Electronic Supplementary Material (ESM) for:

A Bizarre New Toothed Mysticete (Cetacea) from Australia and the Early Evolution of Baleen Whales

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1. Materials and methods:
The holotype specimen (NMV P216929) of *Janjucetus hunderi* was initially prepared prior to 2001 by Ms K. Archdall using acetic acid etching. This preparation was discontinued after about six months. However, cessation of the acid etching at this point proved to be fortuitous, as within the matrix surrounding the skeleton were abundant pyrite nodules. There were also, in some areas, large growths of pyrite on the bones themselves. After acid is used up in one preparation session, the fluid is decanted, and the remaining fragments of matrix and the fossils are washed in freshwater. This repeated exposure of the pyrite to water (pyrite is unstable in moist environments; relative humidity \( \geq 60\% \)) resulted in the oxidation of many of the pyrite nodules. Unfortunately, by the time I began mechanical preparation of P216929 in February 2003, the pyrite that had in-filled some cavities in bones, including parts of the skull, had oxidised, resulting in the onset of 'pyrite disease', whereby the fossil bone crumbled to dust. This precluded the further use of acid in the preparation of this specimen.

The inability to utilise acid preparation techniques meant that mechanical methods had to be relied upon for further preparation. Tools used consisted of an array of modified engraving pens (or ‘air-scribes’), and air chisels. This has directly affected the extent to which NMV P216929 can be prepared. For example, the risk of irreparable damage to the right side of the skull was considered too great to detach the right mandible from the skull via mechanical techniques. This in turn has meant that some matrix has been left covering parts of the skull and mandible in order to retain the mandible in place and prevent it from breaking off (and thence damaging the right upper dentition).

Of equal significance has been the degree of induration of the enclosing sediment, which consists of a phosphate and glauconite-rich, calcareous mudstone. This matrix is extremely indurated, and adheres very tightly to the bone, making thorough cleaning of the fossil almost impossible without removing the outer layers of compact bone and damaging enamel. In the latter respects the preservation of NMV P216929 is analogous to that of Late Oligocene cetacean fossils recovered from the Pacific Northwest of the USA (see Fordyce 2002). It is for the above reasons that NMV P216929 remains incompletely, albeit adequately, prepared. I completed mechanical preparation of NMV P216929 in November 2005.

*Janjucetus hunderi* was compared with two other Australian Late Oligocene toothed mysticete specimens in the Palaeontology Collections of Museum Victoria (NMV P) that are for the most part undescribed in the published literature. The nature of the latter specimens are summarised below:

NMV P199986 [HOLOTYPE]
*Mammalodon colliveri*
Elements preserved: Virtually complete skull with left C1-P4 in situ; right periotic (with stapes in situ); right tympanic bulla; loose upper incisor; right mandible with p1-m2 in situ; left thyrohyal; manubrium of sternum; axis vertebra. An associated left p3 (NMV P17535) represents the same individual as NMV P199986.
Locality, stratigraphy, and age: Bird Rock, near Torquay, Victoria, Australia; upper Jan Juc Marl, Late Oligocene (see Fitzgerald 2004 and Pritchard 1939 for details).
NMV P199587

*Mammalodon* sp. cf. *M. colliveri*

Elements preserved: Left tympanic bulla; right mandible with m1 in situ; two upper premolars; two lower incisors; one lower canine; one right lower premolar; one right lower molar; 3 cervical vertebrae; 5 thoracic vertebrae; 2 lumbar vertebrae; 14 ribs; radius; left metacarpal II. An associated ulna (NMV P198871) represents the same individual as NMV P199587.

Locality, stratigraphy, and age: Bells Beach, near Torquay, Victoria, Australia; Point Addis Limestone, Late Oligocene (see Fitzgerald 2004 for details).

2. Character list:
The character list was modified and expanded from (Geisler & Sanders 2003; see the latter reference for sources of characters and states that are not new to this study). A total of 263/304 characters from (Geisler & Sanders 2003) were included. A number of new characters were added in order to more rigorously test the relationships of *Janjucetus*, as well as *Mammalodon*, the latter taxon’s phylogenetic position within Cetacea being hitherto uncertain. These include: premaxillae on rostrum adjacent and anterior to level of P2, or on anterior half of rostrum [char. 9]; anterior edge (orbital margin) of postorbital process of frontal [char. 63]; and posterior edge of the ascending process of maxilla [char. 80]. In addition, a new state for character 41 [mandibular symphysis], state 2 [not sutured, shallow longitudinal fossa for ligamentous connection], was included in recognition of the novel morphology of this feature in both *Janjucetus* and *Mammalodon*. All facial soft tissue and vertebral characters from (Geisler & Sanders 2003) were excluded as they are too poorly known, or cannot be scored, in fossil taxa. One postcranial character [char. 266 (radial and ulnar facets of humerus)] was included as it is important for testing the monophyly of crown-group Cetacea [Mysticeti + Odontoceti = Autoceta of (Geisler & Sanders 2003)].

**Rostrum, Dental, and Mandibular**

1. Baleen
   0: Absent
   1: Present

*Janjucetus*: ? = Unknown.

2. Length of rostral portion of maxilla
   0: Short, rostral portion of maxilla <43% of condylobasal length excluding the premaxillae
   1: Intermediate, rostral portion between 48 and 70% of modified condylobasal length
   2: Elongate, rostral portion >73% modified condylobasal length

*Janjucetus*: 0 = Short, rostral portion of maxilla <43% of condylobasal length excluding the premaxillae.

3. Rostrum
   0: Narrows in width anteriorly or anterior half approximately the same width as posterior half
   1: Anterior part widened transversely

*Janjucetus*: 0 = Narrows in width anteriorly or anterior half approximately the same width as posterior half.

4. Anterior half of maxilla
   0: Its lateral edge in cross section forms an angle of 60-45°
   1: highly acute angle with flattened maxilla

*Janjucetus*: 0 = Its lateral edge in cross section forms an angle of 60-45°.

5. Mesorostral canal
   0: Open, vomer in cross section is V-shaped or U-shaped
   1: partially or completely filled in with bone, becomes solid rod of bone

*Janjucetus*: 0 = Open, vomer in cross section is V-shaped or U-shaped.

6. Rostral constriction well anterior to antorbital notch
0: Absent
1: present

*Janjucetus*: 0 = Absent.

7. Width of rostrum at antorbital notch
   0: Wide, rostral width >92% the width across of middle of orbits
   1: fairly wide, between 82 and 72% the width across orbits
   2: narrow, between 68 and 46% the orbital width
   3: very narrow, between 32 and 29% the orbital width

*Janjucetus*: 0 = Wide, rostral width >92% the width across of middle of orbits.

8. Premaxilla in dorsal view
   0: Portion adjacent to and anterior to nasal opening narrows or remains the same width anteriorly
   1: widens at anterior end

*Janjucetus*: 1 = widens at anterior end.

9. Premaxillae on rostrum adjacent and anterior to level of P2, or on anterior half of rostrum
   0: Do not clearly overhang maxillae
   1: clearly overhang maxillae

*Janjucetus*: 1 = clearly overhang maxillae.

10. Premaxillae on anterior two thirds of rostrum
    0: With skull in dorsal view, contact along midline for most or entire length
    1: sporadic contact along rostrum
    2: separated by a narrow fissure for entire length
    3: clear separation although mesorostral canal still has a partial roof
    4: very wide separation, mesorostral canal is completely open along entire length

*Janjucetus*: 4 = very wide separation, mesorostral canal is completely open along entire length.

11. Suture between maxilla and premaxilla on rostrum
    0: Suture fused along most of rostrum
    1: anterior quarter of rostrum fused with remaining portions unfused
    2: unfused along entire rostrum but articulation tight
    3: suture is unfused and marked by a deep groove

*Janjucetus*: 2 = unfused along entire rostrum but articulation tight.

12. Posterior region of rostral edge
    0: Lateral margin is straight or gently concave with skull in dorsal view
    1: slightly bowed outward causing a V-shaped antorbital notch
    2: bowed far outward forming a deep U-shaped antorbital notch
    3: lateral margin of maxilla nearly contact lacrimal and jugal resulting in the opening of the notch being a narrow slit

*Janjucetus*: 0 = Lateral margin is straight or gently concave with skull in dorsal view.

13. Posterodorsal portion of maxilla
    0: Sutured to frontal
    1: not sutured, separated from frontal by a distinct gap, which is situated between the maxilla anterodorsal and the frontal ventrally

*Janjucetus*: 0 = Sutured to frontal.

14. Steep face on anterolateral edge of zygomatic process of maxilla clearly separating it from rostral portion of maxilla
    0: Absent
    1: present but low
    2: present and well-developed

*Janjucetus*: 2 = present and well-developed.

15. Posterior end of ascending process of maxilla
    0: Tapers to a point
    1: end is squared-off

*Janjucetus*: 0 = Tapers to a point.

16. Posterior wall of antorbital notch
    0: Maxilla
    1: lacrimal and jugal

*Janjucetus*: 0 = Maxilla.

17. Palatal surface of rostrum
    0: Flat or gently concave
    1: bears pronounced longitudinal keel (formed by vomer and medial edges of maxillae) along the midline of the rostrum

*Janjucetus*: 0 = Flat or gently concave.
18. Palatal surface of maxilla
   0: Bears few vascular foramina, those that are present are small
   1: bears many, large vascular foramina that open laterally and anterolaterally into long sulci
   2: bears numerous small vascular foramina that lack sulci
   \textit{Janjucetus:} 0 = Bears few vascular foramina, those that are present are small

19. Posterior end of palatal surface of rostrum at the suture between palatine and maxilla
   0: Concave to flat, depth of rostrum, measured as the dorsoventral distance from the level of the lateral edge of rostrum to the ventralmost part of rostrum, is <8% the width of rostrum at antorbital notches
   1: convex, depth between 11 and 25% the rostral width
   2: highly convex, rostral depth >27% the rostral width
   \textit{Janjucetus:} 0 = Concave to flat, depth of rostrum, measured as the dorsoventral distance from the level of the lateral edge of rostrum to the ventralmost part of rostrum, is <8% the width of rostrum at antorbital notches.

20. Palatine
   0: Sutured to maxilla and suture visible
   1: fused to maxilla
   \textit{Janjucetus:} 0 = Sutured to maxilla and suture visible.

21. Palatine/Maxilla suture
   0: In ventral view, suture between both palatines and both maxillae is straight transversely or bowed anteriorly
   1: maxillae have posterior processes that separate palatines anteriorly, suture around midline is V-shaped and points posteriorly
   \textit{Janjucetus:} 0 = In ventral view, suture between both palatines and both maxillae is straight transversely or bowed anteriorly.

22. Teeth in females
   0: Erupt in adulthood
   1: do not erupt in adulthood but remain in the crypt
   \textit{Janjucetus:} ? = Unknown.

23. Tooth rows
   0: Separated and diverge posteriorly
   1: left and right sides adjacent to the midline and thus close together, are nearly parallel
   \textit{Janjucetus:} 0 = left and right sides adjacent to the midline and thus close together, are nearly parallel.

24. Number of double-rooted teeth in maxilla
   0: None
   1: 1 or 2
   2: 4
   3: 5
   4: 6
   5: 7
   6: 8 or more
   \textit{Janjucetus:} ? = Unknown.

25. Number of teeth with alveoli completely enclosed in the maxilla
   0: None, 1, 2, or 3
   1: 7 to 8
   2: 9 to 10
   3: 11 to 13
   4: 15 to 17
   5: 21 to 23
   6: 26 to 29
   7: 32 to 39
   8: 50 to 60
   \textit{Janjucetus:} 1 = 7 to 8.

26. Large diastemata between posterior buccal teeth
   0: Absent
   1: present
   \textit{Janjucetus:} 1 = present.

\textbf{Teeth Morphology}

27. Tooth enamel
   0: Smooth
   1: bears reticulating striae
2: nodular

Janjucetus: 1 = bears reticulating striae.

28. Lower anterior mandibular teeth
   0: conical
   1: spatulate
   2: laterally compressed

Janjucetus: 0 = conical.

29. Lower anterior teeth
   0: Deeply rooted with at least half of tooth forming root
   1: not deeply rooted

Janjucetus: 0 = Deeply rooted with at least half of tooth forming root.

30. Accessory shelf on posterior teeth
   0: Present
   1: absent

Janjucetus: 0 = Present.

31. Posterior cheek teeth
   0: High peg-shaped teeth, crown base is <37% the crown height
   1: nearly and equilateral triangle, crown base is between 100 to 148% the crown height
   2: wide low teeth, crown base is >180% the crown height

Janjucetus: 1 = nearly and equilateral triangle, crown base is between 100 to 148% the crown height.

32. Cheek teeth ectocingulum
   0: Absent
   1: Present

Janjucetus: 0 = Absent.

33. Cheek teeth entocingulum
   0: Present
   1: absent

Janjucetus: 1 = absent.

34. Cheek teeth
   0: Bear accessory denticles
   1: Denticles absent

Janjucetus: 0 = Bear accessory denticles.

35. Central cusp as compared to denticles
   0: Much larger
   1: subeual

Janjucetus: 0 = Much larger.

