Origin of flight

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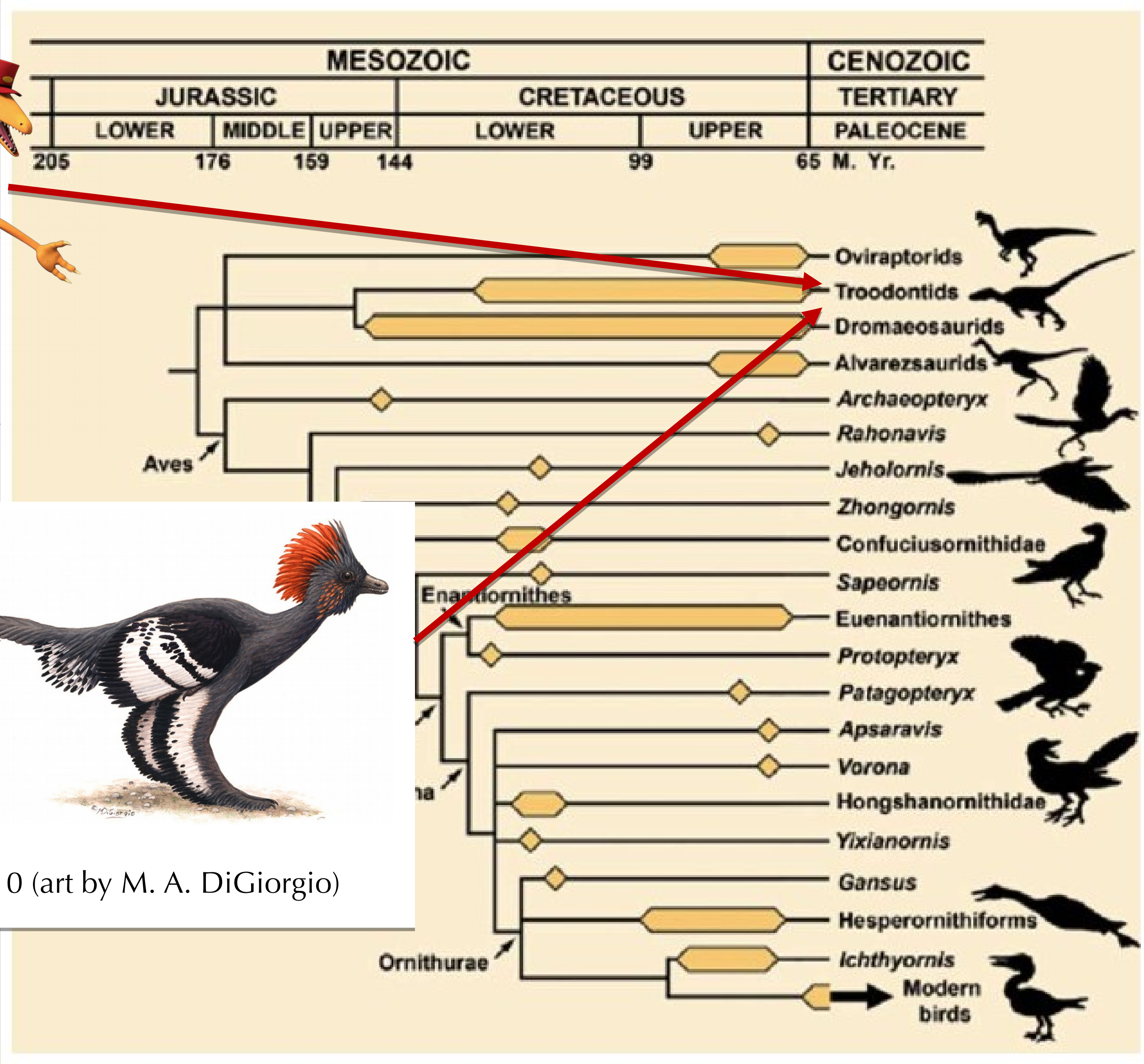
EEB464 Fall 2018

Learning objectives

- Know multiple origins of flight
- Describe hypotheses for origin
- Consider possible evolutionary dead ends

http://www.youtube.com/watch?v=GEP-KgJkYnw



Li et al. 2010 (art by M. A. DiGiorgio)

Chiappe. Downsized dinosaurs: the evolutionary transition to modern birds. Evolution: Education and Outreach (2009) vol. 2 (2) pp. 248-256

