Analysis of the 'family tree' published for *Puijila* in *Nature* 2009

by Dr Carl Werner

Some evolution scientists believe pinnipeds (seals, sea lions and walruses) evolved from otters (family Mustelidae). Others believe pinnipeds evolved from bears (family Ursidae). Still others say that pinnipeds evolved from dogs (Canidae).[1,2]

Imagine for a moment that you are an evolution scientist and you found a fossil of a mammal, order Carnivora, in Northern Canada, near the Arctic Circle. You suspect you have found the missing link between a land creature and pinnipeds.

You name the animal *Puijila*, but then how would you proceed? How would you demonstrate that this animal, *Puijila*, was a missing link and not just an ordinary mammal, such as a member of one of the known 15 living Carnivora families? This is the most important question to ask.

The first thing you would do is form a list of the known families of the order Carnivora. Here is a list from the Integrated Taxonomic Information System (ITIS.gov)[3]

15 Families of Order Carnivora

- Family Ailuridae (red panda)
- Family Canidae (dogs, wolves, foxes, coyotes)
- Family Odobenidae (walruses)
- Family Mustelidae (otter, weasel, ferret, mink, wolverine, badger)
- Family Mephitidae (skunks)
- Family Otariidae (eared seals: sea lions, northern fur seal)
- Family Phocidae (true seals: Weddell seal, harbor seal)

- Family Procyonidae (raccoons, kinkajous, coatimundi)
- Family Ursidae (bears and the giant panda)
- Family Eupleridae (Madagascar fossa)
- Family Felidae (Cats)
- Family Herpestidae (civets, mongooses)
- Family Hayanenidae (Hyenas)
- Family Nandidniidae (two-spotted palm civet)
- Family Viverridae (genets, binturong, most of the civets, and African linsangs)

If you wanted to know if *Puijila* was a pinniped (Family Odobenidae, Family Otariidae, Family Phocidae) an otter (Family Mustelidae), a bear (family Ursidae), a cat (family Felidae) etc., or an in-between animal, you would compare *Puijila* to all of the 15 Carnivora families living today. Once this analysis was complete you would then need to compare *Puijila* to extinct families of the order Carnivora.

What part of the fossil skeleton of *Puijila* do you compare?

What part of the skeleton of *Puijila* do you measure for comparison to the members of these 15 living Carnivora families? There may be hundreds of bones in just one animal. Each of these bones can be measured for length, width and angle. Each bone has many bumps (processes) where the muscles attach. Each of these processes can be measured for size, location, and angle. Also, the ratio of the length of bones can be measured in any one skeleton. For example, front leg length versus back leg length, or femur length versus tibia length, or width of vertebrae versus length of spinous processes of vertebrae. In reality, for any one animal, there are thousands of possible measurements. If you recorded all of these numbers for all of the living species of the mammal order Carnivora you would have tens of millions of numbers to analyze, which would be difficult to make any sense of.

Even if two animals have the same bone shape or length or ratio,

there is another problem called 'homoplasy' (a subset of homology), a term that applies to very similar traits (e.g. bone shape) that are found in different organisms, but not in their supposed common ancestor (that is, they 'must' have evolved independently). This poses a significant problem for the analysis—an animal having the same trait as another animal does not necessarily mean that it is directly related to (that is, shares a common ancestor with) that animal. A good example of this is the placental mole and the marsupial mole, which look indistinguishable but are not closely related. (See Chapter 5, Similarities in *Evolution: The Grand Experiment, The Quest for an Answer.*)

The next problem is choosing which animal to compare *Puijila* to and why? This is another important question. In order to determine if *Puijila* is an ordinary animal or a special missing link, you are going to have to pick some particular traits on your fossil with which to compare to living members of the families of the order Carnivora. The most logical traits to compare would be any unusual traits that distinguish one family of Carnivora from another.

