to enlarged spinous process of axis, specifically as

					interpreted in *Pachyaena*
	Desmostylia†: Desmostylidae† (*Cornwallius*)	Beatty (2009) (q.v., Domning [2002])	✓		Mentioned as inserting into depression on occipital (Domning discusses it in relation to the size of the cranial thoracic spinous processes)
	Xenarthra: Cingulata: Dasypodidae: Dasypodinae (*Dasypodus*)	Uekermann (1912)	✓		Mentioned as origin point for *mm. platysma* and *auriculo-occipitalis*
	Xenarthra: Folivora (various ground sloth species†)	Tambusso et al. (2018)	✓		Mentioned in relation to fused spinous processes of first and second thoracic vertebrae
	Xenarthra: Folivora (*Thalassocnus*†)	Amson et al. (2015)	✓		Mentioned as likely reduced because of aquatic habits
	Afrotheria: Afroinsectivora: Macroscelidea: Macroscelididae (*Rhynchocyon*)	Wortman (1920)	✓		Mentioned in relation to nuchal processes on skull
	Afrotheria: Tubulidentata: Orycteropodidae (*Orycteropus*)	Sonntag (1925)	✓		Mentioned as origination point for *m. trapezius*
	Afrotheria: Hyracoidea: Pliohyracidae† (*Seggeurius*†)	Benoit et al. (2015)	✓		Mentioned in relation to configuration of crests on the occiput
	Afrotheria: Proboscidea: Gomphotheriidae† (*Platybelodon*†)	Wang et al. (2013)	✓		Mentioned in relation to nuchal fossa on skull
	Afrotheria: Proboscidea: Gomphotheriidae† (*Stegomastodon*†)	Alberdi et al. (2009)	✓		Mentioned in relation to nuchal fossae and processes on skull
	Afrotheria: Proboscidea: Deinotheriidae† (*Deinotherium*†)	Konidaris & Koufos (2018)	✓		Mentioned in relation to nuchal fossae on skull
	Afrotheria: Proboscidea: Deinotheriidae† (*Prodeinotherium*†)	Harris (1973)	✓		Mentioned in relation to triangular pits on supraoccipital

	Afrotheria: Proboscidea: Elephantidae (*Elephas* and *Loxodonta*)	Mullen (1682); Blair (1710–1712); Owen (1868); Miall & Greenwood (1878); Mariappa (1986); Bianchi (1989)		✓	Documented by multiple direct observations and dissections
	Afrotheria: Sirenia: Prorastomidae† (*Pezosiren*†)	Domning (2001)	✓		Mentioned in relation to tall spinous processes on cranial thoracic vertebrae
	Afrotheria: Sirenia: Protosirenidae† (*Protosiren*†)	Domning & Gingerich (1994)	✓		Mentioned in relation to tall spinous processes on cranial thoracic vertebrae
	Euarchontoglires: Euarchonta: Scandentia (*Ptilocercus*)	Sargis (2001)	✓		Mentioned as inserting on spinous process of axis along with *m. rectus capitis posterior major*
	Euarchontoglires: Euarchonta: Primates: Haplorhini: Simiiformes: Platyrrhini: Atelidae (*Alouatta*)	Miranda et al. (2022)	✓		Mentioned as origin for *m. rhomboideus thoracis* and *m. trapezius*
	Euarchontoglires: Euarchonta: Primates: Haplorhini: Simiiformes: Platyrrhini: Callitrichidae (*Callithrix*)	Ohara (1943)	✓		Mentioned as strongly developed as elastic via histology
	Euarchontoglires: Euarchonta: Primates: Haplorhini: Simiiformes: Platyrrhini (*Oedipomidas*, *Saimiri*, *Aotus*, *Cebus*, *Ateles*, *Lagothrix*)	Campbell (1937)	✓		Mentioned as origin for *m. rhomboideus*
	Euarchontoglires: Euarchonta: Primates: Haplorhini: Simiiformes: Cercopithecidae (*Macaca*)	Patterson (1942); Castelyn & Bakker (2021)	✓		Mentioned as spanning the occipital and spinous process of the third thoracic vertebra; also as origin/insertion for various epaxial muscles

	Euarchontoglires: Euarchonta: Primates: Haplorhini: Simiiformes: Cercopithecidae (*Rhinopithecus*)	Patterson (1942)	✓		Mentioned as origin for *mm. trapezius* and *rhomboideus*
	Euarchontoglires: Euarchonta: Primates: Haplorhini: Simiiformes: Catarrhini: Hominoidea: Hylobatidae (*Hylobates*, *Symphalangus*)	Diogo et al. (2012a)	✓		Mentioned in relation to *m. trapezius*; noted that some authors report it as 'poorly developed'
	Euarchontoglires: Euarchonta: Primates: Haplorhini: Simiiformes: Catarrhini: Hominoidea: Hominidae: Homininae: (*Sahelanthropus*†)	Wolpoff et al. (2006)	✓		Mentioned as inserting into a significant tuberculum linearum at the center of the superior nuchal line
	Euarchontoglires: Euarchonta: Primates: Haplorhini: Simiiformes: Catarrhini: Hominoidea: Hominidae: Homininae: Hominini: (*Australopithecus*†)	Leakey et al. (1971)	✓		Mentioned as inserting into a tubercle on the external occipital protuberance
	Euarchontoglires: Euarchonta: Primates: Haplorhini: Simiiformes: Catarrhini: Hominoidea: Hominidae: Homininae: Hominini (*Pan*)	Virchow (1909); Hofer (1974)	✓		Mentioned by Hofer in relation to insertion point on the external occipital protuberance
	Euarchontoglires: Euarchonta: Primates: Haplorhini: Simiiformes: Catarrhini: Hominoidea: Hominidae: Homininae: Hominini: Hominina (*Homo*)	Gray (1858); Fielding et al. (1976); Mercer & Bogduk (2003); Netter (2018)		✓	Well documented by numerous authors, particularly in anatomy textbooks
	Euarchontoglires: Glires: Lagomorpha: Leporidae (various species)	Craigie (1969); Seckel & Janis (2008)	✓		Mentioned as source of concentration of yellow elastic fibers as well as origin for *mm. trapezius*, *rhomboideus minor*, *splenius*, and *serratus posterior* (Craigie); mentioned as a 'dorsal medial line'