Mandibular

36. Anteriormost mandibular teeth
   0: Oriented anteriorly
   1: vertical
   2: inclined posteriorly


37. Anteriormost mandibular teeth
   0: Smaller than posterior teeth
   1: approximately same size as posterior teeth
   2: greatly enlarged


38. Number of teeth in lower jaw
   0: None
   1: 1
   2: 2
   3: 8-9
   4: 11-12
   5: 13-14
   6: 20-23
   7: 24-27
   8: 28-34
   9: >40 teeth
Janjucetus: 4 = 11-12.
39. Mandible in lateral view
   0: Straight
   1: arched dorsally
Janjucetus: 0 = Straight.
40. Length of mandibular symphysis
   0: Short, mandibular symphysis forms <28% of the total mandibular length
   1: long, symphysis length between 33 and 40% of the mandibular length
   2: very long, symphysis forms more than 48% of the length of the mandibles
Janjucetus: 0 = Short, mandibular symphysis forms <28% of the total mandibular length.
41. Mandibular symphysis
   0: Fused
   1: not sutured but unfused
   2: not sutured, shallow longitudinal fossa for fibrocartilaginous connection
   3: not sutured, well-developed longitudinal groove for fibrocartilaginous connection
Janjucetus: 2 = not sutured, shallow longitudinal fossa for fibrocartilaginous connection.
42. Length of mandibular symphysis
   0: Short, mandibular symphysis forms <28% of the total mandibular length
   1: long, symphysis length between 33 and 40% of the mandibular length
   2: very long, symphysis forms more than 48% of the length of the mandibles
Janjucetus: 0 = Short, mandibular symphysis forms <28% of the total mandibular length.
43. Mandibular symphysis
   0: Fused
   1: not sutured but unfused
   2: not sutured, shallow longitudinal fossa for fibrocartilaginous connection
   3: not sutured, well-developed longitudinal groove for fibrocartilaginous connection
Janjucetus: 2 = not sutured, shallow longitudinal fossa for fibrocartilaginous connection.
44. Mandibular symphysis
   0: Fused
   1: not sutured but unfused
   2: not sutured, shallow longitudinal fossa for fibrocartilaginous connection
   3: not sutured, well-developed longitudinal groove for fibrocartilaginous connection
Janjucetus: 2 = not sutured, shallow longitudinal fossa for fibrocartilaginous connection.
45. Length of mandibular symphysis
   0: Short, mandibular symphysis forms <28% of the total mandibular length
   1: long, symphysis length between 33 and 40% of the mandibular length
   2: very long, symphysis forms more than 48% of the length of the mandibles
Janjucetus: 0 = Short, mandibular symphysis forms <28% of the total mandibular length.
46. Mandibular symphysis
   0: Fused
   1: not sutured but unfused
   2: not sutured, shallow longitudinal fossa for fibrocartilaginous connection
   3: not sutured, well-developed longitudinal groove for fibrocartilaginous connection
Janjucetus: 2 = not sutured, shallow longitudinal fossa for fibrocartilaginous connection.
47. Mandibular symphysis
   0: Fused
   1: not sutured but unfused
   2: not sutured, shallow longitudinal fossa for fibrocartilaginous connection
   3: not sutured, well-developed longitudinal groove for fibrocartilaginous connection
Janjucetus: 2 = not sutured, shallow longitudinal fossa for fibrocartilaginous connection.
48. Mandibular symphysis
   0: Fused
   1: not sutured but unfused
   2: not sutured, shallow longitudinal fossa for fibrocartilaginous connection
   3: not sutured, well-developed longitudinal groove for fibrocartilaginous connection
Janjucetus: 2 = not sutured, shallow longitudinal fossa for fibrocartilaginous connection.
49. Mandibular symphysis
   0: Fused
   1: not sutured but unfused
   2: not sutured, shallow longitudinal fossa for fibrocartilaginous connection
   3: not sutured, well-developed longitudinal groove for fibrocartilaginous connection
Janjucetus: 2 = not sutured, shallow longitudinal fossa for fibrocartilaginous connection.

Orbit
47. Supraorbital process of frontal
   0: Are horizontal or gradually slope lateroventrally away from vertex of skull
   1: abruptly depressed at base to a level noticeably below that of dorsal surface of interorbital region
   2: slope laterodorsally away from vertex
Janjucetus: 0 = Are horizontal or gradually slope lateroventrally away from vertex of skull.
48. Dorsal edge of orbit relative to lateral edge of rostrum
   0: Below the level of the edge of rostrum
   1: orbit low, either in line with edge of rostrum or slightly above it, height of orbit <46% of the height of rostral base, both heights measured relative to the lateral edge of rostrum
   2: orbit low, height of dorsal edge of orbit between 50 and 92% of the rostral height
   3: orbit high, height between 100 and 128% of the rostral height
   4: orbit elevated well above rostrum, orbital height >163% of the rostral height
Janjucetus: 3 = orbit high, height between 100 and 128% of the rostral height.
49. Frontal//Maxilla suture
   0: With skull in lateral view, suture is approximately horizontal, and lateral exposure of frontal over the orbit does not thicken posteriorly
1: angled posterodorsally at an angle of 50-70% from axis or rostrum, lateral exposure of frontal thickens posteriorly
*Janjucetus*: - = N/A.

50. Anterior edge of the supraorbital process
   - 0: Oriented anteromedially
   - 1: oriented slightly anterolaterally, forms an angle <30° with sagittal plane
   - 2: oriented anterolaterally, forms an angle between 35° and 60°
   - 3: oriented anterolaterally or laterally, forms angle between 68° and 90°
   - 4: oriented posterolaterally, forms an angle between 107° and 120°
   - 5: oriented posterolaterally, forms an angle >142°
*Janjucetus*: 3 = oriented anterolaterally or laterally, forms angle between 68° and 90°.

51. Lacrimal
   - 0: Forms small bone on anterior edge of orbit with small orbital portion
   - 1: enlarged both posteromedially and anterolaterally paralleling anterior edge of supraorbital process of frontal, shaped like a thick rod
*Janjucetus*: 1 = enlarged both posteromedially and anterolaterally paralleling anterior edge of supraorbital process of frontal, shaped like a thick rod.

52. Lacrimal
   - 0: Restricted below supraorbital process of frontal
   - 1: wraps around anterior edge of supraorbital process of frontal and slightly overlies its anterior end
   - 2: greatly expanded posterodorsally and covering much of lateral side of supraorbital process of frontal
*Janjucetus*: 0 = Restricted below supraorbital process of frontal.

53. Lacrimal foramen or groove
   - 0: Present
   - 1: absent
*Janjucetus*: 0 = Present.

54. Lacrimal and jugal
   - 0: Separate
   - 1: fused
*Janjucetus*: 0 = Separate.

55. Jugal and lacrimal
   - 0: Jugal and lacrimal contact each other externally
   - 1: lacrimal excluded from edge of skull, jugal directly contacts anterior edge of frontal
*Janjucetus*: 0 = Jugal and lacrimal contact each other externally.

56. Combined anteroposterior length of the lacrimal and jugal exposure that is posterior to antorbital notch
   - 0: With skull in ventral view, exposure is small and combined length forms <31% of anteroposterior distance from antorbital notch to postorbital ridge
   - 1: intermediate, forms between 50 and 92% of that distance
   - 2: large, forms between 62 and 69% that distance
   - 3: very large, forms >77% of that distance
*Janjucetus*: ? = Unknown.

57. Jugal
   - 0: Thick and sturdy
   - 1: thin splint or incomplete or absent
*Janjucetus*: 0 = Thick and sturdy.

58. Dorsolateral edge of internal opening of infraorbital foramen
   - 0: Formed by maxilla
   - 1: formed by maxilla and lacrimal and/or jugal
   - 2: formed by lacrimal and/or jugal
   - 3: formed by frontal
*Janjucetus*: ? = Unknown.

59. Ventromedial edge of internal opening of infraorbital foramen
   - 0: Formed by maxilla
   - 1: formed by maxilla and palatine and/or pterygoid
   - 2: formed by palatine and/or pterygoid
*Janjucetus*: ? = Unknown.

60. Maxillary infraorbital plate
   - 0: Absent
   - 1: present but small
2: present and large
*Janjucetus*: 2 = present and large.

61. Anteriormost point on the posterior edge of the supraorbital process
   0: The anteriormost point is at the lateral edge of the postorbital process
   1: located laterally, between 70 and 74% of transverse distance from sagittal plane to the lateral edge of postorbital process
   2: positioned approximately midway, located between 42 and 61% of that distance
   3: medially positioned, located at a point <34% of that distance
*Janjucetus*: 3 = medially positioned, located at a point <34% of that distance.

62. Postorbital process
   0: Long and projects posterolaterally and slightly ventrally
   1: short and directed ventrally
*Janjucetus*: 0 = Long and projects posterolaterally and slightly ventrally.

63. Anterior edge (orbital margin) of postorbital process of frontal
   0: In dorsal view, forms >130° with sagittal plane
   1: forms 90-120° with sagittal plane
*Janjucetus*: 0 = In dorsal view, forms >130° with sagittal plane.

64. Postorbital ridge
   0: Present, forms well-defined curved ridge on posterior edge of sulcus for optic nerve
   1: no well-defined ridge, region is gently convex
*Janjucetus*: 1 = no well-defined ridge, region is gently convex.

**Facial Region**

65. Facial region of skull, skull in lateral view
   0: Concave
   1: flat
   2: moderately arched dorsally
   3: greatly arched dorsally
*Janjucetus*: 0 = Concave.

66. Infraorbital foramina
   0: single
   1: two
   2: three or more
*Janjucetus*: 1 = two.

67. Rostral basin
   0: Absent or poorly defined
   1: present, situated medial to antorbital notch and anterior to supraorbital process of frontal, best developed medially and ventrally where lateral edge of maxilla is very thin
*Janjucetus*: 1 = present, situated medial to antorbital notch and anterior to supraorbital process of frontal, best developed medially and ventrally where lateral edge of maxilla is very thin.

68. Transverse distance between lateral edges of right and left premaxillae at antorbital notches
   0: Small, distance <48% the width of rostrum at antorbital notches
   1: intermediate, distance between 52 and 64% the antorbital width
   2: wide, distance >78% the antorbital width
*Janjucetus*: 0 = Small, distance <48% the width of rostrum at antorbital notches.

69. Premaxillae immediately anterior to external bony nares
   0: Widely separate with skull in dorsal view, gap between medial edges of premaxillae >63% the maximum width of external bony nares
   1: narrow separation, gap between premaxillae between 56 and 32% the width of external nares
   2: separation absent or nearly so, gap <28% the nares width
*Janjucetus*: 2 = Unknown.

70. Premaxillae anterior to nasal openings
   0: Are flat or concave, form a premaxillary sac fossa (spiracular plate)
   1: convex transversely
   2: form distinct bosses or “premaxillary eminences” with steep posterior faces on anterior edges of nasal openings
*Janjucetus*: 1 = convex transversely.

71. Premaxillary foramina
   0: Absent
1: present and one on right side
2: two on right side
3: three on right side

*Janjucetus*: 0 = Absent.

72. Premaxillary foramen size
   0: Right and left subequal
   1: left larger than right
   2: left much larger than right

*Janjucetus*: - = N/A.

73. Position of premaxillary foramen
   0: Far anterior of antorbital notch and anterior edge of supraorbital process
   1: approximately medial to or posterior to antorbital notch region, which is at the junction of supraorbital
      process with rostrum

*Janjucetus*: - = N/A.

74. Posterolateral sulcus from premaxillary foramen
   0: Sulcus very short or absent
   1: present and short
   2: present and extends to level equivalent to middle of nasal openings

*Janjucetus*: - = N/A.

75. Premaxillae
   0: Restricted to medial position adjacent to mesorostral canal and nasal opening
   1: extended laterally covering much of the supraorbital process

*Janjucetus*: 0 = Restricted to medial position adjacent to mesorostral canal and nasal opening.

76. Posteriormost end of ascending process of premaxilla
   0: Located just anterior to or in a transverse line with anterior edge of supraorbital process of frontal
   1: in line with anterior half of supraorbital process of frontal or halfway point, anteroposteriorly, of supraorbital
      process
   2: in line with posterior half of supraorbital process or postorbital process of frontal
   3: in line with gap between postorbital process and anterior tip of zygomatic process of the squamosal or in line
      with anterior tip of the latter process
   4: in line with space between anterior tip of zygomatic process of squamosal and anterior edge of floor of the
      squamosal fossa or in line with anterior edge of floor of the squamosal fossa
   5: located posterior to the anterior edge of floor of the squamosal fossa

*Janjucetus*: 1 = in line with anterior half of supraorbital process of frontal or halfway point, anteroposteriorly, of
      supraorbital process.

77. Maxillary foramen
   0: Absent
   1: present and one, situated over supraorbital process of frontal
   2: two
   3: foramina absent because roof of canal that carries posterior branches of internal maxillary artery and the
      maxillary division of infraorbital nerve is unossified

*Janjucetus*: 0 = Absent.

78. Maxilla
   0: Abuts anterior edge of supraorbital process of frontal
   1: partially covers supraorbital process
   2: covers almost entire surface

*Janjucetus*: 0 = Abuts anterior edge of supraorbital process of frontal.