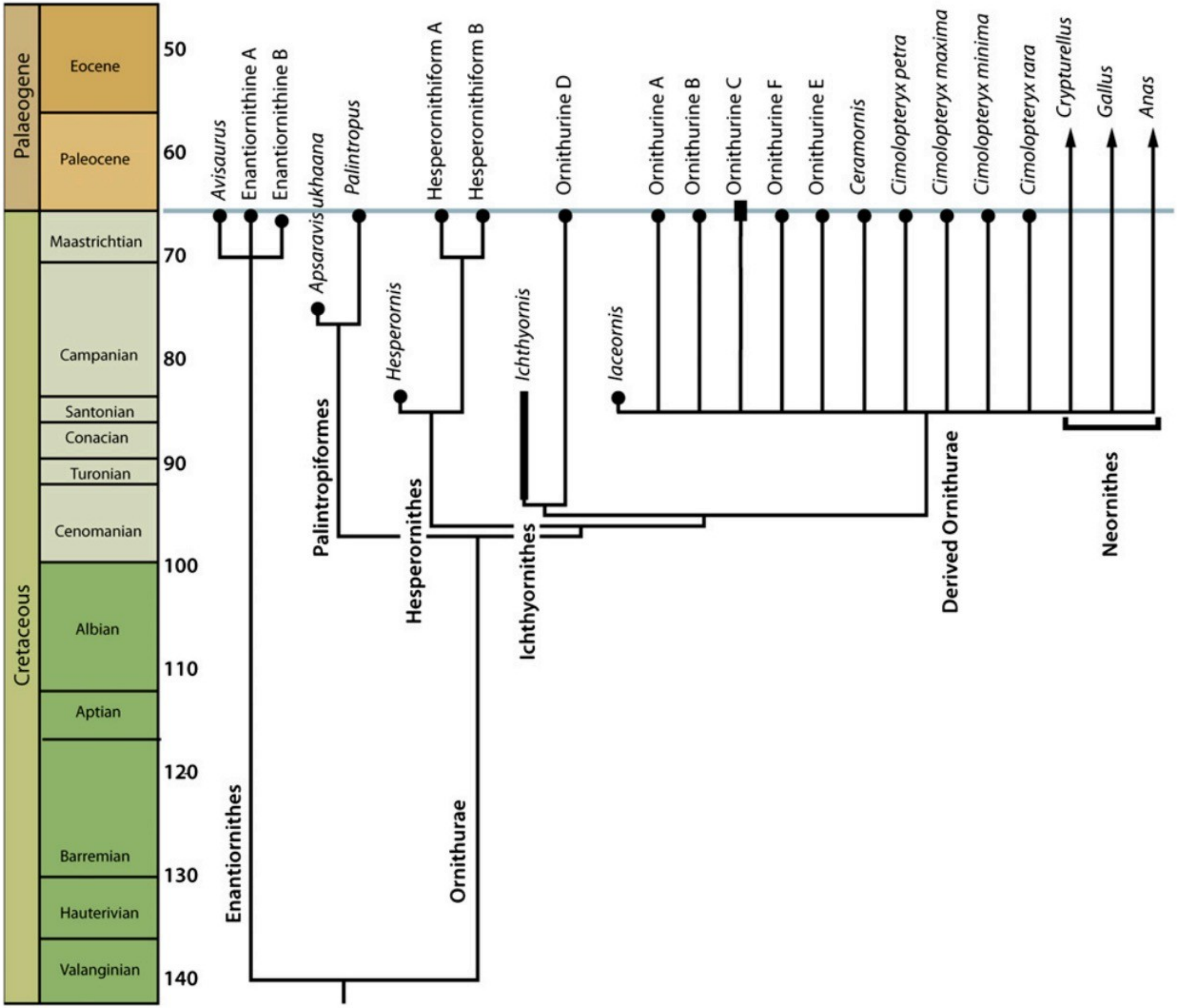
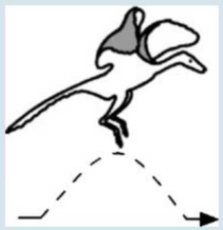
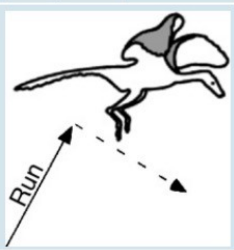
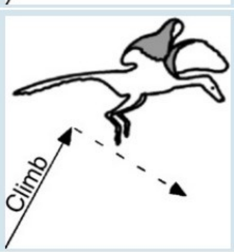


Fig. 4. Phylogeny showing relationships and stratigraphic distribution of late Maastrichtian birds (bold) and other avians. Note that the extension of neornithine branches into the mid Late Cretaceous is the result of an unresolved polytomy; the earliest fossil evidence of Neornithes is Maastrichtian (9). See *SI Appendix* for full results and details of the analysis.