					as an origin point for *m. acromiotrapezius* (Seckel & Janis)
	Euarchontoglires: Glires: Rodentia: Cricetidae: Sigmodontinae: Ichthyomyini	Salazar-Bravo et al. (2013)	✓		Mentioned as inserting on spinous process of third thoracic vertebra—implies dissection, but not documented
	Euarchontoglires: Glires: Rodentia: Cricetidae: Cricetinae (*Mesocricetus*)	Salih & Kent (1964)	✓		Mentioned as origin point for *m. splenius*
	Euarchontoglires: Glires: Rodentia: Cricetidae: Cricetinae (*Neotoma*, *Oryzomys*, *Peromyscus*, *Sigmodon*)	Rinker (1954)	✓		Mentioned as origin point for *mm. cervicoauricularis*, *cervico-occipitalis*, *splenius*, *serratus posterior superior*, and *rhomboideus anterior* & *posterior*
	Euarchontoglires: Glires: Rodentia: Dipodoidea: Zapodidae (*Zapus* and *Napaeozapus*)	Klingener (1964)	✓		Mentioned as origin point for *m. rhomboideus*
	Euarchontoglires: Glires: Rodentia: Dipodoidea: Sminthidae (*Sicista*)	Klingener (1964)	✓		Mentioned as origin point for *m. rhomboideus*
	Euarchontoglires: Glires: Rodentia: Dipodoidea: Dipodinae (*Jaculus*)	Klingener (1964)	✓		Mentioned as origin point for *m. rhomboideus*
	Euarchontoglires: Glires: Rodentia: Geomyoidea: Geomyidae (*Cratogeomys*, *Geomys*, *Thomomys*)	Mosier (1947)	✓		Mentioned as origin point for pouch *levator* muscle
	Euarchontoglires: Glires: Rodentia: Geomyoidea: Heteromyidae: Dipodomyinae (*Dipodomys*)	Howell (1932)	✓		Mentioned as insertion point for *m. semispinalis*
	Euarchontoglires: Glires: Rodentia: Geomyoidea: Heteromyidae: Heteromyinae (*Heteromys*)	Ryan (1989)	✓		Mentioned as origin point for *mm. cervico-auricularis, cervico-occipitalis, splenius,* and *serratus posterior superior*

	Euarchontoglires: Glires: Rodentia: Caviomorpha: Cavioidea: Caviidae (several species)	García-Esponda et al. (2020)	✓		Mentioned as origin point for *m. trapezius*
	Eulipotyphla: Erinaceidae: Erinaceinae (*Erinaceus*)	Neveu & Gasc (2002)	✓		Mentioned as origin point for *mm. trapezius anterior* and *rhomboideus capitis et cervicis*
	Eulipotyphla: Erinaceidae: Galericinae (*Deinogalerix*†)	Villier & Carnevale (2013)	✓		Mentioned in relation to flattened, irregular dorsal surface of atlas
	Eulipotyphla: Erinaceidae: Hylomyinae (*Echinosorex*)	Neveu & Gasc (2002)	✓		Mentioned as origin point for *mm. trapezius anterior* and *rhomboideus capitis et cervicis*
	Eulipotyphla: Soricidae: Soricinae (*Crocidura*)	Neveu & Gasc (2002)	✓		Mentioned as origin point for *mm. trapezius anterior* and *rhomboideus capitis et cervicis*
	Eulipotyphla: Talpidae (*Neurotrichus*)	Carraway & Verts (1991)	✓		Mentioned as origin point for *mm. trapezius* and *splenius*
	Eulipotyphla: Talpidae (*Scalopus*)	Gaughran (1954)	✓		Mentioned as ossified and origin point for *mm. splenius* and *rhomboideus*
	Eulipotyphla: Talpidae (*Talpa*)	Owen (1868); Freeman (1886)	✓		Mentioned in quotes as ossified (Owen: 17); mentioned in relation to the interscapular ligament (Freeman)
	Eulipotyphla: Talpidae (various species)	Whidden (2000)	✓		Mentioned as origin point for *mm. splenius* and *rhomboideus cervicis*
	Eulipotyphla: Tenrecidae: Tenrecinae (*Tenrec*)	Neveu & Gasc (2002)	✓		Mentioned as origin point for *mm. trapezius*