79. Posteriormost edge of the ascending process of maxilla
   0: Situated well anterior to anterior edge of orbit
   1: in transverse line with anterior half of supraorbital process of frontal or in line with the halfway point,
      anteroposteriorly, of supraorbital process
   2: in line with posterior half of supraorbital process or in line with postorbital process of frontal
   3: in line with gap between postorbital process and the anterior tip of zygomatic process of squamosal or in line
      with anterior tip of the latter process
   4: in line with space between anterior tip of zygomatic process of squamosal and anterior edge of floor of the
      squamosal fossa or in line with anterior edge of floor of the squamosal fossa
   5: posterior to anterior edge of floor of squamosal fossa

*Janjucetus*: 1 = in transverse line with anterior half of supraorbital process of frontal or in line with the halfway point,
      anteroposteriorly, of supraorbital process.

80. Posterior edge of the ascending process of maxilla
0: In dorsal view, anterior to posterior edge of nasal
1: approximately in transverse line with, or posterior to, posterior edge of nasal

*Janjucetus:* 0 = In dorsal view, anterior to posterior edge of nasal.

81. Anterolateral corner of maxilla overlying supraorbital process of frontal
0: Thin and equal in thickness to parts posteromedial
1: thickened with thinner maxilla in posteromedial direction

*Janjucetus:* = N/A.

82. Maxillary ridge
0: Absent
1: present
2: form transversely compressed and high crest
3: crest arches over and encloses a cavity for the melon

*Janjucetus:* = N/A.

83. Anterior edge of nasals
0: In transverse line with incisors, canines, or intervening diastema
1: in line with P1
2: in line with P2 or about 18% of the total rostral length towards anterior edge of rostrum
3: just anterior to or in line with anterior edge of supraorbital process of frontal
4: in line with anterior half of supraorbital process of frontal or in line with the halfway point, anteroposteriorly, of supraorbital process
5: in line with posterior half of supraorbital process or in line with postorbital process of frontal
6: in line with gap between postorbital process of frontal and the anterior tip of the zygomatic process of squamosal or in line with the anterior tip of the latter process
7: in line with space between the anterior tip of zygomatic process of squamosal and anterior edge of the floor of squamosal fossa or in line with anterior edge of the floor of squamosal fossa
8: posterior to the anterior edge of the floor of the squamosal fossa

*Janjucetus:* = Unknown.

84. Anterior edge of nasal openings
0: V-shaped, premaxillae gradually converge anteriorly to the midline
1: U-shaped, premaxillae abruptly converge anteriorly to the midline

*Janjucetus:* = Unknown.

85. Maxillae
0: In region anterior to nasal openings, maxillae are exposed lateral to premaxillae
1: maxillae are exposed at posterior end of roof of mesorostral canal, medial to the premaxillae and nearly converge on midline
2: same as 1 except maxilla also exposed on anterior edge of nasal openings

*Janjucetus:* 0 = In region anterior to nasal openings, maxillae are exposed lateral to premaxillae.

86. Ossicles
0: Absent
1: present, occur in anteromedial corners of nasal openings, probably a derivative of the maxilla

*Janjucetus:* 0 = Absent.

87. Right premaxilla
0: Posterior edge approximately in line with posterior edge of left premaxilla
1: right premaxilla extended distinctly further than left
2: right extended much further than left

*Janjucetus:* 0 = Posterior edge approximately in line with posterior edge of left premaxilla.

88. Transverse width of right premaxilla immediately anterior to external bony nares
0: Distinctly narrower than left premaxilla
1: subequal, width of right premaxilla within 10% of the width of left premaxilla
2: right wider, width is between 130 and 145% the width of the left
3: right much wider, width >167% the width of the left

*Janjucetus:* 1 = subequal, width of right premaxilla within 10% of the width of left premaxilla.

89. Right premaxilla
0: Portion posterior to nasal openings wider than portion anterior to opening, with nasal septum angled anteriorly and to the right
1: portion anterior wider than portion posterior to nasal opening, septum angled anteriorly and to the left

*Janjucetus:* = N/A.

90. Osseous external nasal openings
0: Left and right are the same size
1: left is twice or more the size of the right
91. Supracranial basin
0: Absent
1: present
Janjucetus: 0 = Absent.
92. Posterior end of premaxilla
0: Posterior end adjacent to lateral edge of nasal opening
1: angled slightly laterally resulting in the following sequence, from lateral to medial, in one transverse plane:
premaxilla, maxilla, anterior edge of nasals, or mesethmoid
Janjucetus: 0 = Posterior end adjacent to lateral edge of nasal opening.
93. Angle of premaxillae anterior to external bony nares, skull in lateral view
0: Low angle, premaxillae form an angle <28° with the lateral edge of rostrum
1: intermediate angle, form an angle between 30 and 40°
2: high angle, form an angle >45°
Janjucetus: 0 = Low angle, premaxillae form an angle <28° with the lateral edge of rostrum.
94. Premaxillae adjacent to nasal opening
0: Thin dorsoventrally and porous internally
1: pachyostotic, in direction perpendicular to face, and pachyosteosclerotic but nasals and premaxillae equally
project dorsally and anteriorly
2: extreme pachyostosis, premaxillae adjacent to nasals project further outward, anteriorly and dorsally
95. Proximal ethmoid region
0: Not visible in dorsal view, roofed over by nasals
1: exposed dorsally
Janjucetus: 0 = Not visible in dorsal view, roofed over by nasals. 
96. Mesethmoid
0: Forms T-shaped bone with median plate separating right and left nasal passages, not all of the dorsal part is
divided by median plate
1: bears expanded posterodorsal plate which is not divided by median plate, median plate situated more
ventrally

Vertex and Area Adjacent to Nares
97. Inflection of ascending process of premaxilla
0: Gradual with premaxilla in dorsal view smoothly tapering as premaxilla shifts from a horizontal to a mostly
vertical position
1: abrupt with an anterior splint of maxilla that emarginates the posterior edge of premaxilla and splits it into a
posterolateral plate and posteromedial splint
Janjucetus: 0 = Gradual with premaxilla in dorsal view smoothly tapering as premaxilla shifts from a horizontal to a
mostly vertical position.
98. Position of inflection of premaxilla
0: In transverse line with P1
1: in line with P2 or about 18% of total rostral length towards anterior edge of rostrum
2: just anterior to or in line with anterior edge of supraorbital process of frontal
3: in line with anterior half of supraorbital process of frontal or in line with the halfway point, anteroposteriorly,
of supraorbital process
4: in line with posterior half of supraorbital process or in line with postorbital process of frontal
5: in line with gap between postorbital process and the anterior tip of zygomatic process of squamosal or in line
with the anterior tip of the latter process, space is absent in some taxa
6: in line with space between the anterior tip of the zygomatic process of squamosal and anterior edge of floor
of the squamosal fossa
7: posterior to anterior edge of the floor of the squamosal fossa
Janjucetus: 1 = in transverse line with P1. 
99. Premaxillary cleft
0: Absent
1: present, posterior part of ascending process of premaxilla bears a distinct cleft that originates from at
posterior edge of the premaxilla and continues anteriorly dividing the premaxilla in two
2: present but cleft is shallow
Janjucetus: 0 = Absent.
100. Premaxillae adjacent to and at posterior edge of the nasal opening
   0: Do not clearly overhang maxillae
   1: premaxillae overhang maxillae
   2: premaxillae greatly enlarged laterally, region between lateral edge of the right premaxilla and supraoccipital
      is partially enclosed
Janjucetus: 0 = Do not clearly overhang maxillae.

101. Narial pit
   0: Absent
   1: present, an anterior extension of nasal passage and forms a blind pocket in the maxilla just dorsal to maxilla
      and palatine suture; medial wall of pocket is formed by vomer

102. Posterior end of the ascending process of premaxillae
   0: Face anterolaterally
   1: face anteriorly
   2: face anteromedially
Janjucetus: 1 = face anteriorly.

103. Nasal bones
   0: Two
   1: one
   2: none
Janjucetus: 0 = Two.

104. Suture between right and left nasals and right and left frontals
   0: Shifted towards right side
   1: situated on midline
   2: shifted towards left side
Janjucetus: 1 = situated on midline.

105. Dorsoventral thickness of anterior edge of nasal
   0: Very thin, nasal thickness <82% of the anterior nasal width
   1: thick, nasal thickness between 100 and 173% of the nasal width
   2: very thick, >200% the nasal width

106. Both nasals in dorsal view
   0: Anterior edges are straight in one transverse plane
   1: with point on midline and a gap on each side between premaxilla and nasal

107. Nasal
   0: Elongate anteroposterior plate or blocky
   1: anteroposteriorly compressed into a nearly vertical plate with fossa on ventrolateral surface for posterior
      nasal sac
   2: fossa well-excavated with boss delimiting dorsal edge
Janjucetus: 0 = Elongate anteroposterior plate or blocky.

108. Nasals
   0: Medial portions roughly in same horizontal plane as lateral portions or higher
   1: medial portions greatly depressed forming a median trough immediately posterior to nasal openings
Janjucetus: 0 = Medial portions roughly in same horizontal plane as lateral portions or higher.

109. Maximum transverse width of both nasals
   0: Very narrow, <37% of the maximum width of the external bony nares
   1: narrow, width between 55 and 89% of the nares width
   2: within 10% of the nares width
   3: wide, width between 123 and 140% the nares width
   4: very wide, between 152 and 160% the nares width
   5: extremely wide, width >188% the width of external bony nares
Janjucetus: 2 = within 10% of the nares width.

110. Combined width of posterior edge of nasals
   0: Wide, width >150% the maximum width of external bony nares
   1: subequal to external nares, width between 85 and 135% the nares width
   2: narrow, width between 79 and 50% the nares width
   3: very narrow, width between 44 and 39% the nares width
   4: extremely narrow, width <31% the nares width
Janjucetus: 1 = subequal to external nares, width between 85 and 135% the nares width.
111. Nasal/Frontal suture
   0: Approximately straight transversely
   1: frontal has anterior wedge between posterior ends of nasals
   \textit{Janjucetus}: 1 = frontal has anterior wedge between posterior ends of nasals.

112. Position of posteriormost edge of nasals
   0: Just anterior to or in a transverse line with anterior edge of supraorbital process of frontal
   1: in line with anterior half of supraorbital process of frontal or in line with the halfway point, anteroposteriorly, of supraorbital process
   2: in line with posterior half of supraorbital process or in line with postorbital process of frontal
   3: in line with gap between postorbital process and the anterior tip of zygomatic process of squamosal or in line with the anterior tip of the latter process
   4: between anterior tip of zygomatic process of squamosal and anterior edge of the floor of the squamosal fossa
   5: posterior to the anterior edge of the floor of the squamosal fossa
   \textit{Janjucetus}: 1 = in line with anterior half of supraorbital process of frontal or in line with the halfway point, anteroposteriorly, of supraorbital process.

113. Height of posterior portions of nasals relative to lateral edge of maxilla
   0: Approximately equal to height of the base of rostrum; nasal height between 92 and 139% the rostral height
   1: elevated above rostrum, height between 156 and 203% the rostral height
   2: very elevated, height of nasals between 229 and 282% the rostral height
   3: extremely elevated, height of nasals between 354 and 420% the rostral height
   4: nasals tower above facial part of skull, height of nasals >548% the rostral height
   \textit{Janjucetus}: 0 = Approximately equal to height of the base of rostrum; nasal height between 92 and 139% the rostral height.

114. Frontals
   0: Lower than nasals
   1: same height as nasals
   2: higher than nasals
   \textit{Janjucetus}: 2 = higher than nasals.

115. Frontals posterior to nasals and between the premaxillae
   0: Wider than maximum transverse width across nasals
   1: same width as nasals
   2: narrower than nasals, maxillae expanded medially posterior to nasals
   \textit{Janjucetus}: - = N/A.

116. Dorsal exposure of frontals
   0: Fairly flat with separation between right and left frontal obscure
   1: frontals are nodular with distinct separating sulcus on midline
   \textit{Janjucetus}: 0 = Fairly flat with separation between right and left frontal obscure.

117. Anterodorsal wall of braincase
   0: Formed by frontal
   1: mostly formed by maxilla
   \textit{Janjucetus}: 0 = Formed by frontal.

118. Supraoccipital
   0: Below frontals and or nasals, whichever is higher
   1: at same level as frontals and or nasals
   2: higher than frontals and or nasals
   \textit{Janjucetus}: 2 = higher than frontals and or nasals.

119. Maxilla on dorsal surface of skull
   0: Does not contact supraoccipital posteriorly, maxilla separated by frontal and or parietal
   1: contact present
   \textit{Janjucetus}: 0 = Does not contact supraoccipital posteriorly, maxilla separated by frontal and or parietal.

**Temporal Fossae, Zygoma, Occiput**

120. Temporal crest
   0: Dorsal surface adjacent to crest is nearly horizontal, crest appears to be directed laterally
   1: dorsal surface is concave and surface of temporal fossa below crest faces almost entirely laterally, crest appears to be oriented dorsolaterally
   \textit{Janjucetus}: 0 = Dorsal surface adjacent to crest is nearly horizontal, crest appears to be directed laterally.