You suspect that your fossil *Puijila* is a pinniped or a missing link to pinnipeds. What are the distinguishing traits of pinnipeds that you could measure in *Puijila* to see if you are right? The following list of distinguishing traits of pinnipeds have been known for over a century and are considered some of the most classic distinguishing characters of pinnipeds as compared to other mammals.[4]

1. Eye socket size (length) compared to skull length. Pinnipeds have huge eye sockets in their skulls and this is one of the hallmarks for pinnipeds. In order to carry out a statistical evaluation, you must put a number on each possible character, either a 0 or a 1. Each fossil trait can be assigned a score of 0 or 1. Mark 0, if eye socket is less than 20%; 1, if eye socket is greater than 20% (I have chosen 20% for the sake of this paper but it may need to have a different percent after you measure all of the pinnipeds.) Thus, a 0 for a trait indicates it is not pinniped-like, whereas a 1 indicates it is pinniped-like.

2. Front extremity 1st metacarpal length. Pinnipeds have a distinguishing front flipper with the 1st metacarpal longer than all of the other metacarpals. Mark 0, if first metacarpal is shorter than any other; 1, if first metacarpal is longest
3. Back extremity 1st metatarsal length. Pinnipeds have a distinguishing back flipper with the 1st metatarsal longer than the middle (3rd) metatarsal. Mark 0, if 1st metatarsal is shorter than the middle (3rd) metatarsal; 1, if 1st metatarsal is longer than the middle (3rd) metatarsal
4. Back extremity 5th metatarsal length. Pinnipeds have a distinguishing back flipper with the 5th metatarsal longer than the middle (3rd) metatarsal. Mark 0, if 5th metatarsal is shorter than the middle (3rd) metatarsal; 1, if 5th metatarsal is longer than the middle (3rd) metatarsal
5. Tail length, number of vertebrae. Pinnipeds have a very short tail compared to many of the other members of the order Carnivora. Mark 0, if long tail, more than 15 vertebrae in tail, 1, if short tail, less than 15 vertebrae. (The range of number of vertebrae in the tail of living pinnipeds is unknown to this author but is readily available. I have chosen 15 for the sake of this paper but it might need to be a different number.)
6. Post-canine teeth. Pinnipeds have only one type of post-canine tooth, but other members of the Carnivora have two, premolars and molars. Mark 0, if both premolars and molars; 1, if only one variety of post-canine teeth.
7. Lacrimal bone. Pinnipeds have an imperforate lacrimal bone which is contained within the orbit. Mark 0 if the lacrimal bone is perforated and/or outside the orbit and 1 if lacrimal bone is not perforated and within the orbit.

These are the distinguishing traits for pinnipeds. Now you must select the distinguishing traits for all of the other Carnivora mammal families such as Mustelidae (otters), Procyonidae (raccoons), etc.

What other animals need to be measured?

Since you suspect that your fossil, *Puijila,* is a pinniped, a pinniped ancestor and a link between another group of Carnivora mammals (mustelid, canid, or ursidae) and pinnipeds, you have to be very careful to measure *all* of the living pinniped skeletons and all of the living Mustelidae skeletons, all of the living Canidae skeletons and all of the living Ursidae skeletons using this system.

Here is a list of the 37 *living* pinniped skeletons that you should measure.

1. Walrus, *Odobenus rosmarus*
2. Antarctic Fur Seal, *Arctocephalus gazella*
3. Guadalupe Fur Seal, *A. townsendi*
4. Juan Fernández Fur Seal, *A. philippii*
5. Galápagos Fur Seal, *A. galapagoensis*
6. Brown Fur Seal, *A. pusillus*
7. Australasian Fur Seal, *A. forsteri*
8. Subantarctic Fur Seal, *A. tropicalis*
9. South American Fur Seal, *A. australis*
10. Northern Fur Seal, *Callorhinus ursinus*
11. Steller Sea Lion, *Eumetopias jubatus*
12. Australian Sea Lion, *Neophoca cinerea*
13. South American Sea Lion, *Otaria flavescens*
14. New Zealand Sea Lion, *Phocarctos hookeri*
15. California Sea Lion, *Zalophus californianus*
16. Japanese Sea Lion, *Z. japonicus* – extinct (1950s)
17. Galápagos Sea Lion, *Z. wollebaeki*
18. Hawaiian Monk Seal, *Monachus schauinslandi*
19. Mediterranean Monk Seal, *Monachus monachus*
20. Caribbean Monk Seal, *Monachus tropicalis*
21. Northern Elephant Seal, *Mirounga angustirostris*
22. Southern Elephant Seal, *Mirounga leonine*
23. Ross Seal, *Ommatophoca rossi*
24. Crabeater Seal, *Lobodon carcinophagus*
25. Leopard Seal, *Hydrurga leptonyx*
26. Weddell Seal, *Leptonychotes weddellii*
27. Swan-necked Seal, *Acrophoca longirostris* (extinct)