					anterior and *rhomboideus capitis et cervicis*
	Ferae: Pholidota: Manoidea: Manidae: Phataginінae (*Phataginus*, *Smutsia*)	Gaudin et al. (2009)	✓		Mentioned as inserting into two depressions on caudodistal end of axial spinous process
	Ferae: Oxyaenodonta†: Oxyaenidae†: Oxyaeninae† (*Patriofelis*†)	Kort et al. (2021)	✓		Suggested as possibly present based on large size of axial spinous process
	Ferae: Carnivora: Musteloidea: Mephitidae (*Martes*, *Mephitis*, *Spilogale*)	Hall (1926)	✓		Called 'cervical ligament'; mentioned as origin of *m. splenius*
	Ferae: Carnivora: Musteloidea: Mustelidae: Taxidiinae (*Taxidea*)	Hall (1927)	✓		Called 'cervical ligament'; mentioned as origin of *mm. splenius* and *biventer cervicis minor*
	Ferae: Carnivora: Musteloidea: Mustelidae: Ictonychinae (*Galictis*)	Ercoli et al. (2016)	✓		Mentioned as origin point for *m. splenius capitis*
	Ferae: Carnivora: Musteloidea: Procyonidae: Procyoninae (*Procyon*)	Windle (1888)	✓		Mentioned as origin point for *m. trapezius*
	Ferae: Carnivora: Ailuridae: Ailurinae (*Ailurus*)	Fisher et al. (2009); Ercoli et al. (2016)	✓		Mentioned as origin point for *m. trapezius* by Fisher et al.
	Ferae: Carnivora: Pinnipedimorpha: Enaliarctidae† (*Enaliarctos*†)	Poust & Bossenecker (2018)	✓		Mentioned as inserting on tubercle on distal spinous process of 7th cervical vertebra
	Ferae: Carnivora: Pinnipedimorpha: Pinnipedia: Phocidae (*Mirounga*)	Bryden (1971)	✓		Mentioned as origin point for *mm. trapezius* and *rhomboideus*
	Ferae: Carnivora: Pinnipedimorpha: Pinnipedia: Phocidae (*Halichoerus*)	Koster et al. (1990)	✓		Mentioned as origin point for *m. trapezius*
	Ferae: Carnivora: Pinnipedimorpha:	Kuhn & Frey (2012)	✓		Mentioned as reinforcement for

	Pinnipedia: Otariidae (no species specified)				cervical suspension muscles
	Ferae: Carnivora: Canoidea: Canidae (*Eucyon*†)	Valenciano et al. (2022)	✓		Mentioned in relation to morphology caudodorsal end of axial spinous process (NL presence likely)
	Ferae: Carnivora: Canoidea: Canidae (*Urocyon, Vulpes*)	Feeney (1999)	✓		Mentioned as present, but not in specific fashion
	Ferae: Carnivora: Canoidea: Canidae (*Canis*)	Done et al. (2009); Singh (2018)		✓	Well documented by numerous authors, particularly in veterinary anatomy textbooks
	Ferae: Carnivora: Canoidea: Canidae (*Nyctereutes*)	Ohara (1943)	✓		Mentioned as poorly developed via histology
	Ferae: Carnivora: Canoidea: Arctoidea: Ursidae (*Helarctos*)	Ohara (1943)	✓		Mentioned as poorly developed and collagenous via histology
	Ferae: Carnivora: Canoidea: Arctoidea: Ursidae (*Ursus*)	Endo et al. (2000)	✓		Mentioned as origin point for *m. splenius*
	Ferae: Carnivora: Feliformia: Viverroidea: Viverridae: Paradoxurinae (*Arctictis*)	Carlsson (1920)	✓		Mentioned as origin point for *mm. biventer cervicis*, *trapezius* (*cucullaris*), and *rhomboideus*
	Ferae: Carnivora: Feliformia: Viverroidea: Viverridae: Viverrinae (*Viverra*)	Young (1880)	✓		Mentioned as origin point for *mm. splenius* and *complexus*
	Ferae: Carnivora: Feliformia: Feloidea: Felidae (*Acinonyx*)	Ross (1883)	✓		Mentioned as origin point for *m. scapularis*
	Ferae: Carnivora: Feliformia: Feloidea: Felidae (*Leopardus*)	Julik et al. (2012)	✓		Mentioned as origin point for *m. rhomboideus*
	Ferae: Carnivora: Feliformia: Feloidea: Felidae (*Leptailurus, Panthera*)	Diogo et al. (2012b)	✓		Mentioned as origin point for *m. acromiotrapezius*
	Ferae: Carnivora: Feliformia: Herpestoidea: Herpestidae (*Herpestes*)	Ohara (1943)	✓		Mentioned as present in histological study

	Ferae: Carnivora: Feliformia: Herpestoidea: Hyaenidae (no species specified)	Windle & Parsons (1897)	✓		Mentioned as origin point for *m. trapezius*
	Euungulata: Mesonychia†: Mesonychidae† (*Pachyaena*†)	Zhou et al. (1992)	✓		Mentioned in relation to head size and size of spinous process of axis
	Euungulata: Anthracobunia†: Cambaytheriidae† (*Cambaytherium*†)	Rose et al. (2020)	✓		Mentioned in relation to axial spinous process size
	Euungulata: Perissodactyla: Brontotheriidae† (*Palaeosyops*†)	Leidy (1873)	✓		Mentioned as attaching to rugose area on occipital
	Euungulata: Perissodactyla: Brontotheriidae† (several species†)	Gregory (1929); Stanley (1974)	✓		Mentioned in relation to deep pits on occiput (Osborn) and forces acting on the skull and neck (Stanley)
	Euungulata: Perissodactyla: Chalicotherioidea†: Eomoropidae† (*Litolophus*†)	Bai et al. (2010)	✓		Mentioned in relation to depression on occipital crest
	Euungulata: Perissodactyla: Equoidea: Palaeotheriidae† (*Hyracotherium*†)	Wood et al. (2010)	✓		Mentioned in relation to tall spinous processes on axis and cranial thoracic vertebrae
	Euungulata: Perissodactyla: Equoidea: Equidae (several Miocene species)	Janis et al. (2023)	✓		Implied presence despite shorter necks, probably based on close phylogenetic positions to *Equus*
	Euungulata: Perissodactyla: Equoidea: Equidae (*Equus*)	Percivall (1832); Gellman & Bertram (2002); Budras et al. (2011); May-Davis et al. (2020)		✓	Well documented by numerous authors, particularly in veterinary anatomy textbooks
	Euungulata: Perissodactyla:	Murie (1871); Campell (1936)		✓	Described in detail based on dissection