121. Temporal crest
   0: In posterior position, frontal roofs over the anterior third or more of temporal fossa
1. on posterior edge of supraorbital process of frontal
2. lateral end of temporal crest on dorsal surface of supraorbital process
3. entire crest on dorsal surface of supraorbital process

Janjucetus: 2 = lateral end of temporal crest on dorsal surface of supraorbital process.

122. Roof of temporal fossa
0: Frontal
1: frontal but with large opening through which maxilla and or premaxilla is exposed, margins of the window are formed by a frontal ring

Janjucetus: = N/A.

123. Frontal/parietal suture in lateral view
0: Vertical or slightly angled posterovertrally
1: dorsal portion of suture pointed and extended far anterior so that the anteriormost point of parietal is anterior to the posteriormost point of premaxilla

Janjucetus: 0 = Vertical or slightly angled posterovertrally.

124. Parietals in dorsal view
0: Contact each other on the midline or are separated by an interparietal
1: are in place in the skull roof but are visible only as small triangular areas at edges of the intertemporal constriction, supraoccipital overlaps median portions of parietals and obscures them
2: are completely absent in the skull roof
3: visible only as triangular areas dorsolateral to supraoccipital, supraoccipital does not overlap parietals but separates and contacts them along an irregular suture

Janjucetus: 0 = Contact each other on the midline or are separated by an interparietal.

125. Interparietal
0: Present
1: absent or fused so that it is not distinguishable from parietals and frontals

Janjucetus: 1 = absent or fused so that it is not distinguishable from parietals and frontals.

126. Cross section through intertemporal region, including parietals
0: Ovoid cross section with sagittal crest
1: ovoid but sagittal crest absent
2: pinched ventrally and dorsal part expanded laterally, expanded part is rounded over in cross section
3: dorsal part is greatly expanded, overhangs more ventral portions, and lateral edge of dorsal surface is a sharp ridge

Janjucetus: 0 = Ovoid cross section with sagittal crest.

127. Length of intertemporal region, ventral view of skull roof with basicranium removed
0: Intertemporal region absent or short, canal in frontals that contained olfactory stem and bulbs is <10% of the length from posterior edge of dorsal nasal sinuses to posterior edge of skull
1: long, canal is between 18 and 35% of that length
2: very long, canal >44% of that length


128. Dorsoventral thickness of intertemporal region
0: Thin, thickness is <25% the maximum height of skull, as measured from intercondylar notch to dorsalmost point of the supraoccipital
1: thick, thickness between 30 and 43% of the skull height
2: very thick, thickness >54% of the skull height

Janjucetus: 2 = very thick, thickness >54% of the skull height.

129. Anteriormost point of the supraoccipital, in dorsal view
0: In transverse line with space between posterior edge of skull and anterior edge of the floor of squamosal fossa
1: in line with space between anterior edge of the floor of squamosal fossa and the anterior tip of zygomatic process of squamosal
2: in line with gap between anterior edge of zygomatic process of squamosal and the anteriormost point along posterior edge of the supraorbital process of frontal
3: in line with supraorbital process of frontal
4: in line with or anterior to anterior edge of supraorbital process of frontal; anterior edge of supraorbital process is taken at its medialmost point

Janjucetus: 0 = In transverse line with space between posterior edge of skull and anterior edge of the floor of squamosal fossa.

130. Pronounced bulge anterior to alisphenoid exposure in temporal fossa
0: Absent
1: present

131. Alisphenoid
0: Broadly exposed laterally in temporal fossa
1: lateral surface is broadly overlapped by parietal so that only a narrow strip on the ventral edge of temporal fossa is visible in lateral view


132. Zygomatic process of squamosal
0: Directed anteriorly
1: directed anterolaterally

Janjucetus: 0 = Directed anteriorly.

133. Dorsal edge of zygomatic process, skull in lateral view
0: Gently convex dorsally
1: near anterior end there is a distinct dorsal flange or process, flange usually articulates with frontal
2: concave dorsally

Janjucetus: 0 = Gently convex dorsally.

134. Emargination of posterior edge of zygomatic process by sternomastoid muscle fossa, skull in lateral view
0: Absent, posterior edge forms nearly a right angle with dorsal edge of zygomatic process of squamosal
1: slight emargination
2: deep emargination

Janjucetus: 1 = slight emargination.

135. Width of squamosal lateral to exoccipital, skull in posterior view
0: Narrow, exposed portion of squamosal <14% the distance between sagittal plane and lateral edge of exoccipital
1: intermediate width, width between 16 and 35% of that distance
2: wide, width between 40 and 55% of that distance
3: very wide, width >129% the distance between sagittal plane and lateral edge of exoccipital

Janjucetus: 1 = intermediate width, width between 16 and 35% of that distance.

136. Depth of squamosal fossa
0: Absent or very shallow, depth of fossa <52% the horizontal distance from dorsal edge of zygoma to the point above deepest part of squamosal fossa
1: shallow, depth between 55 and 91% that distance
2: deep, depth between 98 and 168% that distance
3: very deep, depth greater than 180% that distance

Janjucetus: 3 = very deep, depth greater than 180% that distance.

137. Longitudinal profile of floor of squamosal fossa
0: Highly sigmoidal, concave posteriorly in region of a secondary squamosal fossa but convex anteriorly
1: slightly sigmoidal, posterior part concave but does not form a discrete pit
2: flat
3: convex

Janjucetus: 2 = flat.

138. Floor of squamosal fossa
0: Same dorsoventral thickness anteriorly and posteriorly
1: thickens posteriorly

Janjucetus: 0 = Same dorsoventral thickness anteriorly and posteriorly.

139. Squamosal prominence
0: Absent
1: present, forms a medial projection on crest that forms the lateral edge of squamosal fossa, is continuous with a dorsoventral ridge on lateral wall of the squamosal fossa

Janjucetus: 0 = Absent.

140. Ventral edge of zygomatic process of squamosal in lateral view
0: Concave ventrally
1: straight
2: convex ventrally

Janjucetus: 0 = Concave ventrally.

141. Postglenoid process in lateral view
0: Tapers ventrally to a point
1: anterior and posterior sides nearly parallel with squared-off ventral end
2: same as state “1” except anteroposterior diameter of postglenoid process is very wide

Janjucetus: 0 = Tapers ventrally to a point.

142. Anterior edge of supraoccipital in dorsoposterior view
0: Triangular, pointed anteriorly
1: semicircular
2: rectangular
*Janjucetus*: 1 = semicircular.

143. Nuchal crests of supraoccipital
0: Horizontal and directed laterally, overhanging temporal fossae
1: directed dorsolaterally, not or only slightly overhanging temporal fossae
2: very low and not directed either way
*Janjucetus*: 1 = directed dorsolaterally, not or only slightly overhanging temporal fossae.

144. Posteromedial wall of temporal fossa
0: Visible in dorsal view
1: hidden in dorsal view by lateral edges of supraoccipital
*Janjucetus*: - = N/A.

145. Occipital shield
0: Smoothly convex or concave
1: bears distinct sagittal crest
*Janjucetus*: 1 = bears distinct sagittal crest.

146. Dorsal condyloid fossa
0: Absent
1: present, situated anterodorsal to dorsal edge of condyle
2: present and forms a deep pit
*Janjucetus*: 1 = present, situated anterodorsal to dorsal edge of condyle.

**Anterior Basicranium**

147. Anterior sinus
0: Absent
1: present but short
2: elongate with corresponding trough on maxilla
*Janjucetus*: 1 = present but short.

148. Palatine
0: Relatively thin, floors posterior part of nasal cavity
1: thick, forms part of the anterior wall of the nasal cavities
*Janjucetus*: 0 = Relatively thin, floors posterior part of nasal cavity.

149. Palatines
0: Exposed ventrally
1: partially covered by pterygoid dividing it into medial and lateral exposures
2: ventral surfaces covered completely by pterygoids
*Janjucetus*: 0 = Exposed ventrally.

150. Palatine
0: Ventral surface flat or convex
1: bears fossa for anterior end of pterygoid sinus
2: fossa well-developed, divides palatine into medial and lateral laminae
*Janjucetus*: 0 = Ventral surface flat or convex.

151. Lateral lamina of palatine
0: Free from or sutured to maxilla
1: fused to maxilla
*Janjucetus*: - = N/A.

152. Pterygoid/palatine suture in ventral view
0: Angled anterolaterally
1: nearly transverse, pterygoid forms a substantial part of subtemporal crest
2: angled anteromedially
*Janjucetus*: 0 = Angled anterolaterally.

153. Pterygoid sinus fossa
0: Absent or cannot be distinguished from anterior part of fossa for cavum tympani
1: present, anterior edge approximately in line with anterior edge of foramen ovale
2: present and extended well anterior to foramen ovale
3: extended anterior to anterior edge of orbit
*Janjucetus*: 2 = present and extended well anterior to foramen ovale.

154. Lateral lamina (outer plate or external duplication) of pterygoid
0: Present
1: partial, restricted to region lateral to the hamular process
2: absent

Janjucetus: 0 = Present.

155. Subtemporal crest
0: Present on alisphenoid and or pterygoid, marks lateral edge of pterygoid fossa
1: subtemporal crest absent, pterygoid fossa extended laterally into orbital region

Janjucetus: 0 = Present on alisphenoid and or pterygoid, marks lateral edge of pterygoid fossa.

156. Inferior lamina of pterygoid
0: Absent or restricted to extreme anterior edge of pterygoid sinus cavity
1: present and floors most of sinus cavity


157. Superior lamina of pterygoid
0: Present and covers most of ventral exposure of alisphenoid
1: absent from the sphenoidal region but present in orbital region
2: partially absent from orbital region
3: completely absent from orbital region


158. Posterior part of pterygoid sinus fossa, region immediately anterior to exit for mandibular branch of trigeminal nerve
0: One single fossa
1: Split into a smaller and shallower posterior fossa and a much larger anteriorly extended deeper fossa by a low ridge
2: same as state "1" except divided by a high ridge

Janjucetus: 0 = One single fossa.

159. Preorbital lobe of pterygoid sinus
0: Absent
1: present but small
2: present and enlarged
3: enlarged and forms distinct excavation anterior to optic foramen
4: enlarged and extended posterodorsally over frontals to be roofed by maxilla


160. Postorbital lobe of pterygoid sinus
0: Absent
1: present but small
2: present and enlarged
3: enlarged and forms prominent fossa on ventral surface of supraorbital process of frontal posterior to optic foramen


161. Coalescence of preorbital and postorbital lobes of pterygoid sinus dorsal to optic nerve
0: Absent
1: present


162. Hamular process of the pterygoid
0: Splint-like
1: solid, long, and subconical
2: hollow and excavated by pterygoid sinus, lateral side highly concave, may or may not have lateral and inferior laminae
3: form thin horizontal plates
4: absent


163. Hamular processes of pterygoids
0: Rounded over in ventral view
1: bear anteroposterior keels


164. Posteriormost point of hamular process of pterygoid, or medial part of pterygoid if the hamular process is absent
0: In transverse line with the middle or orbit
1: in line with postorbital process
2: in line with anterior edge of zygomatic process of squamosal
3: in line with middle of zygomatic process
4: in line with the postglenoid process