28. Bearded Seal, *Erignathus barbatus*
29. Hooded Seal, *Cystophora cristata*
30. Common Seal or Harbor Seal, *Phoca vitulina*
31. Spotted Seal or Larga Seal, *Phoca largha*
32. Ringed Seal, *Pusa hispida* (formerly *Phoca hispida*)
33. Baikal Seal or Nerpa, *Pusa sibirica*
34. Caspian Seal, *Pusa caspica* (formerly *Phoca caspica*)
35. Harp Seal, *Pagophilus groenlandica*
36. Ribbon Seal, *Histriophoca fasciata*
37. Gray Seal, *Halichoerus grypus*

Here are the 58 *living* mustelid skeletons you should measure:

1. African clawless otter, *Aonyx capensis*
2. Oriental small-clawed otter, *Aonyx cinerea*
3. Sea otter, *Enhydra lutris*
4. North American river otter, *Lontra canadensis*
5. Southern river otter, *Lontra provocax*
6. Neotropical river otter, *Lontra longicaudis*
7. Marine otter, *Lontra felina*
8. European otter, *Lutra lutra*
9. Hairy-nosed otter, *Lutra sumatrana*
10. Spotted-necked otter, *Hydrictis maculicollis*
11. Smooth-coated otter, *Lutrogale perspicillata*
12. Giant otter, *Pteronura brasiliensis*
13. Hog badger, *Arctonyx collaris*
14. Tayra, *Eira Barbara*
15. Greater grison, *Galictis vittata*
16. Lesser grison, *Galictis cuja*
17. Wolverine, *Gulo gulo*
18. American badger, *Taxidea taxus*
19. Striped polecat, *Ictonyx striatus*
20. Saharan striped polecat, *Ictonyx libycus*
21. Patagonian weasel, *Lyncodon patagonicus*
22. American marten, *Martes americana*
23. Yellow-throated marten, *Martes flavigula*
24. Beech marten, *Martes foina*
25. Nilgiri marten, *Martes gwatkinsii*
26. Pine marten, *Martes martes*
27. Japanese marten, *Martes melampus*

28. Fisher, *Martes pennanti*
29. Sable, *Martes zibellina*
30. Japanese badger, *Meles anakuma*
31. Asian badger, *Meles leucurus*
32. European badger, *Meles meles*
33. Honey badger, *Mellivora capensis*
34. Bornean ferret-badger, *Melogale everetti*
35. Chinese ferret-badger, *Melogale moschata*
36. Javan ferret-badger, *Melogale orientalis*
37. Burmese ferret-badger, *Melogale personata*
38. Amazon weasel, *Mustela africana*
39. Mountain weasel, *Mustela altaica*
40. Ermine (stoat), *Mustela erminea*
41. Steppe polecat, *Mustela eversmannii*
42. Colombian weasel, *Mustela felipei*
43. Long-tailed weasel, *Mustela frenata*
44. Japanese weasel, *Mustela itatsi*
45. Yellow-bellied weasel, *Mustela kathiah*
46. European mink, *Mustela lutreola*
47. Indonesian mountain weasel, *Mustela lutreolina*
48. Black-footed ferret, *Mustela nigripes*
49. Least weasel, *Mustela nivalis*
50. Malayan weasel, *Mustela nudipes*
51. European polecat, *Mustela putorius*
52. Siberian weasel, *Mustela sibirica*
53. Back-striped weasel, *Mustela strigidorsa*
54. Egyptian weasel, *Mustela subpalmata*
55. American mink, *Neovison vison*
56. Sea mink, *Neovison macrodon* (19th century†)
57. African striped weasel, *Poecilogale albinucha*
58. Marbled polecat, *Vormela peregusna*