	Ceratomorpha: Tapiridae (*Rhinochoerus*)				
	Euungulata: Perissodactyla: Ceratomorpha: Rhinocerotoidea: Amynodontidae† (*Metamynodon*†)	Wall & Heinbaugh (1999)	✓		Mentioned in relation to thoracic spinous process size; mentioned as reduced or absent due to low spinous processes on cervical vertebrae
	Euugulata: Perissodactyla: Ceratomorpha: Rhinoceratoidea: Paraceratheriidae† (*Paraceratherium*†)	Granger & Gregory (1936)	✓		Mentioned in relation to depression on occiput
	Euungulata: Perissodactyla: Ceratomorpha: Rhinocerotoidea: Rhinocerotidae: Aceratheriinae† (*Aceratherium*†)	Deng et al. (2013)	✓		Mentioned in relation to depression on occiput
	Euungulata: Perissodactyla: Ceratomorpha: Rhinocerotoidea: Rhinocerotidae: Elasmotheriinae (*Elasmotherium*†)	Titov et al. (2021)	✓		Mentioned as originating on occiput and serving as origin for *mm. trapezius* and *splenius*
	Euungulata: Perissodactyla: Ceratomorpha: Rhinocerotoidea: Rhinocerotidae: Elasmotheriinae (*Iranotherium*†)	Deng (2005)	✓		Mentioned in relation to depression on occiput
	Euungulata: Perissodactyla: Ceratomorpha: Rhinocerotoidea: Rhinocerotidae: Elasmotheriinae (*Parelasmotherium*†)	Deng (2007)	✓		Mentioned in relation to depression on occiput
	Euungulata: Perissodactyla: Ceratomorpha: Rhinocerotoidea: Rhinocerotidae: Rhinocerotinae (*Dicerorhinus*)	Hiroyuki (2014)		✓	Documented via dissection, but not figured

	Euungulata: Perissodactyla: Ceratomorpha: Rhinocerotoidea: Rhinocerotidae: Rhinocerotinae (*Rhinoceros*)	Darda (2016); Etienne et al. (2021)		✓	Confirmed via dissection (Etienne et al.)
	Euungulata: Perissodactyla: Ceratomorpha: Rhinocerotoidea: Rhinocerotidae: Rhinocerotinae (*Ceratotherium*)	Alexander & Player (1965); Etienne et al. (2021)		✓	Confirmed via dissection (Etienne et al.)
	Euungulata: Cetartiodactyla: Archaeomerycidae†: (*Archaeomeryx*†)	Vislobokova & Trofimov (2002)	✓		Mentioned as originating on occipital crest
	Euungulata: Cetartiodactyla: Tylopoda: Camelidae: Lamini (*Vicugna*)	O'Brien (2017); Waringo (2018)		✓	Mentioned as being supplied by a branch of the external carotid artery (O'Brien); documented via dissection (Waringo)
	Euungulata: Cetartiodactyla: Tylopoda: Camelidae: Camelini (*Camelus*)	Sjomuschkin (1934); Mobarak & Fouad (1977); Dimery et al. (1985); Bianchi (1989)		✓	Documented via dissection; illustrated and discussed
	Euungulata: Cetartiodactyla: Ruminantia: Tragulina: Gelocidae† (*Floridameryx*†)	Webb (2008)	✓		Mentioned in relation to protuberances on occipital
	Euungulata: Cetartiodactyla: Ruminantia: Tragulina: Tragulidae (*Tragulus*)	Pers. obs.		✓	Documented via dissection
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Dromomerycidae† (*Pediomeryx*†)	Webb (1983)	✓		Mentioned in relation to depression on occipital
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Giraffoidea:	Danowitz et al. (2015a)	✓		Mentioned as inserting on external occipital protuberance (or in