Longrich et al, 2011

A Hypothesis		B Behavioral context of incipient wings			C Proposed behavior observed in extant tetrapods?	Extant support for inferred form–function relationships?
			Role of hindlimbs	Role of forelimbs		
Wing-assisted incline running (WAIR, OTW)	[1,2]		Run	Flap	Yes: many birds	[1,47–49]
Thrust generation for faster running	[3–6]				No: birds do not flap to run faster	No
Running on water (Jesus-Christ lizard)	[7,8]				Yes: basilisk lizards (but do not flap), aquatic birds (takeoff, usually)	[8,50]
Leaping biped	[9,10]		Run and jump	Flap	No	No
Insect net	[11,12]			Flap, acquire prey	Yes/No: some bats, but not while running and jumping	[51]
Predatory strike	[13–15]				Yes: mammalian felids jump and swipe, but not birds or reptiles	No
Wings for stability	[16,17]			Glide	No	No
Running into headwind	[18]				No	No
Intraspecific fighting	[19]		Stand and jump	Flap	Yes: many extant adult birds	No
Jumping model	[20]				Yes: many extant birds during takeoff, display, or predator escape	[20]
Ridge gliding	[21–23]		Run and jump	Glide	Yes: petrels, etc.	[52,53]
Controlled flapping descent (CFD, OTW)	[2]		Run	Flap	Yes: immature birds	[2,54]
Arboreal gliding	[24–44]		Climb, ± jump, ± aerodynamic force	Glide, climb	Yes: *Draco*, flying squirrels, etc., but not birds	[55,56]
Pouncing predator	[45]		Climb, jump, acquire prey		Yes/No: swooping birds do not climb to elevated ambush sites	No
Flutter-gliding	[46]		Climb	Glide, flap, climb	Yes/No: immature birds climb but do not glide	No

Heers & Dial, 2011

http://www.youtube.com/watch?v=5Rjin-tjOxU

A		B			C	
Hypothesis		**Behavioral context of incipient wings**			**Proposed behavior observed in extant tetrapods?**	**Extant support for inferred form–function relationships?**
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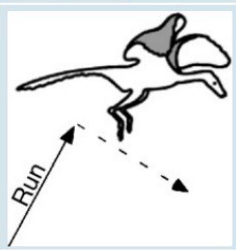
Ridge gliding	[21–23]		Run and jump	Glide	Yes: petrels, etc.	[52,53]
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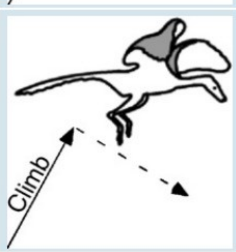
Arboreal gliding	[24–44]		Climb, ± jump, ± aerodynamic force	Glide, climb	Yes: *Draco*, flying squirrels, etc., but not birds	[55,56]
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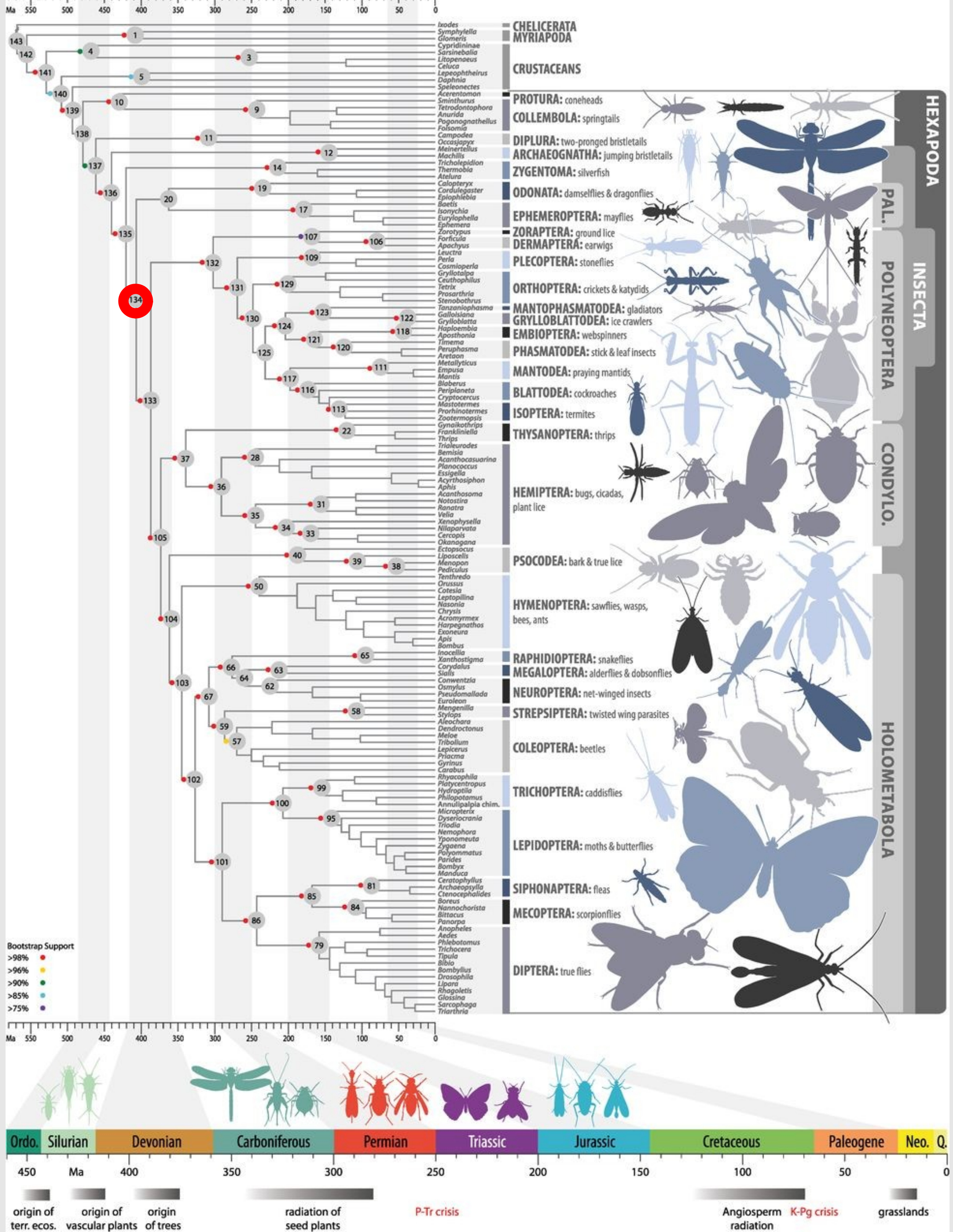
Heers & Dial, 2011