Now you continue this measuring process for all of the other families of the Order Carnivora.

Figure 4 from the *Nature* article

The authors of the *Nature* article carried out two statistical analysis of *Puijila* and came up with three spectacular conclusions

that 1) *Puijila* was a 'missing link', 2) *Puijila* was a pinniped, and 3) *Puijila* was more closely related to the fossil sea lion *Enaliarctos* than the living North American river otter.[5] This was unexpected since the *Puijila* skeleton looks so much like a North American river otter. (This can be seen in the Appendix E in *Evolution: The Grand Experiment*, Second Edition and in the *Creation* magazine article.)

Before proceeding, look at Figure 4 (below) from the original article that appeared in *Nature*.[6] Notice that this diagram shows the North American river otter *Lontra* not closely related to *Puijila*, even though their skeletons look alike. Also notice that *Puijila* looks to be the closest relative to *Enaliarctos* (sea lion) as compared to the other animals in this chart such as bears and mustelids. This chart is the key evidence offered by the authors that *Puijila* is a pinniped, but there are a series of problems.

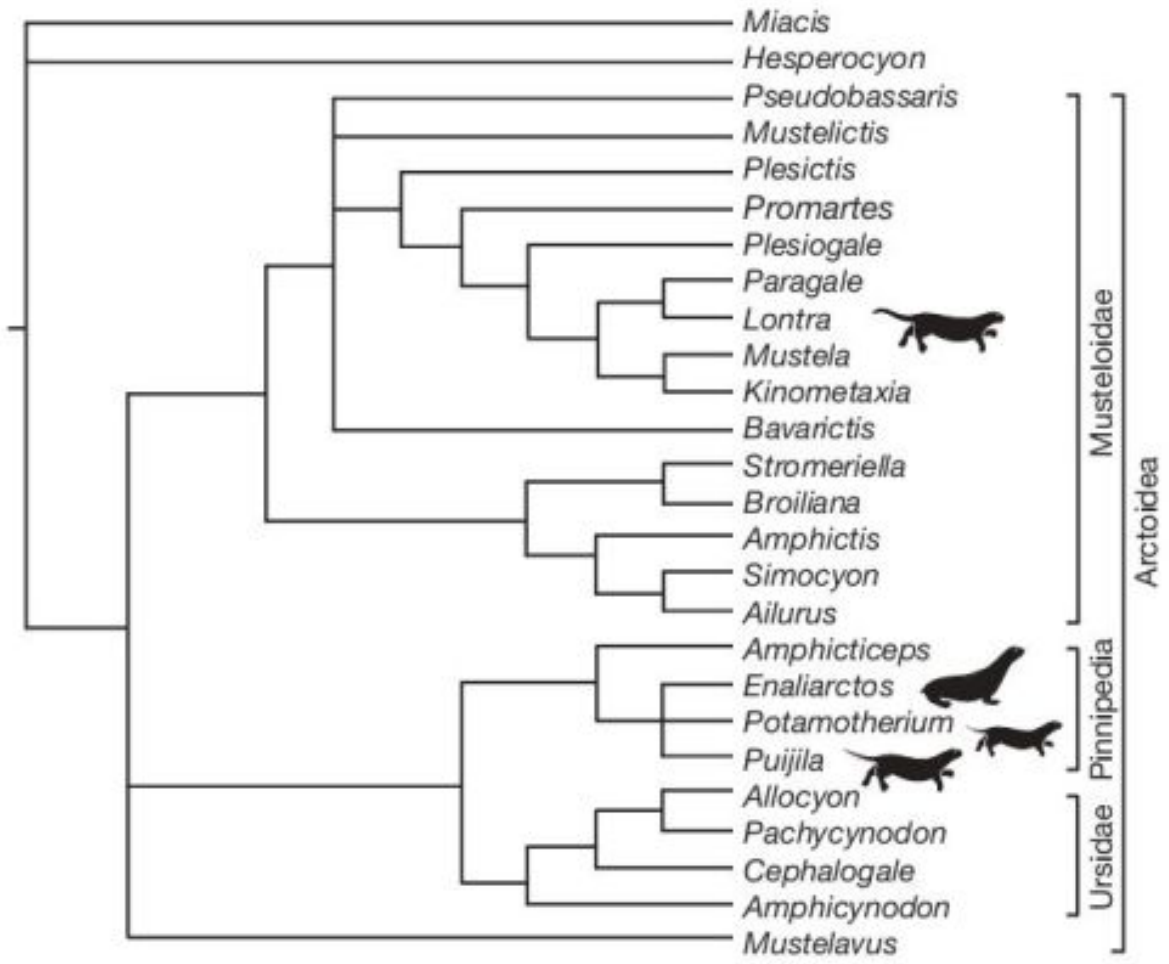

Figure 4 | Phylogenetic position of *Puijila* within Arctoidea. Strict consensus cladogram of the eight most parsimonious trees. See Methods and Supplementary Information for additional details.

Figure 4 from the *Nature* paper, showing the cladogram that suggests *Puijila* was a pinniped.

To get the data to create the analysis in Figure 4, the authors did not measure the bones of ***any*** living pinniped. This is odd because the whole purpose of this study was to make a case that

Puijila was a pinniped. The list of 26 animals that they included in Figure 4 can be seen in this Appendix. They measured only two of the 58 members of the Mustelidae family living today—the North American river otter and the long tailed weasel. Again, this is odd since some scientists believe pinnipeds evolved from mustelids. Also, they did not measure *any* living bears or *any* living canids. This is again odd since some evolution scientists say that pinnipeds evolved from one of these groups.