	Climatoceratidae† (*Prolibytherium*†)				deep pits lateral to ridge)
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Giraffoidea: Giraffidae (*Alcicephalus*†)	Solounias & Danowitz (2016)	✓		Mentioned in relation to depressions on occipital
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Giraffoidea: Giraffidae (*Bramatherium*†)	Lewis (1939); Solounias & Jukar (2023)	✓		Mentioned as inserting into paired supraoccipital pits
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Giraffoidea: Giraffidae (*Giraffa*)	Owen (1839); Queckett (1852); Bianchi (1989); Endo et al. (1997)		✓	Documented via dissection
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Giraffoidea: Giraffidae (*Samotherium*†)	Danowitz et al. (2015b)	✓		Mentioned in relation to short spinous process on cervical 7
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Giraffoidea: Giraffidae (*Schansitherium*†)	Hou et al. (2019)	✓		Mentioned in relation to depression on paroccipital process
	Euungulata: Cetartiodactyla: Ruminantia Pecora: Bovimorpha: Bovidae (*Eotragus*†)	Solounias & Moelleken (1992)	✓		Mentioned in relation to depressions on occiput
	Euungulata: Cetartiodactyla: Ruminantia Pecora: Bovimorpha: Bovidae (*Ovis*)	May (1970); Dimery et al. (1985)		✓	Documented via dissection; illustrated and discussed
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Bovimorpha: Bovidae: Bovinae (*Spirocerus*†)	Sokolov (1959)	✓		Mentioned in relation to tall cranial thoracic spinous processes
	Euungulata: Cetartiodactyla: Ruminantia Pecora: Bovimorpha: Bovidae: Bovinae: Bovini (*Bison*)	Bianchi (1989); Gunji (2023)		✓	Documented via dissection
	Euungulata: Cetartiodactyla: Ruminantia Pecora:	Heath (1979); Bianchi (1989); Gunji		✓	Documented via dissection

	Bovimorpha: Bovidae: Bovinae: Bovini (*Bos*)	(2023); Mansour et al. (2023)			
	Euungulata: Cetartiodactyla: Ruminantia Pecora: Bovimorpha: Bovidae: Bovinae: Bubalina (*Bubalus*)	Moskoff (1933/34)		✓	Documented via dissection
	Euungulata: Cetartiodactyla: Ruminantia Pecora: Bovimorpha: Bovidae: Bovinae: Bubalina (*Syncerus*)	Sandground (1938)	✓		Mentioned in relation to infection by *Onchocerca*
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Bovimorpha: Bovidae: Antilopinae (*Antilope*)	Woodford (1995)	✓		Almost certainly accurate, but only mentioned
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Bovimorpha: Bovidae: Antilopinae (*Procapra*)	Frey et al. (2008)		✓	Documented via CT scan
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Bovimorpha: Bovidae: Antilopinae (*Madoqua*)	Bianchi (1989)		✓	Documented via sampling
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Bovimorpha: Bovidae: Caprinae: Ovibovini (*Bootherium*†)	Richards & McDonald (1991)	✓		Mentioned as inserting on nuchal line of occiput
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Bovimorpha: Bovidae: Caprinae: Caprini (*Budorcas*)	Luo et al. (2012)	✓		Mentioned as site of brucellosis infection (in bursae between NL and primary thoracic spinous processes
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Bovimorpha: Bovidae: Caprinae: Caprini (*Capra*)	Bianchi (1989); Mansour et al. (2023)		✓	Documented via dissection and sampling
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Bovimorpha: Bovidae:	Bianchi (1989)		✓	Documented via sampling

	Caprinae: Caprini (*Oreamnos*)				
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Bovimorpha: Bovidae: Caprinae: Caprini (*Rupicapra*)	Bianchi (1989)		✓	Documented via sampling
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Bovimorpha: Bovidae: Hippotraginae (*Hippotragus*)	Sandground (1938)	✓		Mentioned in relation to possible infection by *Onchocerca*
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Bovimorpha: Cervoidea: Cervidae (*Cervus*)	Ohara (1943); Pianel (2020)		✓	Documented via dissection and histology
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Bovimorpha: Cervoidea: Cervidae (*Capreolus*)	Ohara (1943); Dimery et al. (1985)		✓	Documented via dissection and histology
	Euungulata: Cetartiodactyla: Ruminantia: Pecora: Bovimorpha: Cervoidea: Cervidae (*Muntiacus*)	Ohara (1943)		✓	Documented via histology
	Euungulata: Cetartiodactyla: Whippomorpha: Hippopotamidae (*Choeropsis*)	Fisher et al. (2007)	✓		Mentioned as origin point for *mm. trapezius* and *rhomboideus*
	Euungulata: Cetartiodactyla: Whippomorpha: Cetacea: Archaeoceti†: Protocetidae† (*Carolinacetus*†)	Geisler et al. (2005)	✓		Mentioned as inserting onto the supracondylar ridge
	Euungulata: Cetartiodactyla: Whippomorpha: Cetacea: Archaeoceti†: Protocetidae† (*Qaisracetus*†)	Gingerich et al. (2001)	✓		Mentioned in relation to size of axial spinous process
	Euungulata: Cetartiodactyla: Whippomorpha: Cetacea: Archaeoceti†:	Thewissen & Bajpai (2009)	✓		Mentioned in relation to both tall thoracic spinous processes and large