BBC Earth Unplugged: https://www.youtube.com/watch?v=Lw2dfjYENNE

duncantakeru:https://www.youtube.com/watch?v=Yk4ZN1A6E0M

The origins of winged (pterygote) insects are both unresolved and deeply puzzling, given the absence of transitional fossil forms. Flying insects probably evolved in either the Upper Devonian or early Lower Carboniferous, and by the onset of the Upper Carboniferous (~325 Mya) were well diversified into about fifteen orders, many of which resemble taxa existing today (Grimaldi and Engel 2005). Fossils of these late Paleozoic winged insects and those of ancestrally wingless hexapods at ~390 Mya are separated by approximately 65 million years for which no apterygote, pterygote, or transitional fossil is recorded. The morphological origins of wings and their subsequent elaboration thus remain obscure; pterygote wings are not homologous with the legs (as is the case for volant vertebrates), and accordingly represent true evolutionary novelty.

Bradley et al. Episodes in insect evolution. Integrative and Comparative Biology (2009)



Bernhard Misof et al. Science 2014;346:763-767

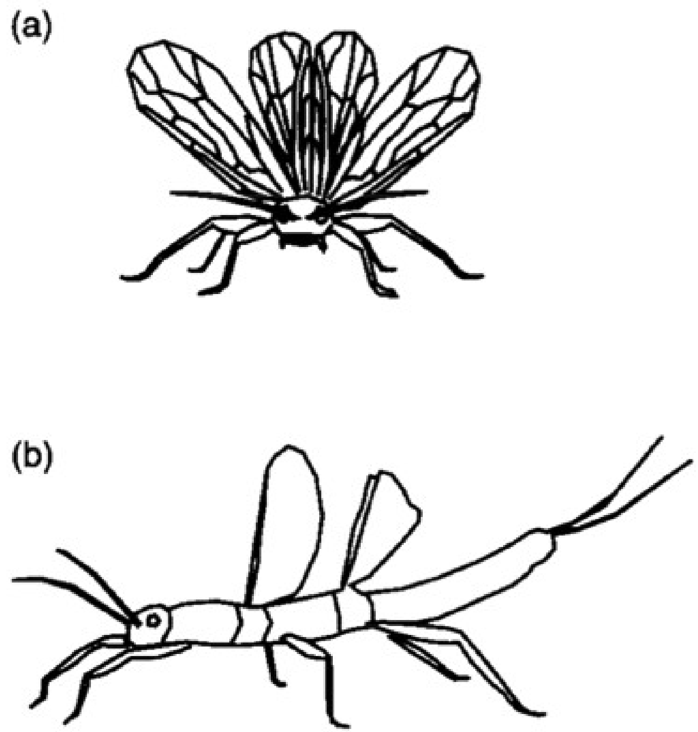


Fig. 1. (a) Female stonefly (*Allocapnia* spp.) in sailing position on the water surface, showing the spinnaker-like arrangement of the wings. (b) Male stonefly sailing. The males of some species have much shorter wings than the females and are unable to fly (or even flap). Instead they use their wings to sail across the water surface. *Drawings based on a series of photographs by Marden and Kramer*[2].

Thomas and Åke Norberg. Skimming the surface--the origin of flight in insects?. Trends Ecol Evol (1996) vol. 11 (5) pp. 187-188

Yanoviak et al. Gliding hexapods and the origins of insect aerial behaviour. Biology Letters (2009) vol. 5 (4) pp. 510

Bristletail picture from http://www.cals.ncsu.edu/course/ent425/library/compendium/archeognatha.html

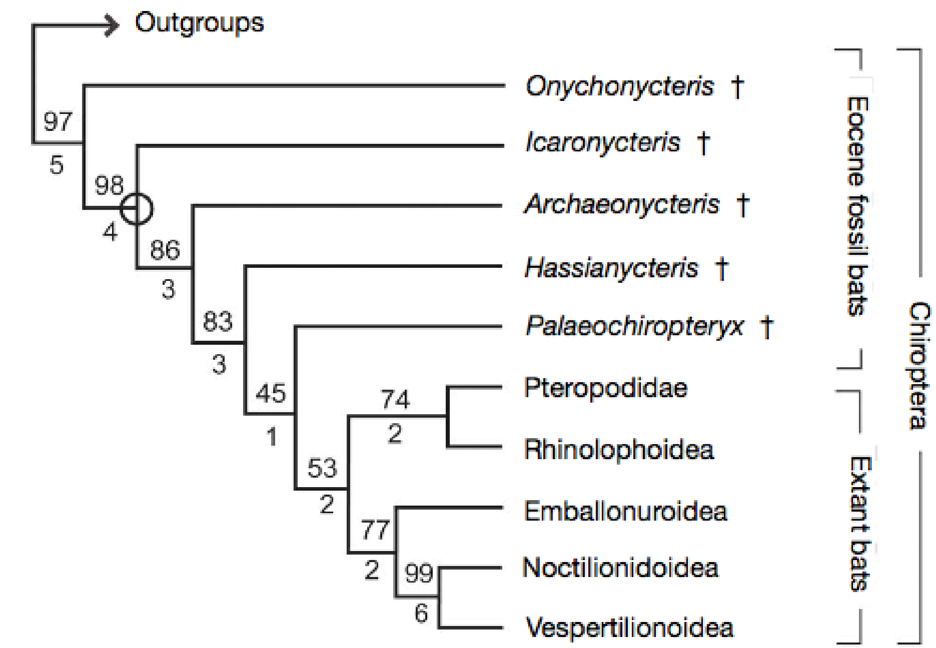


Figure 4 | Phylogenetic position of *Onychonycteris* and other Eocene fossils with respect to extant bat lineages. Relationships of fossil taxa to extant families (here grouped into superfamilies) were constrained by using a backbone scaffold tree derived from molecular studies. Numbers above branches are bootstrap values; numbers below branches are Bremer values. Derived features present in *Icaronycteris*, *Archaeonycteris*, and other extinct and extant bats (clade defined by node circled on tree) but absent in *Onychonycteris* include the following: enlarged orbicular apophysis on the malleus; stylohyal element with an expanded, paddle-like cranial tip; enlarged cochlea; ribs with posterior laminae; claws absent on forelimb digits III–V.