Even more disturbing is the choice of which characters they measured to reach these conclusions for Figure 4. The authors did not measure ***any*** of the seven classic distinguishing characters of pinnipeds listed above, characters that anyone can easily see in a skeleton. Instead they measured more obscure anatomical features such as "carotid artery position", "bulla", "Postlateral sulcus of brain", "Posterior border of palatine (hard palate) location", etc.

Limb analysis of *Puijila*

In a different section of this paper, a second analysis called "limb analysis" (Figure SI-2)[6], the authors obtained measurements from two of eight living bear species (not subspecies but species), one of 12 living skunk species, 16 of the 37 living pinniped species and nine of 58 living Mustelidae (1. Wolverine, *Gulo gulo,* 2. Fisher, *Martes pennanti*, 3. American mink, *Neovison vison*, 4. European otter, *Lutra lutra*, 5. North American river otter, *Lontra canadensis*, 6. Marine otter, *Lontra felina*, 7. Giant otter, *Pteronura brasiliensis*, 8. Oriental small-clawed otter, *Aonyx cinerea,* 9. Sea otter, *Enhydra lutris*). These animals are a completely different set of animals than those used to construct the phylogeny analysis (cladogram) of Figure 4, which again is odd. Why would you study one set of animals in one section and a different set of animals in another?

Before reviewing Figure SI-2, it should be noted again that this analysis again ignored the most accepted criteria for pinnipeds outlined above (large eye socket, shape of front and back

foot/flipper, short tail, the presence of post-canine teeth). None of these criteria were measured for chart SI-2. Instead this second analysis only measures the leg-to-arm index of 32 animals. This chart, SI-2, places *Puijila* with the otters, not the pinnipeds. Again this raises questions, since this conclusion is at odds with the conclusions of the first analysis, Figure 4, which said *Puijila* was more closely related to the fossil pinniped *Enaliarctos* than the living North American river otter.