	Remingtonocetidae† (*Andrewsiphius*†)				nuchal crests on skull
	Euungulata: Cetartiodactyla: Whippomorpha: Cetacea: Archaeoceti†: Remingtonocetidae† (*Remingtonocetus*†)	Bebej et al. (2012)	✓		Mentioned in relation to ventrally hooked, dorsoventrally tall caudal margin of axial spinous process
	Euungulata: Cetartiodactyla: Whippomorpha: Cetacea: Basilosauridae†: Dorudontinae† (*Cynthiacetus*†)	Martínez-Cáceres & de Muizon (2011)	✓		Mentioned as inserting onto two tuberosities on the supraoccipital shield
Sauropsida: Eureptilia (non-diapsid)	Captorhinidae† (*Captorhinus*†)	Vaughn (1970); Sumida (1990)	✓		Mentioned as a possible reason for alternation in spinous process heights
Sauropsida: Eureptilia: Diapsida: Neodiapsida (non-Sauria)	Drepanosauromorpha† ('*Protoavis*' skull material)	Chatterjee (1991)	✓		Mentioned as inserting on crest on supraoccipital
Sauropsida: Eureptilia: Diapsida: Neodiapsida: Sauria: Lepidosauromorpha	Rhynchocephalia: Sphenodontia: Sphenodontidae (*Sphenodon*)	Anderson (1936); Tsuihiji (2007)	✓		Mentioned as origin point for *m. depressor mandibulae*
	Squamata: Lacertilia: Iguanomorpha: Iguania: Gobiguania† (*Zapsosaurus*†)	Gao & Norell (2000)	✓		Mentioned as inserting on crest on supraoccipital
	Squamata: Lacertilia: Iguanomorpha: Iguania: Iguanidae (*Iguana*)	Tschanz (1986)	✓		Mentioned as lying medial to *m. rectus capitis posterior* and as inserting on crest on supraoccipital
	Squamata: Lacertilia: Anguimorpha: Helodermatoidea: Helodermatidae (*Heloderma*)	Herrel & de Vree (1999)	✓		Mentioned as lying adjacent to *m. spinalis capitis*
	Squamata: Lacertilia (various species analyzed; NL-bearing ones not specified)	Abdala & Moro (2003)	✓		Mentioned in character 64 of data matrix used; state 2 = '*m. depressor mandibulae superficialis* origin including: parietal, squamosal,

					posterior arcade, and ligamentum nuchae'
Sauropsida: Eureptilia: Diapsida: Neodiapsida: Sauria: Archosauromorpha: Ichthyosauromorpha†	Ichthyosauria†: Ophthalmosauridae† (*Cryopterygius*†)	Druckenmiller et al. (2012)	✓		Inferred from notched distal ends of presacral spinous processes
Sauropsida: Eureptilia: Diapsida: Neodiapsida: Sauria: Archosauromorpha: Sauropterygia†	Placodontia† (*Placodus*†)	Sues (1987)	✓		Mentioned as inserting on crest on supraoccipital
	Plesiosauria†: Rhomaleosauridae† (*Rhomaleosaurus*†)	Taylor (1992)	✓		Mentioned in relation to roughened patch on dorsal midline of squamosals
	Plesiosauria†: Pliosauridae† (*Gallardosaurus*†)	Gasparini (2009)	✓		Mentioned in relation to rugose, striated scar on midline of caudal end of parietals
	Plesiosauria†: Plesiosauroidea†: Cryptoclidia†: Cryptoclididae† (*Cryptocleidus*†, *Kimmerosaurus*†)	Brown (1981)	✓		Mentioned as inserting into 'hole' at suture between supraoccipital and parietals
	Plesiosauria†: Plesiosauroidea†: Cryptoclidia†: Cryptoclididae† (*Muraenosaurus*†)	Koken & Linder (1913)	✓		Mentioned as inserting into 'hole' on supraoccipital dorsal to foramen magnum
	Plesiosauria†: Plesiosauroidea†: Cryptoclidia†: Xenopsaria†: Elasmosauridae† (*Libonectes*†)	Carpenter (1997)	✓		Mentioned as inserting on crest on supraoccipital
	Plesiosauria†: Plesiosauroidea†: Cryptoclidia†: Xenopsaria†: Leptocleidia†: Polycotylidae† (*Dolichorhynchops*†)	Carpenter (1997)	✓		Mentioned as inserting on crest on supraoccipital
	Plesiosauria†: Plesiosauroidea†: Plesiosauridae† (*Seeleyosaurus*†)	Großman (2006)	✓		Mentioned in relation to pits on caudodorsal area of squamosals

	Plesiosauria†: Plesiosauroidea†: Microcleididae† (*Hydrorion*†)	Großman (2006)	✓		Mentioned in relation to pits on caudodorsal area of squamosals
	Plesiosauria† (various species)	Noè et al. (2017)	✓		Mentioned in relation to shapes of distal ends of cervical spinous processes
Sauropsida: Eureptilia: Diapsida: Neodiapsida: Sauria: Archosauromorpha (non-Archosauria)	(*Teraterpeton*†)	Sues (2003)	✓		Mentioned as inserting on crest on supraoccipital
	Testudines: Cryptodira: Testudinoidea: Testudinidae (*Testudo*)	Bojanus (1819)			Nature unclear
	Testudines: Cryptodira: Chelonioidea (various species)	Young (2022)	✓		Mentioned as landmark for entering dorsocervical sinus for blood collection
	Testudines: Pleurodira: Chelidae: Chelodininae (*Emydura*)	Werneburg (2011)	✓		Mentioned as origin point for *m. constrictor colli*
	Testudines (no species specified)	Gräper (1932)	✓		Mentioned as origin point for part of the *m. sphincter* (*latissimus*) *colli*
Sauropsida: Eureptilia: Diapsida: Neodiapsida: Sauria: Archosauromorpha: Archosauria (non-Dinosauria)	Pseudosuchia: Phytosauria† (*Parasuchus*†)	Chatterjee (1978)	✓		Mentioned in relation to size of axial spinous process; NL mentioned as connecting to it and head as well as to vertebral column
	Pseudosuchia: Phytosauria† (*Machaeroprosopus*†)	Colbert (1947) (q.v., Anderson [1936])	✓		Mentioned as inserting into deep fossa on interparietal
	Pseudosuchia: Suchia: Aetosauria†: Stagonolepididae†: Desmatosuchinae† (*Desmatosuchus*†)	Small (2002)	✓		Mentioned as inserting on crest on supraoccipital
	Pseudosuchia: Suchia: Aetosauria†: Stagonolepididae† (*Neoaetosauroides*†)	Desojo & Báez (2007)	✓		Mentioned as inserting on crest on supraoccipital