Simmons et al. Primitive Early Eocene bat from Wyoming and the evolution of flight and echolocation. Nature (2008) vol. 451 (7180) pp. 818-821

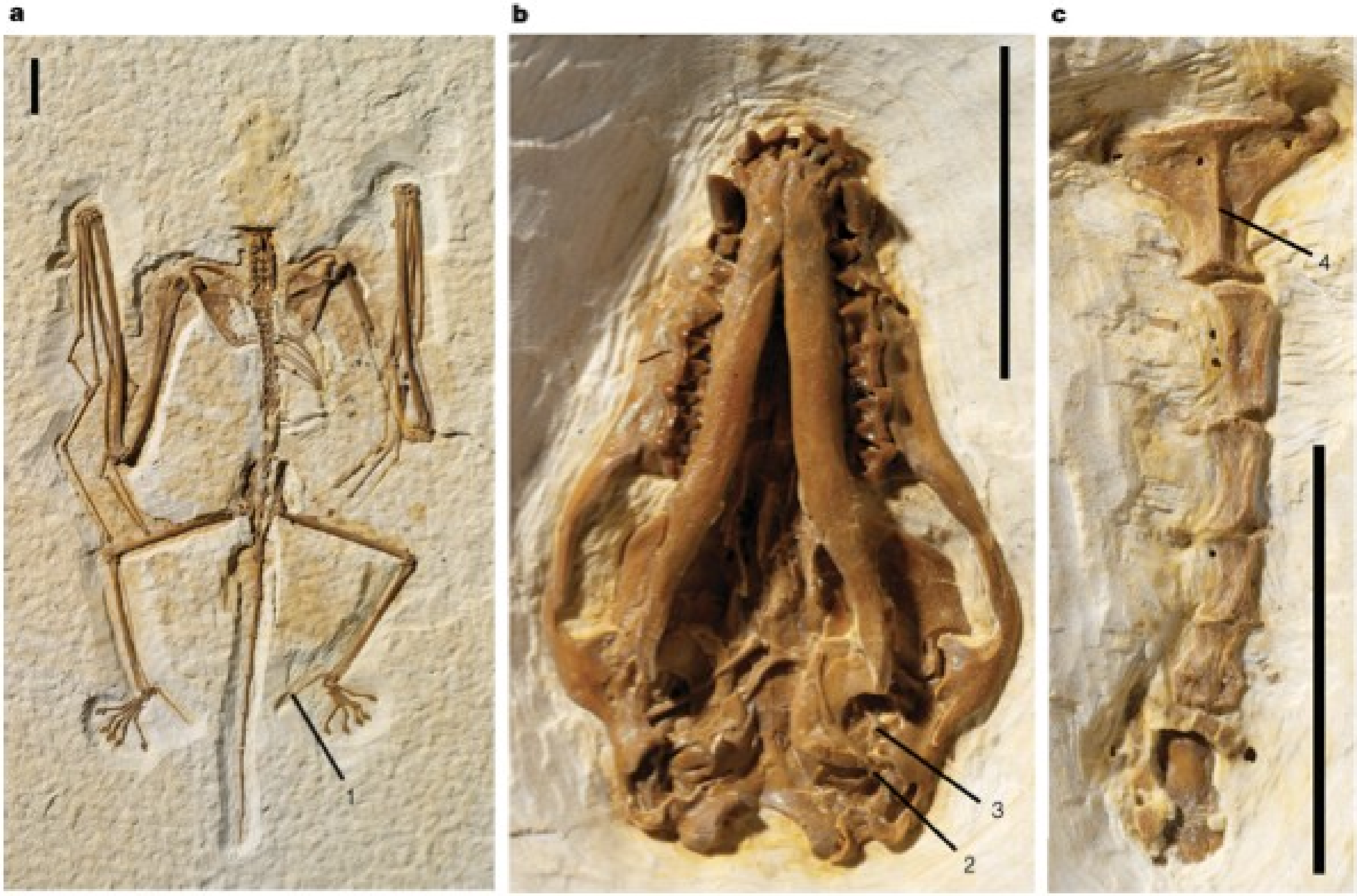
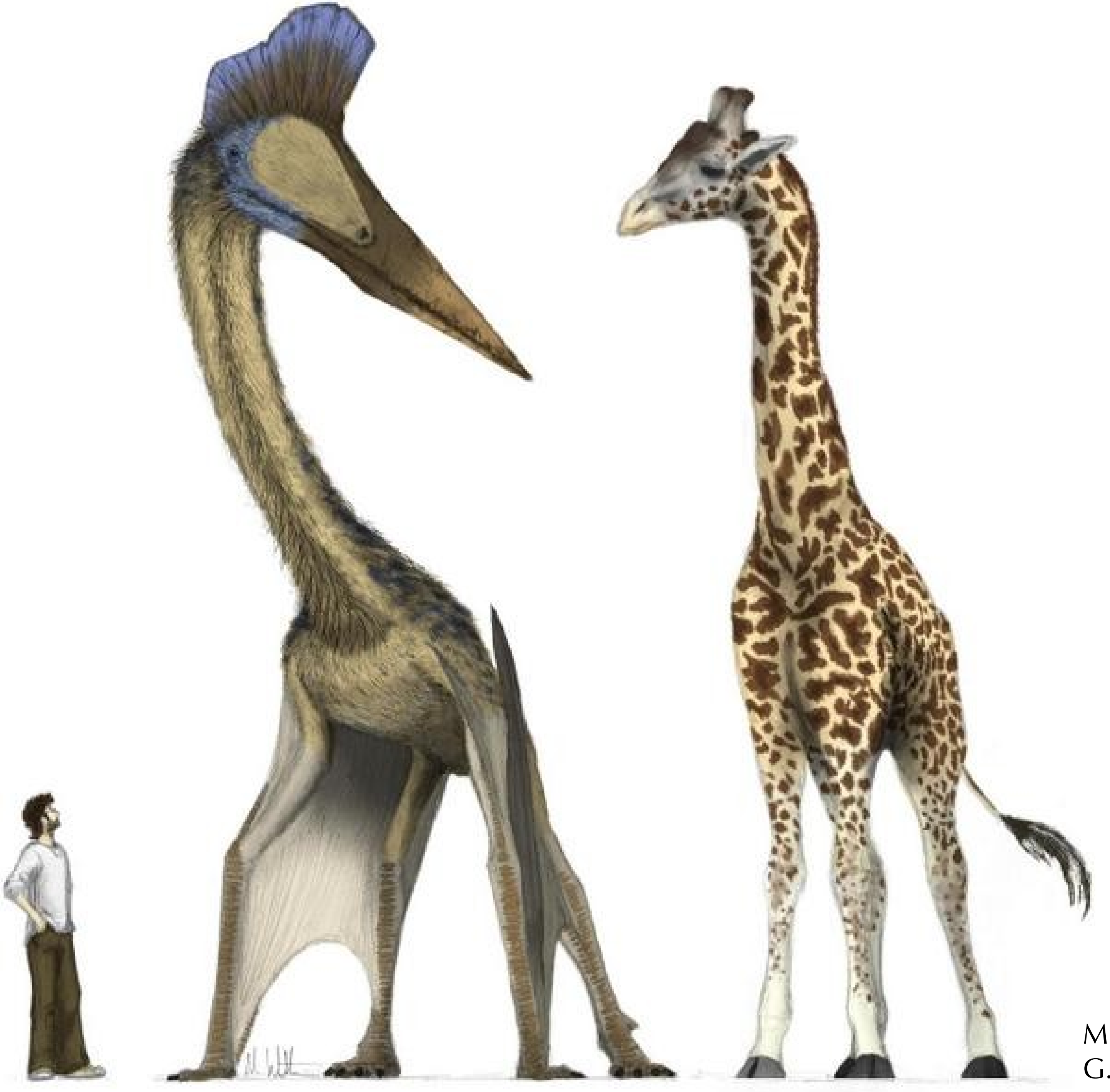