There are three groupings on this SI-2 diagram. The bottom grouping consists of **squares**. These represent bears, skunks, wolverines and minks, an odd grouping indeed since these animals belong to two different families of Carnivora.

The middle grouping of **triangles** represents six living otters. *Puijila* is marked and is very near this grouping, again suggesting that *Puijila* is an otter, not a pinniped. The other animal, *Potamotherium,* is considered by some evolution scientists to be an extinct otter.[7] The upper grouping of circles, both solid and open **circles** represent 16 of 37 living pinnipeds. *Enaliarctos* is a known fossil pinniped that looks indistinguishable from a modern sea lion.

Nature journals

Figure SI-2 from the supplementary paper, showing *Puijila* grouped with otters, not pinnipeds.

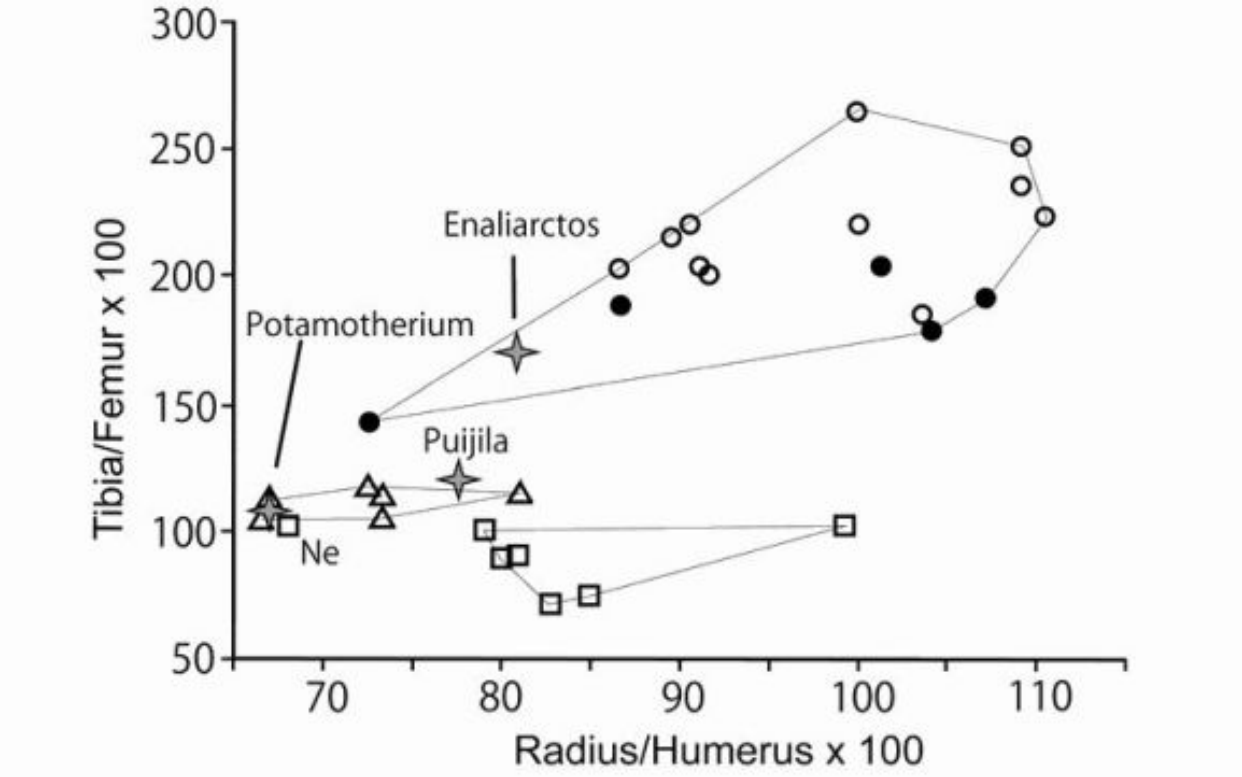

Figure SI-2. Bivariate plot of crural index versus brachial index for 29 living arctoids and three fossil pinnipeds
Legend: Otariidae and Odobenidae: solid circles; Phocidae: open circles; Lutrinae: triangles; terrestrial/arboreal arctoids and the semi-aquatic musteloid, *Neovison vison* (Ne): square; fossil pinnipeds: stars.