Posterior Basicranium
165. Fossa for pterygoid sinus on alisphenoid posterior to groove for mandibular branch of trigeminal nerve
0: Absent, bone is flat or not ossified because of enlarged internal foramen ovale
1: shallow fossa
2: deep subcircular fossa
Janjucetus: 0 = Absent, bone is flat or not ossified because of enlarged internal foramen ovale.
166. Falciform process of squamosal
0: Plate-like with a wide, anteroposteriorly, base
1: rod-like with narrow base
2: poorly developed or absent
Janjucetus: 0 = Plate-like with a wide, anteroposteriorly, base.
167. Falciform process of the squamosal
0: Medial surface sutured to lateral lamina of pterygoid
1: not sutured
168. Tymanosquamosal recess
0: Absent
1: absent but a small rectangular fossa for sigmoid process of the tympanic present, its long axis is transverse, and it is located medial to postglenoid process of squamosal
2: present and enlarged, forms a triangular fossa medial and anteromedial to postglenoid process
3: very large, forms large fossa that borders entire medial edge of glenoid fossa
Janjucetus: 1 = absent but a small rectangular fossa for sigmoid process of the tympanic present, its long axis is transverse, and it is located medial to postglenoid process of squamosal.
169. Lateral edge of middle sinus
0: Smooth
1: deckle-edged
170. Position of alisphenoid/squamosal suture, skull in ventral view
0: Anterior to external foramen of foramen ovale or homologous groove
1: courses along groove for mandibular branch of trigeminal nerve, or just posterior to it
2: just medial to anterior edge of floor of squamosal fossa, foramen ovale, and or groove situated entirely on alisphenoid
Janjucetus: 0 = Anterior to external foramen of foramen ovale or homologous groove.
171. Groove for mandibular branch of trigeminal nerve
0: Directed laterally and is entirely posterior to pterygoid sinus fossa
1: lateral end of groove wraps laterally around the posterior end of the pterygoid sinus fossa and opens primarily anteriorly
Janjucetus: 0 = Directed laterally and is entirely posterior to pterygoid sinus fossa.
172. Ventral part of squamosal posterior to postmeatic process
0: Large area of laminated bone, appears externally as multiple sutures
1: small area of laminated bone restricted to ventrolateral edge of squamosal
2: without laminated bone
173. Cranial hiatus
0: Absent, periotic contacts basioccipital medially or partially separated by narrow fissure
1: present but constricted, a medial projection of parietal partially divides fenestra
2: absent, parietal contacts basisphenoid and or basioccipital dividing fenestra in two
3: present, wide space between basioccipital and both petrosal and squamosal
Janjucetus: 3 = present, wide space between basioccipital and both petrosal and squamosal.
174. Periotic fossa
0: Bowl-shaped
1: has transverse ridge that divides it into anterior and posterior portions
175. Suprameatal pit of squamosal
0: Absent
1: present but shallow, situated dorsolateral to spiny process of squamosal
2: forms a deep dorsolateral excavation into squamosal
176. Foramen spinosum
   0: Absent
   1: present, located in anteromedial corner of anterior part of periotic fossa near or on squamosal parietal suture
177. Posterior portion of periotic fossa
   0: Posteromedial part contains a deep, large fossa
   1: fossa present but shallow
   2: fossa is highly compressed and forms a narrow slit or a small blind foramen
   3: fossa absent, posterior portion of the periotic fossa is of uniform depth
178. Zygomatic process of squamosal
   0: Very short, length of process <92% of the maximum width of glenoid fossa
   1: short, length between 103 and 162% of glenoid width
   2: intermediate length, length between 171 and 189% of the glenoid width
   3: long, length between 198 and 271% of glenoid width
   4: very long, length >300% of the width of glenoid fossa
179. External acoustic meatus
   0: Wide
   1: narrow
Janjucetus: 0 = Wide.
180. Vomer
   0: Posterior edge terminates on or at anterior edge of basisphenoid
   1: terminates on basioccipital covering basisphenoid suture ventrally
Janjucetus: 1 = terminates on basioccipital covering basisphenoid suture ventrally.
181. Basioccipital crest
   0: Narrow transversely
   1: wide and bulbous
Janjucetus: 1 = wide and bulbous.
182. Rectus capitus anticus muscle fossa
   0: Absent or poorly developed
   1: present with a well-defined anterior edge
Janjucetus: 0 = Absent and poorly developed.
183. Posteroventralmost point of basioccipital crest
   0: Rounded over
   1: forms a closely adjacent separate flange, a narrow crease separates it dorsally from rest of basioccipital crest
   2: distinct flange that projects posteriorly
   3: distinct but separated by a pronounced notch that interrupts basioccipital crest
Janjucetus: 0 = Rounded over.
184. Angle formed by the basioccipital crests in ventral view
   0: Parallel with no angle formed
   1: 15-40°
   2: 45-68°
   3: 74-90°
   4: >100°
Janjucetus: 2 = 45-68°.
185. Hypoglossal foramen
   0: Thick bone separating it from jugular foramen, or jugular notch
   1: separating bone very thin or absent, in the latter case hypoglossal foramen becomes confluent with jugular foramen
Janjucetus: ? = unknown.
186. Jugular notch, gap between paroccipital process and basioccipital crest
   0: Open notch, opening and depth of the notch are roughly equal
   1: narrow and almost slit-like, depth is much greater than width of opening
Janjucetus: 0 = Open notch, opening and depth of the notch are roughly equal.
187. Paroccipital process, skull in ventral view
   0: Angled posterolaterally, extends posterior to posteriormost edge of condyle
   1: posterior edge in transverse line with posterior edge of condyle
2: posterior edge is well anterior to posterior edge of condyle

*Janjucetus*: 2 = posterior edge is well anterior to posterior edge of condyle.

**Malleus**

188. Tuberculum of the malleus

0: Unreduced
1: highly reduced, almost indistinguishable from articular head

*Janjucetus*: ? = Unknown.

189. Processus muscularis of malleus

0: Processus muscularis shorter than manubrium of malleus
1: subequal
2: processus muscularis longer than manubrium

*Janjucetus*: ? = Unknown.

**Periotic**

190. Apex of anterior process of the periotic

0: In ventral or dorsal view blunt or pointed
1: bears tubercle

*Janjucetus*: 0 = In ventral view or dorsal view blunt or pointed.

191. Anterior process in lateral view

0: Anterior edge of anterior process squared off
1: comes to a blunt apex
2: comes to a slender point

*Janjucetus*: 0 = Anterior edge of anterior process squared off.

192. Apex of anterior process of the periotic

0: At same level or dorsal to ventral edge of pars cochlearis
1: well ventral to ventral edge of the pars cochlearis, process appears to be ventrally deflected

*Janjucetus*: 0 = At same level or dorsal to ventral edge of pars cochlearis.

193. Length of anterior process of the periotic

0: Absent
1: present but very short, length <36% of the length of pars cochlearis
2: short, length between 59 and 94% of the promontorial length
3: nearly the same length of pars cochlearis, length between 100 and 134% of the promontorial length
4: long, length between 141 and 174% of the promontorial length
5: very long, length >212% of the length of the pars cochlearis

*Janjucetus*: 3 = nearly the same length of pars cochlearis, length between 100 and 134% of the promontorial length.

194. Anterior process in lateral view

0: Ventral edge convex ventrally or nearly flat
1: ventral edge clearly concave

*Janjucetus*: 0 = Ventral edge convex ventrally or nearly flat.

195. Anteroexternal sulcus

0: Absent
1: present on lateral surface of anterior process of periotic, oriented primarily anteroposteriorly but bowed ventrally

*Janjucetus*: ? = Unknown.

196. Sulcus for capsuloparietal emissary vein

0: Present, forms a dorsoventral groove on lateral side of anterior process immediately anterior to lateral tuberosity
1: absent

*Janjucetus*: 0 = Present, forms a dorsoventral groove on lateral side of anterior process immediately anterior to lateral tuberosity.

197. Articulation of anterior process with squamosal

0: Extensive, most of lateral side contacts squamosal
1: large centrally oriented ovoid region contacts squamosal, free around edges
2: contact is very small
3: contact is absent, articularates via ligaments

*Janjucetus*: 1 = large centrally oriented ovoid region contacts squamosal, free around edges.

198. Shape of cross section through anterior process at midlength

0: Highly elliptical, transverse diameter is <36% the dorsoventral diameter
1: ovoid, transverse diameter is between 51 and 78% of the dorsoventral diameter
2: approximately circular, transverse diameter between 85 and 134% of the dorsoventral diameter
3: bulbous, transverse diameter >141% of the dorsoventral diameter

*Janjucetus:* 1 = ovoid, transverse diameter is between 51 and 78% of the dorsoventral diameter.

199. Contact of anterior process of periotic with portion of ectotympanic bulla anterior to accessory ossicle
   0: Absent
   1: present but no clear fossa for articulation on periotic
   2: anterior bullar facet present but shallow with poorly defined medial edge
   3: present with well-defined medial and lateral edges

*Janjucetus:* 1 = present but no clear fossa for articulation on periotic.

200. Flange of anterior process of periotic
   0: Absent
   1: present

*Janjucetus:* 0 = Absent.

201. Lateral tuberosity
   0: Absent
   1: present, forms a bulbous prominence lateral to fossa for malleus
   2: present and elongate, forms a lateral process that articulates dorsally with squamosal

*Janjucetus:* 2 = present and elongate, forms a lateral process that articulates dorsally with squamosal.

202. Emargination of lateral edge of periotic by hiatus epitympanicus
   0: With periotic in ventral view, emargination is narrow and is situated slightly anterior to base of posterior process
   1: emargination is wide and approximately in line with gap between fenestrae ovalis and rotunda

*Janjucetus:* 0 = With periotic in ventral view, emargination is narrow and is situated slightly anterior to base of posterior process.

203. Fossa incudis
   0: Poorly defined or cannot be differentiated from rest of epitympanic recess
   1: forms a clear circular fossa
   2: circular fossa present on a short pedestal, the incudal process

*Janjucetus:* ? = Unknown.

204. Mallear fossa
   0: Present
   1: absent or poorly developed

*Janjucetus:* 0 = Present.

205. Ventrolateral ridge of periotic
   0: Absent
   1: present
   2: present and expanded

*Janjucetus:* 0 = Absent.

206. Lateral side of periotic
   0: Entire side of periotic contains pitted and rugose bone
   1: all but anterior process is rugose
   2: lateral side of posterior process of periotic is pitted and rugose, remaining portions are smooth
   3: entire side of periotic is smooth

*Janjucetus:* ? = Unknown.

207. Origin of tensor tympani muscle
   0: Deep, pocket-like fossa with anterior groove
   1: anterior groove only
   2: broad, poorly defined origin without a clear groove

*Janjucetus:* 1 = anterior groove only.

208. Angle between anterior process of periotic and anterior edge of pars cochlearis
   0: Obtuse, pars cochlearis appears transversely compressed
   1: nearly 90°, pars cochlearis looks rectangular or semicircular in ventral view
   2: acute, pars cochlearis looks globular

*Janjucetus:* 0 = Obtuse, pars cochlearis appears transversely compressed.

209. Anteromedial corner of pars cochlearis
   0: Rounded
   1: angular

*Janjucetus:* 0 = Rounded.

210. Pars cochlearis
0: Most convex part is on ventrolateral surface
1: most convex part is on medial surface. Area of greatest convexity begins anteromedial to fenestra rotunda and extends anterodorsally on the medial face. With periotic in dorsal view, there is a wide expanse of bone medial to internal acoustic meatus

*Janjucetus*: 0 = Most convex part is on ventrolateral surface.

211. Ridge on anterolateral side of pars cochlearis, periotic in ventral view
0: Present and high, forms an anteroposterior ridge that also forms the medial edge of a trough for tensor tympani muscle
1: present and low
2: absent

*Janjucetus*: 1 = present and low.

212. Fenestra rotunda
0: Oval
1: shaped like a teardrop with a fissure directed towards the perilymphatic foramen

*Janjucetus*: 1 = shaped like a teardrop with a fissure directed towards the perilymphatic foramen.

213. Posterodorsal edge of stapedius muscle fossa
0: Ventral to or in line with dorsal edge of fenestra rotunda
1: well dorsal to fenestra rotunda

*Janjucetus*: ? = Unknown.

214. Stylo mastoid fossa
0: Absent
1: present, situated on posterior face of pars cochlearis posterodorsal to stapedial muscle fossa
2: enlarged dorsally and medially, covers much of posterior face of pars cochlearis
3: enlarged posterolaterally on to posterior process of the periotic

*Janjucetus*: 3 = enlarged posterolaterally on to posterior process of the periotic.

215. Caudal tympanic process of the periotic
0: Prominent, its ventral and posterior edges form a right angle in medial view
1: low, its ventral and posterior edges are joined by a smooth curve

*Janjucetus*: 1 = low, its ventral and posterior edges are joined by a smooth curve.

216. Caudal tympanic process of the periotic in posteromedial view
0: Well separated from crista parotica, no division between stapedial muscle fossa and stylomastoid foramen
1: narrow separation or contact, clear separation of stapedial muscle fossa and stylomastoid foramen

*Janjucetus*: 1 = narrow separation or contact, clear separation of stapedial muscle fossa and stylomastoid foramen.

217. Perilymphatic foramen
0: Smaller than endolymphatic foramen
1: approximately the same size
2: much larger with narrow posterior edge

*Janjucetus*: ? = Unknown.

218. Distance between perilymphatic foramen and fenestra rotunda
0: No distance, both apertures are confluent
1: narrow, distance <89% of the distance between fenestra ovalis and fenestra rotunda
2: wide, distance between 96 and 122% of the space between fenestrae ovalis and rotunda
3: very wide, distance >146%

*Janjucetus*: ? = Unknown.

219. Distance between endolymphatic foramen and fenestra rotunda
0: Very narrow, distance <112% of the distance between fenestra ovalis and fenestra rotunda
1: narrow, distance between 121 and 185%
2: wide, distance between 192 and 211%
3: very wide, distance >222% the distance between fenestra ovalis and fenestra rotunda

*Janjucetus*: ? = Unknown.

220. Elongation of pars cochlearis towards cranial cavity, dorsally and medially
0: Absent
1: present, inner porous bone expanded towards cranial cavity
2: present, outer periosteal bone of pars cochlearis expanded towards cranial cavity

*Janjucetus*: ? = Unknown.

221. Excavation of tegmen tympani at base of anterior process
0: Absent
1: present, fossa on dorsolateral side of tegmen tympani

*Janjucetus*: ? = Unknown.