	Pseudosuchia: Suchia: Loricata (cf. *Halticosaurus*†)	Sues & Schoch (2013)	✓		Mentioned as inserting on crest on supraoccipital
	Pseudosuchia: Suchia: Loricata (*Prestosuchus*†)	Mastrantonio et al. (2013)	✓		Mentioned as inserting on crest on supraoccipital
	Pseudosuchia: Suchia: Loricata: Crocodylomorpha: Notosuchia†: Sebecosuchia†: Peirosauridae† (*Hamadasuchus*†)	Larsson & Sues (2007)	✓		Mentioned as inserting in depressions on either side of median ridge on supraoccipital
	Pseudosuchia: Suchia: Loricata: Crocodylomorpha: Neosuchia: Tethysuchia†: Dyrosauridae† (indet.†)	Storrs (1986)	✓		Assumed present due to cranium size
	Pseudosuchia: Suchia: Loricata: Crocodylomorpha: Neosuchia: Tethysuchia†: Dyrosauridae† (various species†)	Schwarz-Wings (2014)	✓		Mentioned in relation to heights of cervical and cranial thoracic spinous processes
	Pseudosuchia: Suchia: Loricata: Crocodylomorpha: Neosuchia: Eusuchia: Crocodylia: Mekosuchinae† (*Trilophosuchus*†)	Willis (1993)	✓		Mentioned as inserting low on occiput
	Pseudosuchia: Suchia: Loricata: Crocodylomorpha: Neosuchia: Eusuchia: Crocodylia: Alligatoridae (*Alligator*)	Seidel (1978)		✓	Mentioned as connecting to dorsal tip of proatlas; illustrated as supraspinous ligament (fig. 53)
	Ornithodira: Pterosauria† (various species†)	Buchmann & Rodrigues (2024)	✓		Roughened distal tips of cervical spinous processes
	Ornithodira: Pterosauria†: Pterodactyloidea†: Ornithocheiroidea† (various species†)	Witton & Naish (2008)	✓		*Hatzegopterus*, ornithocheirids, and pteranodontids mentioned as having well-developed medial ridge on the supraoccipital for NL insertion

Sauropsida: Eureptilia: Diapsida: Neodiapsida: Sauria: Archosauromorpha: Archosauria: Dinosauria (non-Avialae)	Ornithischia†: Thyreophora†: Ankylosauria†: Nodosauridae† (indet.)	Hawakaya et al. (2005)	✓		Mentioned as inserting on knob on supraoccipital
	Ornithischia†: Marginocephalia†: Pachycephalosauridae† (*Stegoceras*†)	Sues & Galton (1987)	✓		Mentioned as inserting on crest on supraoccipital
	Ornithischia†: Marginocephalia†: Pachycephalosauridae† (*Stygimoloch*†)	Goodwin et al. (1998)	✓		Mentioned as inserting on crest on supraoccipital
	Ornithischia†: Marginocephalia†: Ceratopsia†: Psittacosauridae† (*Psittacosaurus*†)	Sereno (1987); Zhou et al. (2006); Napoli et al. (2019)	✓		Mentioned as inserting on crest on supraoccipital
	Ornithischia†: Marginocephalia†: Ceratopsia†: Ceratopsidae† (no species specified)	VanBuren (2013)	✓		Mentioned as possibly associated with enlarge axial spinous process
	Ornithischia†: Ornithopoda†: Iguanodontia† (*Tenontosaurus*†)	Thomas (2015)	✓		Mentioned as inserting into fossa on supraoccipital
	Ornithischia†: Ornithopoda†: Iguanodontia†: Dryosauridae† (*Dysalotosaurus*†)	Hübner & Rauhut (2010)	✓		Mentioned as inserting on crest on supraoccipital
	Ornithischia†: Ornithopoda†: Iguanodontia†: Styracosterna† (*Planicoxa*†)	DiCroce & Carpenter (2001)	✓		Mentioned in relation to rugose area in place of cervical spinous process
	Ornithischia†: Ornithopoda†: Iguanodontia†: Styracosterna†: Hadrosauroidea†: Hadrosauridae†: Saurolophinae† (*Maiasaura*†)	McFeeters et al. (2021)	✓		Mentioned as inserting into pit on supraoccipital
	Ornithischia†: Ornithopoda†: Iguanodontia†: Styracosterna†:	Maryanska & Osmólska (1981)	✓		Mentioned in relation to depth of presumed insertion point on