It should be noted that this supplemental article identifies *Puijila* as a "Fossil Pinniped" even though it has none of the classic pinniped characteristics necessary to call it a pinniped.

By ignoring the most obvious identifying characters of a group you can easily change the relatedness produced by analysis of the data .

Animal selection bias for Figure 4 and Figure SI-2

The selection of the animals to compare reflects a presuppositional bias that a particular animal is the evolutionary close relative to *Puijila*. But how do you know that *Puijila* was not a member of another family of mammals within Carnivora? In order to eliminate this bias you would need to compare *all* of the 15 families in this group, not just a few that you think may be related to *Puijila*. This study is woefully inadequate as it only studies a few living families within the order Carnivora.

Trait selection bias for Figure 4 and Figure SI-2

The selection of which traits to compare can give you a false impression of relatedness. By ignoring the most obvious identifying characters of a group you can easily change the relatedness produced by analysis of the data.

Trait modification for Figure 4

Many evolutionary paleontologists believe *Potamotherium* was an otter. In Figure 4 *Potamotherium* is more closely related to the pinniped *Enaliarctos* than the living otter, *Lonta,* which is higher up on the figure. The authors of the article state that they measured the skeleton of *Potamotherium* but did not use the measurements they obtained. Rather they changed the scores. The authors wrote, "Some characters were modified and some scores for *Potamotherium* were corrected."[8] Again, this is odd.

Appendix: Animals studied for Figure 4 of the *Nature* paper

Ailurus Red panda (family Ailuridae) Skeleton: CM 17508 (*A. fulgens*)

Allocyon Fossil bear (family Ursidae) Skull and mandible: AMNH 30074, cast of University of California 3606/24106 Literature: Merriam, 1930

Amphictis A member of the Raccoon family (Procyonidae) http://zipcodezoo.com/Animals/a/amphictis_antiquus/ Skull: AMNH 117488, cast of PU 11455

Amphicynodon Fossil bear (family Ursidae) Skull: AMNH 88390, cast of skull of NHM 7491 (*A. typicus*) Literature: Cirot and deBonis, 1992

Amphicticeps Unknown fossil skull Parent taxon: Ursoidea according to X. Wang et al. 2005, but Mustelidae according to http://zipcodezoo.com/Animals/A/Amphicticeps_dorog/ Skull: AMNH 19010 (*A. shackelfordi*)

Broiliana A fossil member of Procyonidae (Raccoon family) http://paleodb.org/cgi-bin/bridge.pl?a=basicTaxonInfo&taxon_no=41309 Skull: AMNH 108382, cast of type BSPG 13524 Skull: AMNH 108381, cast of Wintershof-West 1937 II 13191 (*B. nobilis*)

Cephalogale Fossil bear-like animal Skull and postcrania: F:AM 54464

Enaliarctos Fossil sea lion-like animal Literature: Mitchell and Tedford, 1973; Berta and Wyss, 1994

Hesperocyon Fossil of an extinct dog, family Canidae (the name means 'Western dog') Skull: CMNMA 8753, holotype (*H. gregarious*) Postcrania: Matthew, 1901; Wang, 1994

Lontra Modern (extant) North American otter (family Mustelidae) Skeleton: CMNMA 41069, Z-170 (*L. canadensis*)

Miacis Extinct weasel-sized animal Literature: Clark, 1939; Heinrich and Rose, 1995

Mustela Modern (extant) long tailed weasel (family Mustelidae) Skeleton: CMNMA 75144, 75356, Z-622 (*M. frenata*)