222. Dorsal edge of tegmen tympani dorsolateral to internal acoustic meatus and anterior process
0: Present and high, dorsoventral height >114% the width of pars cochlearis
1: present, height between 58 and 34% of promontorial width
2: low, height between 23 and 11%
3: forms a low ridge or is absent, height <4% of the width of pars cochlearis


223. Dorsal edge of tegmen tympani lateral to endolymphatic foramen
0: Present and very high, dorsoventral height >112% of the width of pars cochlearis
1: high, height between 95 and 50% the promontorial width
2: low, height between 12 and 4%
3: faint ridge
4: absent


224. Fundus of internal acoustic meatus
0: Funnel like, smaller at the blind end and wide near the rim
1: tubular


225. Lateral wall of internal acoustic meatus
0: Low, does not protrude noticeably from suprameatal fossa and surrounding bone
1: high, a wedge-shaped area of elevated bone occurs between dorsal edge of tegmen tympani and internal acoustic meatus, extending the latter ventrally and increasing its depth


226. Vestibular foramen
0: In common recess with the cochlear foramen, transverse septum separating the vestibular foramen from the internal facial foramen is well developed
1: in common recess with cochlear foramen, transverse septum separating it from internal facial foramen is low, and aperture of internal facial foramen within common recess with other foramina of internal acoustic meatus
2: separated by partitions of equal height from cochlear foramen and internal facial foramen
3: in common recess with internal facial foramen


227. Aperture of internal facial foramen
0: Anterior to cochlear foramen
1: slightly anterior, posterior edge of aperture of internal facial foramen is lateral to centre of cochlear foramen
2: lateral to cochlear foramen


228. Morphology of aperture of internal facial foramen
0: Continuous with an anterior fissure
1: oval-shaped
2: circular


229. Articular rim
0: Absent
1: present but small, forms a ridge anterolateral to articulation surface of the posterior process of the periotic and separated from it by a sulcus; the ridge fits into a corresponding cavity posterolateral and slightly dorsal to spiny process of squamosal
2: present, long, oriented posterodorsally, and posterior end intersects dorsal margin of periotic; in lateral view has sigmoidal shape
3: present with sigmoidal shape and laterally elongate with hook-like process


230. Contact of periotic, not including anterior process, with skull
0: Distal end of posterior process of periotic, lateral surface of posterior process of the periotic, and entire dorsal edge of tegmen tympani (or homologous bone) contact squamosal and possibly parietal
1: same as state "0" except dorsal edge contacts from posterior end of posterior process of periotic to region just lateral to endolymphatic foramen
2: only dorsal and lateral sides of posterior process articulate with squamosal
3: periotic articulates with squamosal along hiatus epitympanicus and adjacent regions on the posterior process
4: periotic only articulates with skull via ligaments


231. Articulation surfaces on posterior processes of ectotympanic and periotic
0: Surfaces smooth
1: bear complementary longitudinal grooves and ridges
2: fused in adults

*Janjucetus*: Unknown.

232. Ventral surface of posterior process of periotic, along a straight path perpendicular to its long axis

0: Concave
1: flat
2: convex

*Janjucetus*: Unknown.

233. Bullar facet on posterior process of periotic

0: Restricted to ventral surface
1: extends dorsally on to posteromedial face of posterior process

*Janjucetus*: Unknown.

234. Facial nerve sulcus

0: Long sulcus on posterior process of periotic or the compound periotic tympanic posterior process of most mysticetes
1: short, no sulcus posterior to stylomastoid notch

*Janjucetus*: Long sulcus on posterior process of periotic or the compound periotic tympanic posterior process of most mysticetes.

235. Length of posterior process of periotic

0: Absent or very short, length <47% the length of pars cochlearis
1: short, length between 88 and 119% of the promontorial length
2: slightly longer than pars cochlearis, length between 131 and 153%
3: long, length between 191 and 404%
4: very long, length >613% of the length of pars cochlearis

*Janjucetus*: slightly longer than pars cochlearis, length between 131 and 153%.

236. Orientation of posterior process of periotic

0: Forms an angle <130° with the long axis of tegmen tympani
1: forms an angle between 135 and 165°
2: directed nearly posteriorly, forms a 180° with tegmen tympani

*Janjucetus*: Forms an angle <130° with the long axis of tegmen tympani.

237. Dorsal edge of posterior process, periotic in lateral or medial view

0: Straight or convex ventrally
1: concave ventrally, helps to form the neck of posterior process of periotic

*Janjucetus*: Unknown.

238. Posterior process of periotic

0: Robust
1: horizontal plate and very thin for most of its length

*Janjucetus*: Robust.

239. Mastoid exposure of posterior process of periotic on the outside of skull

0: Exposed externally
1: not exposed, enclosed by the exoccipital and squamosal

*Janjucetus*: not exposed, enclosed by the exoccipital and squamosal.

**Ectotympanic**

240. Anterior spine, or conical anterior tip, of ectotympanic bulla

0: Absent
1: present but small
2: present and long

*Janjucetus*: Absent.

241. Shape of ectotympanic bulla

0: Narrow and long, width of bulla at sigmoid process is <64% the length of bulla along its long axis
1: wide, width of bulla >65% of its long axis

*Janjucetus*: wide, width of bulla >65% of its long axis.

242. Posterior end of ventromedial keel

0: Forms a smooth curve around posterior part of involucrum
1: protrudes and points medially

*Janjucetus*: Unknown.

243. Accessory ossicle

0: Absent
1: present
<table>
<thead>
<tr>
<th>Feature Description</th>
<th>Category 0</th>
<th>Category 1</th>
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<tbody>
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258. Profile of ectotympanic bulla in lateral view
0: Ventral edge convex or flat
1: concave because of posteroventral expansion of lateral prominence

*Janjucetus*: 0 = Ventral edge convex or flat.

259. Medial prominence of involucrum
0: Posterior edge approximately in line with posterior edge of lateral prominence
1: posterior edge distinctly anterior to posterior edge of lateral prominence

*Janjucetus*: 0 = Posterior edge approximately in line with posterior edge of lateral prominence.

260. Involucrum
0: In medial view, dorsal and ventral borders converge anteriorly
1: excavated anterior to base of posterior process so that dorsal and ventral sides are parallel

*Janjucetus*: 0 = In medial view, dorsal and ventral borders converge anteriorly.

261. Involucrum
0: Bears prominent transverse groove on dorsal surface that divides involucrum into a thicker posterior part and thinner anterior part
1: groove absent

*Janjucetus*: 1 = groove absent.

262. Ridge on inside of bulla
0: Present, transverse ridge extends laterally from involucrum and partially divides cavum tympani into anterior and posterior portions
1: absent

*Janjucetus*: ? = Unknown.

263. Ventromedial keel of the ectotympanic bulla
0: Present along entire length
1: terminates approximately at level of lateral furrow
2: poorly defined along entire length

*Janjucetus*: 0 = Present along entire length.

264. Shape of ventromedial keel, bulla in dorsomedial view
0: Nearly straight
1: bowed medially

*Janjucetus*: 0 = Nearly straight.

265. Region on dorsomedial side of ventromedial keel
0: Flat or convex
1: gently concave

*Janjucetus*: 0 = Flat or convex.

Postcranial

266. Radial and ulnar facets of humerus
0: Forms one articulation surface that is semicircular in lateral view
1: two distinct facets that in lateral view form an obtuse angle

*Janjucetus*: ? = Unknown.

3. Data matrix:

Abbreviations used in the matrix (after Geisler & Sanders 2003): A=0/1; B=0/2; C=1/2; D=2/3; E=3/4; F=0/1/2; G=1/2/3; H=2/3/4; I=4/5; J=0/1/2/3; K=1/3; L=5/6/7; M=5/6; N=4/5/6/7/8; O=8/9; P=3/4/5; Q=3/4/5/6; R=0/1/2/3/4; S=4/5/6; T=4/5/6/7/8/9; U=3/4/5/6/7/8/9; V=6/7/8/9; W=0/1/2/3/4/5/6; X=6/7; Y=3/4/5/6/7/8; Z=2/3/4/5/6.

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<td>Pelocetus</td>
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<td>Squalodon</td>
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<td>Mesopododon</td>
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<td>Physeter</td>
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<td>Tursiops</td>
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</table>
4. Taxon sampling:
Taxa were included in order to adequately sample the known diversity of Mysticeti and Odontoceti, within the context of testing the phylogenetic position of *Janjucetus* and *Mammalodon*, as well as the monophyly of Mysticeti and Odontoceti. Emphasis was placed on the inclusion of primitive fossil taxa, which are important in testing the monophyly of crown group cetaceans. The geologically oldest mysticete, *Llanocetus denticrenatus*, was not included in the present analysis as it is currently under study by Dr R. E. Fordyce, and its inclusion in cladistic analyses must await the full description of the relatively complete skull. In this study, character scores for *Xenorophus* sp. are based on Charleston Museum specimen ChM PV4823, after (Geisler & Sanders 2003) and personal observations. Several characters which are scored as unknown (?) in the matrix of (Geisler & Sanders 2003), have been scored in this analysis based on the personal observations of the author. The character state scores for *Mammalodon colliveri* are based on the holotype specimen (NMV P199986), and an undescribed skeleton (NMV P198871, P199587) referred to *Mammalodon* sp. cf. *M. colliveri*.

The table below lists the method used to score the modified/new characters in this analysis. Abbreviations: pers.obs. = Personal observation of original specimens/casts by author; lit. = Score based on study of literature (followed by reference).

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Char. 9</th>
<th>Char. 41</th>
<th>Char. 63</th>
<th>Char. 80</th>
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<td>lit. (Kellogg 1968)</td>
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<tr>
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<td>lit. (Kellogg 1965)</td>
<td>lit. (Kellogg 1965)</td>
<td>lit. (Kellogg 1965)</td>
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<tr>
<td><em>Eubalaena glacialis</em></td>
<td>lit.(True 1904)</td>
<td>lit. (True 1904)</td>
<td>lit. (True 1904)</td>
<td>lit. (True 1904)</td>
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<tr>
<td><em>Balaenoptera physalus</em></td>
<td>lit. (True 1904)</td>
<td>lit. (True 1904)</td>
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<tr>
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<td>lit. (True 1904; Wolman 1985)</td>
<td>lit. (True 1904; Wolman 1985)</td>
<td>lit. (True 1904; Wolman 1985)</td>
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<tr>
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<tr>
<td><em>Physeter macrocephalus</em></td>
<td>pers.obs.; lit.(Flower 1869; Omura et al. 1962; van Bened &amp; Gervais 1868-1880)</td>
<td>pers.obs.; lit. (Flower 1869; Omura et al. 1962; van Bened &amp; Gervais 1868-1880)</td>
<td>pers.obs.; lit. (Flower 1869; Omura et al. 1962; van Bened &amp; Gervais 1868-1880)</td>
<td>pers.obs.; lit. (Flower 1869; Omura et al. 1962; van Bened &amp; Gervais 1868-1880)</td>
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</tbody>
</table>

5. Analysis protocol and results:

The character state scores for all taxa, except *Janjucetus* and *Mammalodon*, were adapted with modifications from (Geisler & Sanders 2003). Character data entry and formatting was performed in MacClade (version 4.05) (Maddison & Maddison 2002). The matrix includes 266 morphological characters. All characters, except chars. 24, 25, 38, 41, 104, and 178, were treated as unordered. The data matrix was analysed with parsimony using PAUP* (version 4.0b10) (Swofford 2002). The analysis protocol consisted of 5000 Tree Bisection and Regrafting (TBR) heuristic search replicates holding a single tree for each replicate, with branch swapping on the shortest trees. Branches were collapsed if the minimum branch length was zero (“amb-” option) (see Kearney & Clark 2003 for discussion). Where taxa were coded for multiple states, the coding was interpreted as uncertainty. Where taxa were coded for gaps, the gap coding was interpreted as an additional state. Character state optimisation was ACCTRAN. *Sus* and *Hippopotamus* were employed as outgroups, and outgroup rooting was used. One thousand bootstrap replicates with ten random stepwise addition heuristic searches per replicate were performed, with branch support values (Bremer 1988, 1994; Donoghue *et al.* 1992; Wilkinson 2003) calculated using the TreeRot
(version 2.0) (Sorenson 1999) software in conjunction with PAUP* (version 4.0b10) (Swofford 2002).

The analysis of the data set found 3 shortest trees of 1167 steps [consistency index (CI) = 0.4790; retention index (RI) = 0.5679; rescaled consistency index (RC) = 0.2720]. The strict consensus tree of the three most parsimonious trees is shown in Fig. S1. Odontoceti are a highly supported clade (bootstrap = 99%; branch support = 9). Mysticeti are comparatively weakly supported (branch support = 1). The undescribed family of toothed mysticetes in the collections of the Charleston Museum (Barnes & Sanders 1996; Geisler & Sanders 2003) form the most primitive monophyletic clade within Mysticeti, and are well supported (bootstrap = 90%; branch support = 7). A clade consisting of Chonecetus and all more derived mysticetes is relatively weakly supported (bootstrap = 57%; branch support = 2). Chaeomysticeti (sensu Geisler & Sanders 2003; Mitchell 1989) are highly supported (bootstrap = 92%; branch support = 5). Balaenomorpha (sensu Geisler & Sanders 2003) are also strongly supported (bootstrap = 100%; branch support = 13). The relationship between Zygorhiza (Family Basilosauridae) and mysticetes and odontocetes is poorly resolved in the strict consensus tree. In two of the three most parsimonious trees, Zygorhiza is the sister group of a monophyletic Autoceta (Odontoceti + Mysticeti), whereas in the third most parsimonious tree, Zygorhiza is the sister group of a monophyletic Mysticeti. Unlike previous studies (Barnes et al. 1995; Berta & Deméré 2005; Geisler & Sanders 2003), this analysis failed to find a monophyletic Aetiocetidae. In all most parsimonious trees, Aetiocetus is more closely related to the clade Chaeomysticeti than it is to Chonecetus. Toothed mysticetes included in this analysis comprise a pectinate series of stem taxa to the edentulous, baleen-bearing, mysticete clade Chaeomysticeti.