	Hadrosauroidea†: Hadrosauridae†: Saurolophinae† (*Saurolophus*†)				supraoccipital–squamosal
	Ornithischia†: Ornithopoda†: Iguanodontia†: Styracosterna†: Hadrosauroidea†: Hadrosauridae†: Saurolophinae† (*Shantungosaurus*†)	Hu et al. (2001)	✓		Presumed insertion point labeled on diagram of caudal view of skull
	Ornithischia†: Ornithopoda†: Iguanodontia†: Styracosterna†: Hadrosauroidea†: Hadrosauridae†: Lambeosaurinae† (*Olorotitan*†)	Godefroit et al. (2012)	✓		Mentioned in relation to deep excavations on caudal surface of parietal
	Ornithischia†: Ornithopoda†: Iguanodontia†: Styracosterna†: Hadrosauroidea†: Hadrosauridae†: Lambeosaurinae† (*Parasaurolophus*†)	Bertozzo et al. (2020)	✓		Based on paleopathological lesions on the spinous processes of the cranial thoracic vertebrae
	Saurischia: Sauropodomorpha†: Sauropoda†: Diplodocoidea†: Dicraeosauridae† (*Dicraeosaurus*†)	Janensch (1929); Bailey (1997)	✓		Presence of rugose pseudospinous tubercula (*sensu* Harris [2006]) on cervical vertebrae
	Saurischia: Sauropodomorpha†: Sauropoda†: Diplodocoidea†: Dicraeosauridae† (‘*Morosaurus*’ *agilis*†)	Whitlock & Wilson Mantilla (2020)	✓		Rugose distal tips of cervical spinous processes
	Saurischia: Sauropodomorpha†: Sauropoda†: Diplodocoidea†: Diplodocidae† (*Apatosaurus*†, *Diplodocus*†)	Woodruff (2016) (q.v., Stevens & Parrish [1999])		✓	Based on histology and muscle reconstruction, but illustration and description are of a supraspinous ligament, not an NL (q.v., Schwarz et al., 2007)
	Saurischia: Sauropodomorpha†:	Jensen (1988)	✓		Assumed to occupy ‘trough’ created by

	Sauropoda†: Macronaria† (*Camarasaurus*†)				bifid cervical and thoracic spinous processes
	Saurischia: Sauropodomorpha†: Sauropoda†: Macronaria†: Titanosauriformes†: Brachiosauridae† (*Brachiosaurus*†, *Giraffatitan*†)	Paul (1988), Christiansen (2000), Woodruff (2016)	✓		Inferred from slight 'withers' hump of cranial thoracic spinous processes and from the presence of rugosities on the exoccipital and supraoccipital
	Saurischia: Sauropodomorpha†: Sauropoda†: Macronaria†: Titanosauriformes†: Titanosauria†: Saltasauridae† (*Opisthocoelicaudia*†)	Borsuk-Bialynicka (1977)	✓		Assumed to occupy 'trough' created by bifid cervical and thoracic spinous processes; mentioned as present along with supraspinous ligament
	Saurischia: Theropoda: Neotheropoda (*Cryolophosaurus*†)	Smith et al. (2007)	✓		Mentioned as inserting on rugose part of crest on supraoccipital
	Saurischia: Theropoda: Neotheropoda: Ceratosauria†: Abelisauroidea†: Abelisauridae† (*Majungasaurus*†)	Sampson & Witmer (2007)	✓		Mentioned as possibly inserting on crest on supraoccipital; mentioned parenthetically as homologous with supraspinal ligament and only hypothetical in this taxon
	Saurischia: Theropoda: Neotheropoda: Ceratosauria†: Abelisauroidea†: Abelisauridae† (*Rajasaurus*†)	Wilson et al. (2003)	✓		Mentioned as inserting on crest on supraoccipital
	Saurischia: Theropoda: Neotheropoda: Ceratosauria†: Abelisauroidea†: Abelisauridae† (various species†)	Stiegler (2019)	✓		Mentioned in relation to caudal projection from distal axial spinous process, presumed to be mineralized NL

	Saurischia: Theropoda: Neotheropoda: Megalosauroidea†: Spinosauridae† (*Irritator*†)	Sues et al. (2002)	✓		Mentioned as inserting on crest on supraoccipital
	Saurischia: Theropoda: Neotheropoda: Allosauroidea†: Allosauridae† (*Allosaurus*†)	McClelland (1990); Chure & Loewen (2020)	✓		Mentioned as inserting on crest on supraoccipital
	Saurischia: Theropoda: Neotheropoda: Coelurosauria: Tyrannoraptora: Tyrannosauroidea†: Tyrannosauridae† (*Alioramus*†)	Kurzanov (1976); Bever et al. (2013)	✓		Mentioned in relation to two small cavities on caudal end of parietals, dorsal to supraoccipital
	Saurischia: Theropoda: Neotheropoda: Coelurosauria: Tyrannoraptora: Tyrannosauroidea†: Tyrannosauridae† (*Tarbosaurus*†)	Maleev (1974)	✓		Mentioned as inserting on crest on supraoccipital
	Saurischia: Theropoda: Neotheropoda: Coelurosauria: Tyrannoraptora: Maniraptora (*Falcarius*†)	Smith et al. (2011)	✓		Mentioned as inserting in pit on supraoccipital dorsal to foramen magnum
Sauropsida: Eureptilia: Diapsida: Neodiapsida: Sauria: Archosauromorpha: Archosauria: Dinosauria: Avialae	Ornithuromorpha: Ornithurae: Aves: Neognathae: Galloanserae: Galliformes: Phasianidae (*Gallus*)	Yasuda (2002)		✓	Essentially a 'sheath' or 'ligamentous septum' structure separating epaxial muscles—see Tsuihiji (2004) for discussion
	Ornithuromorpha: Ornithurae: Aves: Neognathae: Galloanserae: Galliformes: Phasianidae (*Coturnix*)	Fitzgerald (1970)	✓		Called 'ligamentum nuchae', but actually tendons of the *mm. biventer cervicis* and *splenius*

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