Mustelavus Fossil skull of the Procyonidae (Raccoon family) Skull: AMNH 129168 Skull: ITD 376

Pachycynodon Fossil only. Parent taxon: Amphicyonidae according to R. M. Hunt 1998, but Canidae according to http://paleodb.org/cgi-bin/bridge.pl?a=basicTaxonInfo&taxon_no=49577 Partial skeleton: AMNH 10064B Literature: Cirot and deBonis, 1992

Paragale An obscure fossil animal Literature: Petter, 1967

Plesictis Fossil weasel-like animal of the family Mustelidae; http://paleodb.org/cgi-bin/bridge.pl Skull: AMNH 117488, cast of PU11455 Humerus: AMNH 10090 (*P. palmidens*) Skull and partial skeleton: AMNH 11001 (*P. genettoides*) Literature: Wolsan, 1993

Plesiogale Fossil mustelid; http://paleodb.org/cgi-bin/bridge.pl Literature: Helbing, 1930

Potamotherium Fossil otter (Mustelidae), Savage, R.J.G., The anatomy of Potamotherium an Oligocene lutrine**,** *Journal of Zoology* (formerly *Proc. Zoological Soc. London*) **129**(2): 151–244, 2009. Collections housed at the Naturhistorisches Museum (Basel, Switzerland) and the American Museum of Natural History (New York, U.S.A.). Mandible, left: AMNH 22520 Literature: Savage, 1957

Promartes A Miocene mustelid Skull: AMNH 27583, original bone Humerus: AMNH field number 464-Lusk-box96 UVA breaks Femur: AMNH 27583 Literature: Riggs, 1942; Riggs, 1945

Simocyon An extinct member of Ailuridae (Red panda family) Skull: AMNH 129872, cast of IVPP v-12162 (*S. primigenius* Literature: Wang, 1997

Stromeriella Some consider Procyonidae family (Raccoon) others mustelid http://zipcodezoo.com/Animals/S/Stromeriella_franconica/ Skull AMNH 108380, cast of BSPG 13352 Mandible: AMNH 108378, cast of BSPG 13010

New Taxon: ***Puijila*** Skull and skeleton: NUFV 405.

Also note that on page 10 of Data Matrix, they listed four additional fossil mustelids that were not on this list above: *Bavarictis, Kinometaxia, Mustelicitis, Pseuobassaris* bringing the total to 26 animals measured.

References

1. See Chapter 10, *Evolution: The Grand Experiment*, page 108 for details of the suggestion that some pinnipeds evolved from a dog-like animal.

2. Rybczynski, N., Dawson, M.R., and Tedford, R.H., A semi-aquatic Arctic mammalian Carnivora from the Miocene epoch and origin of Pinnipedia, *Nature* **458**:1021–1024, 23 April 2009, p. 1021. "Recent phylogenetic studies using morphological and molecular evidence support pinniped monophyly, and suggest a sister relationship with ursoids (for example bears) or musteloids." Return to text.
3. ITIS report on Caniformia (Kretzoi, 1938); www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=552303.
4. Allen, J., *History of North American pinnipeds: a monograph of the walruses, sea-lions, sea bears and seals of North America*, Washington Government Printing Office, 1880.
5. Rybczynski, N., Dawson, M.R., and Tedford, R.H., A semi-aquatic Arctic mammalian Carnivora from the Miocene epoch and origin of Pinnipedia, *Nature* **458**:1021–1024, 23 April 2009.
6. *Nature*, Supplementary Information, doi: 10.1038/nature07985.

7. Savage, R.J.G., The anatomy of *Potamotherium* an Oligocene lutrine, *Journal of Zoology* (formerly Proc. *Zoological Soc. London*) **129**(2): 151–244, 2009.

8. Rybczynski, N., Dawson, M.R., and Tedford, R.H., A semi-aquatic Arctic mammalian Carnivora from the Miocene epoch and origin of Pinnipedia, *Nature* 458, 23 April 2009, p. 1023.