Figure 1 | Holotype of *Onychonycteris finneyi* (ROM 55351A). **a**, Skeleton in dorsal view. **b**, Skull in ventral view. **c**, Sternum in ventral view. Scale bars, 1 cm. All elements are preserved on a single slab with the skeleton exposed on one side, and the skull and sternum on the reverse. The counter-part slab (ROM 55351B, not shown) preserves impressions of parts of the dorsal aspect of the skeleton. Features labelled: 1, calcar; 2, cranial tip of stylohyal; 3, orbicular apophysis of malleus; 4, keel on manubrium of sternum.

Simmons et al. Primitive Early Eocene bat from Wyoming and the evolution of flight and echolocation. Nature (2008) vol. 451 (7180) pp. 818-821

Forelimb anatomy indicates that the new bat was capable of powered flight like other Eocene bats, but ear morphology suggests that it lacked their echolocation abilities, supporting a ‘flight first’ hypothesis for chiropteran evolution. The shape of the wings suggests that an undulating gliding–fluttering flight style may be primitive for bats, and the presence of a long calcar indicates that a broad tail membrane evolved early in Chiroptera, probably functioning as an additional airfoil rather than as a prey- capture device. Limb proportions and retention of claws on all digits indicate that the new bat may have been an agile climber that employed quadrupedal locomotion and under-branch hanging behaviour.