6. Clade diagnoses for select clades:
Mysticeti
Steep face on anterolateral edge of zygomatic process of maxilla, clearly separating it from rostral portion of maxilla, present and well-developed (14: 0 $\Rightarrow$ 2); Superior lamina of pterygoid present and covers most of ventral exposure of alisphenoid (157: 1 $\Rightarrow$ 0); Basioccipital crest is wide and bulbous (181: 0 $\Rightarrow$ 1); Large centrally oriented ovoid region of the anterior process of periotic contacts squamosal, with the edges of the anterior process not contacting the squamosal (197: 0 $\Rightarrow$ 1).

*Janjucetus* + all more crownward Mysticeti
Mandibular symphysis is not sutured and consists of a longitudinal fossa for a fibrocartilaginous connection (41: 1 $\Rightarrow$ 2)

*Janjucetus* [Janjucetidae]
Premaxillae on rostrum adjacent and anterior to level of P2, or on anterior half of rostrum clearly overhang maxillae (9: 0 $\Rightarrow$ 1); Anteriormost point on the posterior edge of the supraorbital process is medially positioned (2 $\Rightarrow$ 3); Posteriormost end of ascending process of premaxilla in line with anterior half of supraorbital process of frontal (0 $\Rightarrow$ 1)
**Mammalodon [Mammalodontidae]**

Anterior edge (orbital margin) of postorbital process of frontal forms 90-120° with sagittal plane (63: 0 ⇒ 1); Pars cochlearis of periotic is elongated dorsally and medially, with outer periosteal bone of pars cochlearis expanded towards cranial cavity (220: 0 ⇒ 2)

**Chonecetus + all more crownward Mysticeti**

Mandibular symphysis is not sutured and consists of a longitudinal groove for a fibrocartilaginous connection (41: 2 ⇒ 3); Posteriormost end of ascending process of premaxilla in line with posterior half of supraorbital process or postorbital process of frontal (76: 0 ⇒ 2); Median furrow of ectotympanic bulla forms notch on posterior edge of bulla between medial and lateral prominences (256: 2 ⇒ 1)

**Chaeomysticeti (edentulous, baleen-bearing Mysticeti)**

Edentulous rostrum (25: 1 ⇒ 0); Temporal crest is entirely on dorsal surface of supraorbital process of frontal (121: 1 ⇒ 3)

### 7. Supplementary discussion

**Phylogenetic Aspects:**

A recent study (Geisler & Sanders 2003) has provided a new diagnosis for a more inclusive, stem-based, Mysticeti based on synapomorphies. The phylogenetic positions of *Janjucetus* and *Mammalodon* in this study supports the monophyly of Mysticeti, as well as the hypothesised synapomorphies of Mysticeti proposed by (Geisler & Sanders 2003). More recently, the following features have been listed as unequivocal synapomorphies of Mysticeti:

1. lateral margin of maxillae thin; 2) infraorbital process (plate) of maxilla present; 3) posterior portion of vomer exposed on basicranium and covering basisphenoid/basioccipital suture; 4) expanded basioccipital crest; 5) unfused mandibular symphysis with ligamentous connection; 6) short mandibular symphysis with boss dorsal to symphyseal groove; and 7) dorsal aspect of mandible curved laterally (Deméré *et al.* 2005).

Character 4 is interpreted here as a synapomorphy of Mysticeti. Character 3 [char. 180 of this analysis] occurs in several basal odontocetes (Fordyce 2002; Geisler & Sanders 2003; this study), as well as *Zygorhiza*, and is interpreted here as a symplesiomorphy of mysticetes and odontocetes. Character 2 is also present in archaeocetes such as *Georgiacetus* and *Zygorhiza* (Geisler & Sanders 2003). Characters 1, 5, 6, and 7 of (Deméré *et al.* 2005) are interpreted here as probable synapomorphies of a more exclusive clade within Mysticeti (*Chonecetus* + all more crownward Mysticeti).

This study corroborates the results of (Geisler & Sanders 2003) in which undescribed toothed mysticetes in the collections of the Charleston Museum represent a strongly supported basal clade within a stem-based monophyletic Mysticeti. The latter undescribed family is characterised by the possession of basilosaurid-like dentition, and rostral morphology, yet possesses cranial morphology comparable to basal Chaeomysticeti (Barnes & Sanders 1996; Fraser & Dooley 2002; pers. obs.). However, unlike all known Basilosauridae, the Charleston Museum toothed mysticetes possess a third upper molar
(M3) and a fourth lower molar (m4) (Barnes & Sanders 1996). The ultimate upper and lower molars in all basilosaurids are M2 and m3, respectively (Kellogg 1936; Uhen 1998).

The Aetiocetidae (Barnes et al. 1995; Emlong 1966) have been considered a monophyletic family by numerous authors (Barnes et al. 1995; Berta & Deméré 2005; Fordyce & Barnes 1994; Fordyce & Muizon 2001; Geisler & Sanders 2003; Ichishima 2005; Mitchell 1989; Sanders & Barnes 2002). However, in this analysis, Aetiocetidae is paraphyletic. Berta and Deméré (2005) have suggested five synapomorphies of a monophyletic Aetiocetidae. One of these characters (lobate or triangular parietal-frontal suture) is also present in Janjucetus and Mammalodon, and is interpreted here as a possible synapomorphy of a more inclusive clade (Janjucetus + all more crownward Mysticeti).

Another aetiocetid synapomorphy suggested by (Berta & Deméré 2005) (exposure of vomer in the palate) also occurs in Janjucetus (and less certainly in Mammalodon), and may also be a synapomorphy of a more inclusive clade. Other supposed aetiocetid synapomorphies listed in (Barnes et al. 1995; Berta & Deméré 2005) are either mysticete symplesiomorphies, or require more clear definition, and were not considered in this analysis. Further detailed comparisons of all described (Barnes et al. 1995), and undescribed (Barnes 1998; Goedert et al. 2001; Olivares-Bañuelos et al. 2001; pers. obs.), presumed aetiocetids with each other, and non-aetiocetid toothed mysticetes, and their inclusion in phylogenetic analyses, are necessary to more rigorously test the hypothesis that Aetiocetidae is paraphyletic. That some aetiocetid genera are probably paraphyletic (including Aetiocetus itself) (Ichishima 2005), indicates that the systematics of this diverse group of toothed mysticetes may be more complex than previously thought, and requires revision.

Of critical importance in regards to the latter point is the taxonomic and phylogenetic status of “Aetiocetus” polydentatus (Barnes et al. 1995). Ichishima (2005) has already mooted the probability that this species does not belong in the genus Aetiocetus. I concur with Ichishima’s (2005) suggestion. In addition, and based on the phylogeny presented herein, “A.” polydentatus shares key synapomorphies with Chaeomysticeti, which other Aetiocetidae (sensu lato) lack: 1) ascending process of maxilla terminates slightly posterior to antorbital notch, at a point level with the anterior third (anteroposteriorly) of the supraorbital process of frontal; 2) anteroposteriorly foreshortened supraorbital process of frontal; 3) concavity in lateral margin of supraorbital process is poorly developed such that the orbit opens laterally but not anterolaterally and dorsolaterally as in more basal mysticetes; and 4) elongated intertemporal region with well-developed sagittal crest. I interpret these derived features as reversals, based on this phylogenetic hypothesis, and note that it requires further testing via the inclusion of a wider range of aetiocetid taxa, and new characters.

The implication of such a phylogenetic hypothesis is that the intertemporal region with salient sagittal crest of Eomycteris whitmorei (Sanders & Barnes 2002) is secondarily elongated. The functional implications of secondary elongation of the intertemporal region in “Aetiocetus” polydentatus + Chaeomysticeti are not clear. The phylogenetic hypothesis presented herein implies that foreshortening of the intertemporal region with anterior extension of the supraoccipital shield evolved at least twice in Mysticeti, not once as previously thought: once in aetiocetids, and a second time in mysticetes more crownward than Eomycticetoidea. The anteroposterior elongation of the
supraorbital process of frontal in many post-Eomysticetoidea chaeomysticetes is secondarily derived.

Sanders and Barnes (2002) proposed the Superfamily Aetiocetoidea to include the families Llanocetidae, Mammalodontidae, and Aetiocetidae. Based on this analysis, Aetiocetoidea is clearly a paraphyletic grouping, and does not reflect the complexity of stem-mysticete interrelationships, or the fact that some toothed mysticetes are more closely related to Chaeomysticeti than they are to other toothed mysticetes. Given that the phylogenetic interrelationships of basal Mysticeti is still essentially a work-in-progress, and that the relationship of Llanocetus to other toothed mysticetes is yet to be established, it would seem unwise at the present time to erect new taxa to encompass the described stem mysticete families. Nevertheless, future work may resolve two or more stem mysticete families into a monophyletic clade, thus warranting the establishment of a higher level taxon. I therefore propose the following revised classification for basal Mysticeti, with no superfamilial grouping of toothed stem-mysticetes:

Order CETACEA Brisson, 1762
Suborder MYSTICETI Flower, 1864
Family LLANOCETIDAE Mitchell, 1989
Family JANJUCETIDAE new family
Family MAMMALODONTIDAE Mitchell, 1989
Family AETIOCETIDAE [sensu lato] Emlong, 1966
Infraorder CHAEOMYSTICETI Mitchell, 1989

Feeding Ecology of Janjucetus hunderi and Other Toothed Mysticetes:
Two issues merit further discussion here: 1) The viability of the extant crabeater seal (Lobodon carcinophaga) (Fig. S2D) prey capture strategy as a modern analog for that of toothed mysticetes; and 2) the interpretation of the prey capture method and masticatory system of Janjucetus hunderi.

Most authors presume that the crabeater seal is a bulk filter-feeder that uses its intricately lobate cheek teeth, which form a sieve-like structure when occluded, to filter krill from sea water (Adam & Berta 2002; Barnes et al. 1995; Berta et al. 2006; Fordyce 1984; Fordyce 2002; Fordyce & Barnes 1994; Fordyce & Muizon 2001; Ichishima 2005; King 1961, 1983; Kooyman 1981; Marshall 2002; Mitchell 1989; Pabst et al. 1999; Riedman 1990; Sanderson & Wassersug 1993). This functional interpretation of the dentition of Lobodon is corroborated by the fact that krill comprises up to 94% of its diet (Riedman 1990). However, the data supporting the hypothesis that Lobodon is a bulk filter-feeder have been considered dubious, when assessed in a comparative context (Sanderson & Wassersug 1993). There is certainly little doubt that the highly derived cheek tooth morphology of Lobodon does form an effective filtering device when the jaws are fully adducted. What remains open to question is whether Lobodon actually ingests krill in bulk,
or selects its prey singly. This is a problem that must be resolved by more detailed field observations and functional analyses of the masticatory system.

Leaving aside the problem of whether *Lobodon* is, indeed, a bulk filter-feeder, and for the purposes of this study assuming that it is, we then face the issue of whether the crabeater seal feeding style can be applied by analogy to fossil toothed mysticetes. The latter analogy has hitherto been criticised only once (Ichishima 2005), but invoked on numerous occasions (Barnes *et al.* 1995; Berta *et al.* 2006; Fordyce 1984; Fordyce 2002; Fordyce & Barnes 1994; Fordyce & Muizon 2001; Fraser & Dooley 2002; Mitchell 1989). I concur with Ichishima (2005) that the similarities in dental morphology, and their inferred function, between the crabeater seal and toothed mysticetes are more apparent than real. No toothed mysticetes discovered to date possess intricately denticulate cheek teeth, that are closely spaced along the entire lateral margin of the jaws, and when in occlusion, form a closely interdigitating lattice-like buccal surface. The only possible exception to the latter statement is in the form of the denticulate and broadly palmate cheek teeth of *Llanocetus denticrenatus* (Mitchell 1989). However, the analogy between the dental morphology of *Llanocetus* and *Lobodon* is weakened when one considers that the cheek teeth of *Llanocetus* are separated from one another, along the tooth row, by wide diastemata, and thus did not interdigitate. The dentition and feeding strategy of Aetiocetidae have also been likened to those of *Lobodon* (Barnes *et al.* 1995; Fordyce & Muizon 2001; Ichishima 2005). On the contrary, the dentition of aetiocetids is quite unlike that of the crabeater seal, consisting of small, widely spaced teeth, that are virtually homodont apart from vestigial accessory denticles on the more posterior cheek teeth. Again, the dentition of *Mammalodon* has been compared to that of *Lobodon* (Fordyce 1984). The cheek teeth of *Mammalodon* are closely spaced along the tooth row, but the accessory denticles of *Mammalodon* are relatively low and not lobate. Furthermore, the wear pattern on the teeth of *Mammalodon* is unique among mysticetes in being in the same, almost horizontal, plane along the upper and lower tooth row, and is so heavy that the crowns of the teeth are all but completely worn off. This aberrant dental wear pattern speaks against the teeth of *Mammalodon* possessing a filtering function.