Simmons et al. Primitive Early Eocene bat from Wyoming and the evolution of flight and echolocation. Nature (2008) vol. 451 (7180) pp. 818-821



M. Witton via
G. Trivedi

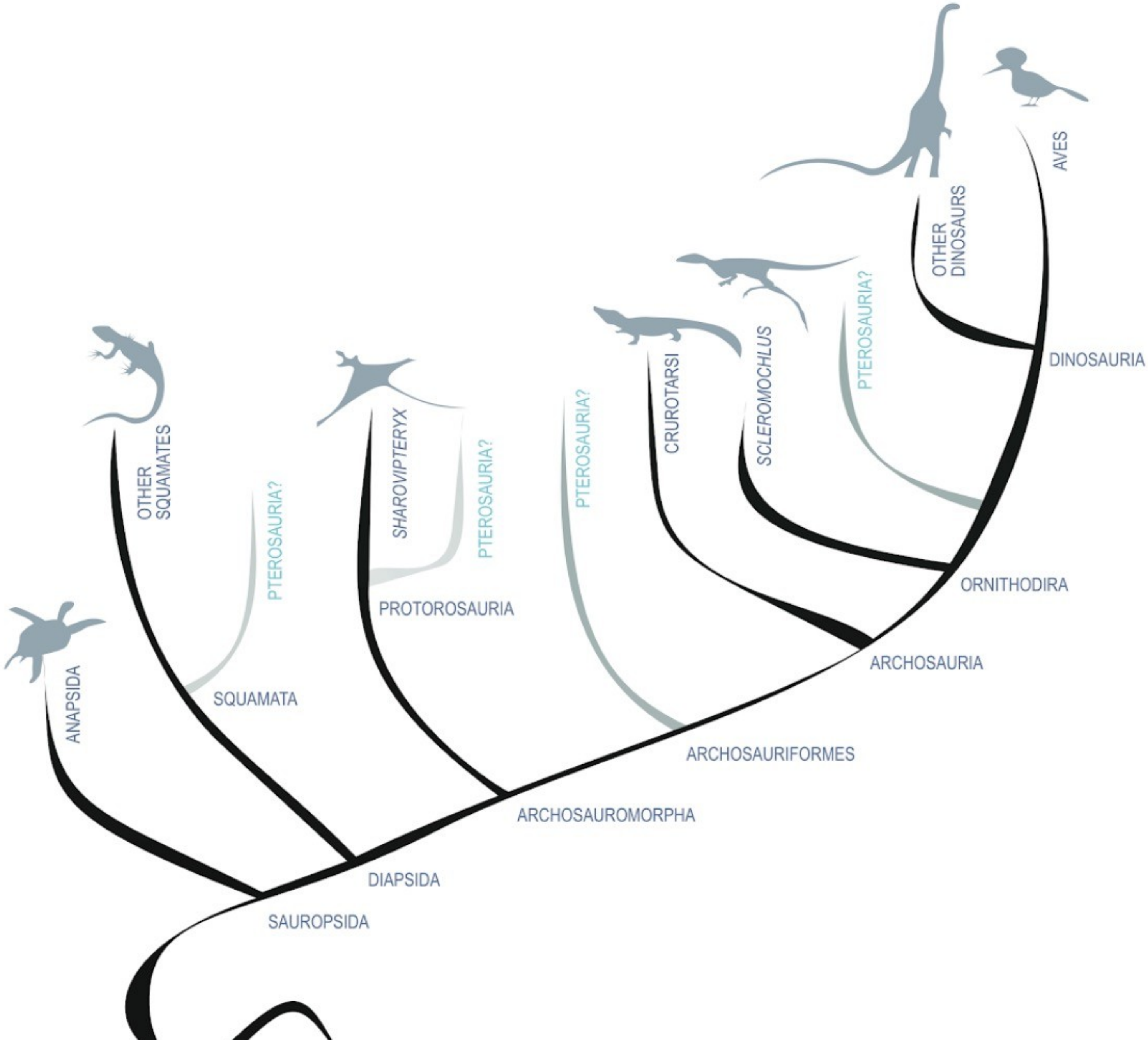


FIG. 3.3. Sauropsid phylogeny and the many suggested homes of Pterosauria.

Witton 2013

Almost, or dead end? [gliding]

- Flying fish
- Gliding frogs
- Gliding snakes
- Gliding worker ants
- Flying squid
- Flying squirrels
- Plant adaptations (maple seeds, dandelions, etc.)

http://www.youtube.com/watch?v=RLbkVanjHVU

http://www.youtube.com/watch?v=UCSf5_894B4

http://www.youtube.com/watch?v=8nEwte-x-iw