In light of the preceding discussion, *Janjucetus hunderi* arguably has dental morphology which is most similar, among mysticetes, to that of the crabeater seal: accessory denticles on the cheek teeth are well-developed, and the teeth are not separated by broad diastemata. However, the details of rostral and dental morphology, and the presence of heavy wear facets on teeth, suggests that *Janjucetus* was not a mysticete analog of *Lobodon carcinophaga*. Rather, and critically, the accessory denticles of the cheek teeth of *Janjucetus* (and indeed all known toothed mysticetes) are not slender and elongate with lobate apices, and are not separated from one another by a deep notch. This results in teeth that do not form an interdigitating lattice-like sieve along the margins of the rostrum. The lack of the latter dental features renders all known toothed mysticetes as poorly adapted for tooth-assisted bulk filter-feeding as hypothesised for the crabeater seal, and to a lesser extent, the leopard seal *Hydrurga leptonyx* (Adam & Berta 2002; Berta *et al.* 2006) (Fig. S2C)

8. Sources for skull images in Fig. 3:
**Georgiacetus**  
Source: Original skull reconstruction by author from photographs in (Hulbert et al. 1998).

**Zygorhiza**  
Source: Redrawn from (Kellogg 1936).

Odontoceti (represented by *Tursiops*)  
Source: Redrawn from (Rommel 1990).

**Janjucetus**  
Source: Original skull reconstruction by author based on NMV P216929.

**Mammalodon**  
Source: Redrawn from (Fordyce & Muizon 2001).

**Chonecetus**  
Source: Redrawn from (Barnes et al. 1995).

**Aetiocetus**  
Source: Redrawn from (Barnes & McLeod 1984; Barnes et al. 1995; Emlong 1966; Fordyce & Muizon 2001)

**Eomysticetus**  
Source: Redrawn from (Sanders & Barnes 2002).

**Diorocetus**  
Source: Redrawn from (Kellogg 1968).

**Pelocetus**  
Source: Redrawn from (Kellogg 1965).

**Caperea**  
Source: Redrawn from (Barnes & McLeod 1984).

**Eubalaena**  
Source: Redrawn from (Barnes & McLeod 1984).

**Eschrichtius**  
Source: Redrawn from (Barnes & McLeod 1984).

**Balaenoptera**  
Source: Redrawn from (Barnes & McLeod 1984).

9. **Select measurements of the holotype (NMV P216929) specimen of *Janjucetus* (in mm) [Adapted with modifications from (Perrin 1975)].**
<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condylobasal length (CBL)</td>
<td>460.00+</td>
</tr>
<tr>
<td>Length of rostrum</td>
<td>174.40+</td>
</tr>
<tr>
<td>Length of rostral portion of maxilla</td>
<td>138.40</td>
</tr>
<tr>
<td>Maximum height of skull</td>
<td>128.00</td>
</tr>
<tr>
<td>Height of rostrum at base</td>
<td>79.00</td>
</tr>
<tr>
<td>Width of rostrum at base</td>
<td>160.00</td>
</tr>
<tr>
<td>Width of rostrum at ¼ length of rostrum</td>
<td>130.00</td>
</tr>
<tr>
<td>Width of rostrum at midlength</td>
<td>104.00</td>
</tr>
<tr>
<td>Width of premaxillae at midlength of rostrum</td>
<td>51.00</td>
</tr>
<tr>
<td>Width of rostrum at ¾ length</td>
<td>69.00</td>
</tr>
<tr>
<td>Distance from tip of rostrum to internal nares</td>
<td>315.00+</td>
</tr>
<tr>
<td>Maximum preorbital width</td>
<td>151.00</td>
</tr>
<tr>
<td>Maximum postorbital width</td>
<td>280.00</td>
</tr>
<tr>
<td>Minimum supraorbital width</td>
<td>150.00</td>
</tr>
<tr>
<td>Maximum width across middle of orbits</td>
<td>154.00</td>
</tr>
<tr>
<td>Transverse distance from sagittal plane to lateral edge of postorbital process of frontal</td>
<td>139.00</td>
</tr>
<tr>
<td>Maximum width across zygomatic process of squamosal</td>
<td>312.00 (est.)</td>
</tr>
<tr>
<td>Maximum width of premaxillae</td>
<td>52.00</td>
</tr>
<tr>
<td>Maximum dorsoventral thickness of intertemporal region</td>
<td>92.00</td>
</tr>
<tr>
<td>Maximum parietal width within temporal fossa</td>
<td>153.00</td>
</tr>
<tr>
<td>Maximum length of right temporal fossa</td>
<td>175.00</td>
</tr>
<tr>
<td>Maximum width of right temporal fossa</td>
<td>152.00</td>
</tr>
<tr>
<td>Major diameter of right temporal fossa</td>
<td>156.00</td>
</tr>
<tr>
<td>Minor diameter of right temporal fossa</td>
<td>105.40</td>
</tr>
<tr>
<td>Projection of premaxillae beyond maxillae</td>
<td>36.00+</td>
</tr>
<tr>
<td>Maximum anteroposterior diameter of right orbit</td>
<td>112.62</td>
</tr>
<tr>
<td>Length of left lacrimal</td>
<td>24.00</td>
</tr>
<tr>
<td>Maximum width of anterior overhang of supraoccipital crest</td>
<td>116.00</td>
</tr>
<tr>
<td>Maximum width of squamosal lateral to exoccipital, skull in posterior view</td>
<td>25.00</td>
</tr>
<tr>
<td>Maximum length of right mandibular ramus</td>
<td>400.00+</td>
</tr>
<tr>
<td>Maximum height of right mandibular ramus at right angles to greatest length</td>
<td>149.70</td>
</tr>
<tr>
<td>Maximum anteroposterior length of coronoid process (measured at midpoint of ascending ramus)</td>
<td>88.00</td>
</tr>
<tr>
<td>Length of mandibular fossa</td>
<td>118.00</td>
</tr>
</tbody>
</table>

10. Comparative measurements of mammalian orbit diameter/CBL (in mm). Measurements of *Simocetus* and *Odobenocetops* are from (Fordyce 2002) and (Muizon *et al.* 2002), respectively. Abbreviations: CBL = Condylobasal length; OD = Orbit diameter.
(measurement made on right orbit). Institutional Abbreviations: NMV C/R = Museum Victoria Comparative Anatomy Collection; AMP = Ashoro Museum of Paleontology; NMV P = Museum Victoria Palaeontology Collection; OU = Geology Museum, Department of Geology, University of Otago; USNM = Collections of the National Museum of Natural History, which include those of the former United States National Museum.

<table>
<thead>
<tr>
<th>Taxon Specimen</th>
<th>CBL</th>
<th>OD</th>
<th>OD/CBL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Janjucetus hunderi</td>
<td>460</td>
<td>112</td>
<td>0.24</td>
</tr>
<tr>
<td>Aetiocetus polydentatus</td>
<td>640</td>
<td>90</td>
<td>0.14</td>
</tr>
<tr>
<td>Odobenocetus peruvianus</td>
<td>457</td>
<td>105</td>
<td>0.23</td>
</tr>
<tr>
<td>Simocetus rayi</td>
<td>449</td>
<td>51</td>
<td>0.11</td>
</tr>
<tr>
<td>Platanista gangetica</td>
<td>400</td>
<td>13</td>
<td>0.03</td>
</tr>
<tr>
<td>Delphinus delphis</td>
<td>390</td>
<td>45</td>
<td>0.11</td>
</tr>
<tr>
<td>Stenella attenuata</td>
<td>410</td>
<td>50</td>
<td>0.12</td>
</tr>
<tr>
<td>Tursiops truncatus</td>
<td>500</td>
<td>63</td>
<td>0.12</td>
</tr>
<tr>
<td>Tursiops truncatus</td>
<td>375</td>
<td>59</td>
<td>0.15</td>
</tr>
<tr>
<td>Pseudoroscanus crassidens</td>
<td>625</td>
<td>96</td>
<td>0.15</td>
</tr>
<tr>
<td>Orcinus orca</td>
<td>1030</td>
<td>130</td>
<td>0.12</td>
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<tr>
<td>Phocoena phocoena</td>
<td>230</td>
<td>38</td>
<td>0.16</td>
</tr>
<tr>
<td>Monodon monoceros</td>
<td>565</td>
<td>76</td>
<td>0.13</td>
</tr>
<tr>
<td>Mesoplodon layardii</td>
<td>1120</td>
<td>99</td>
<td>0.08</td>
</tr>
<tr>
<td>Caperea marginata</td>
<td>830</td>
<td>93</td>
<td>0.11</td>
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<tr>
<td>Balaenoptera acutorostrata</td>
<td>520</td>
<td>75.60</td>
<td>0.14</td>
</tr>
<tr>
<td>Balaenoptera acutorostrata</td>
<td>1120</td>
<td>129</td>
<td>0.11</td>
</tr>
<tr>
<td>Balaenoptera edeni</td>
<td>1440</td>
<td>138</td>
<td>0.09</td>
</tr>
<tr>
<td>Dugong dugon</td>
<td>380</td>
<td>52</td>
<td>0.13</td>
</tr>
<tr>
<td>Odobenus rosmarus</td>
<td>386</td>
<td>58</td>
<td>0.15</td>
</tr>
<tr>
<td>Neophoca cinerea</td>
<td>301</td>
<td>64</td>
<td>0.21</td>
</tr>
<tr>
<td>Lobodon carcinophaga</td>
<td>258</td>
<td>53</td>
<td>0.20</td>
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<tr>
<td>Hydrurga leptonyx</td>
<td>372</td>
<td>80</td>
<td>0.21</td>
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<tr>
<td>Hydrurga leptonyx</td>
<td>415</td>
<td>82</td>
<td>0.19</td>
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<tr>
<td>Pteronura brasiliensis</td>
<td>149</td>
<td>27</td>
<td>0.18</td>
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<tr>
<td>Ursus maritimus</td>
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<tr>
<td>Ursus maritimus</td>
<td>392</td>
<td>40</td>
<td>0.10</td>
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<tr>
<td>Panthera onca</td>
<td>222</td>
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<td>Cryptoprocta ferox</td>
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<td>22</td>
<td>0.19</td>
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<tr>
<td>Procavia capensis</td>
<td>85.60</td>
<td>20.40</td>
<td>0.23</td>
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<tr>
<td>Babroca babrussa</td>
<td>265</td>
<td>31</td>
<td>0.11</td>
</tr>
<tr>
<td>Hippopotamus amphibius</td>
<td>215</td>
<td>34</td>
<td>0.15</td>
</tr>
<tr>
<td>Hippopotamus amphibius (juvenile)</td>
<td>640</td>
<td>70</td>
<td>0.10</td>
</tr>
<tr>
<td>Daubentonia madagascariensis</td>
<td>65</td>
<td>21.70</td>
<td>0.33</td>
</tr>
<tr>
<td>Nycticebus cougang</td>
<td>NMV C30989</td>
<td>54</td>
<td>15.80</td>
</tr>
</tbody>
</table>
11. Electronic Supplementary Figure S1

Figure legend: Strict consensus of 3 trees depicting phylogenetic relationships of *Janjucetus hunderi* within Cetacea, and Mysticeti, based on a parsimony analysis of 266 characters in 26 taxa. Genera marked with * represent toothed mysticetes. Numbers to the left of, and above and below, nodes represent bootstrap and branch support values, respectively. Solid circles denote named clades (clade names below and to the left of solid circles). See Electronic Supplementary Material text for further information.
Figure legend: (A) and (B) Reconstructions of the skull and mandible of *Janjucetus hunderi* in right lateral view. (C) Skull and mandible of leopard seal *Hydrurga leptonyx* in right lateral view. (D) Skull and mandible of crabeater seal *Lobodon carcinophaga* in right lateral view. Scale bars, 100 mm. Note the strong development of anterior caniniform dentition and posterodorsally located origins of temporalis muscles in the leopard seal and *Janjucetus*. These features are weakly developed in the crabeater seal.
13. Electronic Supplementary Figure S3

Figure legend: (A) Reconstruction of the skull of *Janjucetus hunderi* in dorsal view. (B) Reconstruction of the skull of the Jurassic pliosauroid *Rhomaleosaurus megacephalus* in dorsal view (after Cruickshank 1994). The skulls are scaled to approximately the same length. Skull length of *Janjucetus hunderi* is 460 mm+; skull length of *Rhomaleosaurus megacephalus* is about 838 mm (Cruickshank 1994). This figure illustrates the convergence of *Janjucetus* cranial morphology on that of *Rhomaleosaurus*, the most salient similarities being: 1) caniniform tooth-bearing anterior rosette formed by premaxillae; 2) robust, sharply triangular, foreshortened, rostrum; 3) relatively enormous anterolaterally directed orbits; and 4) voluminous temporal fenestration for origins of adductor musculature.
14. References to Electronic Supplementary Material


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Goedert, J. L., Crowley, B. J. & Barnes, L. G. 2001 Very primitive, Early Oligocene toothed mysticetes (Cetacea: Mysticeti) from the eastern North Pacific. *J. Vertebr. Paleontol.* **21** (Suppl. to 3), 55A.


Olivares-Bañuelos, N. C., Flores-Ramirez, S., Gonzalez-Barba, G., Herrera-Gil, L. & Goedert, J. L. 2001 Description and morpho-evolutionary analysis of an aetiocetid fossil (Cetacea: Aetiocetidae) of El Cien Formation, San Juan Member, Baja California Sur, Mexico. *J. Vertebr. Paleontol.* **21** (Suppl. to 3), 85A.


