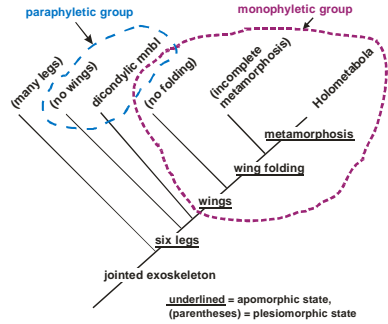


General Entomology
The Biology of Insects



...a bit of systematics...

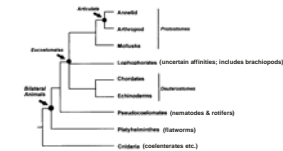


What sort of animals are insects?

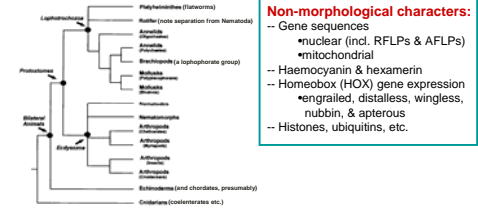
GEOLOGIC TIME SCALE				Development of Plants and Animals	
Time Units of the Geologic Time Scale					
Eon	Era	Period	Epoch		
Phanerozoic	Cenozoic	Quaternary	Holocene	0.01	Earliest Homo sapiens
			Pleistocene	1.6	Earliest hominids
		Tertiary	Pliocene	5.3	
			Miocene	23.8	"Age of Mammals"
			Oligocene	33.7	
			Eocene	56	
		Mesozoic	Cretaceous	65	Extinction of dinosaurs and many other species
				145	First flowering plants
				208	First birds
			Jurassic	208	Dinosaurs dominant
	Triassic		248	First mammals	
	Paleozoic		Permian	286	Extinction of trilobites and many other marine animals
		252			
		Carboniferous	Pennsylvanian	320	First reptiles
			Mississippian	360	Large coal swamps
	Precambrian	Proterozoic	544	Amphibians abundant	
			410	"Age of Fishes"	
			360	First amphibians	
			286	First insect fossils	
		Archaean/Proterozoic	Cambrian	544	First land plants
544				Trilobites dominant	
Vendian			650	First organisms with shells	
			650	Abundant Ediacaran faunas	
Archaean/Proterozoic	Precambrian	2500	Collectively called Precambrian		
		3800	comprises about 87% of the geological time scale		
	Hadaean	4600 Ma	First one-celled organisms		
				Age of oldest rocks	
				Origin of the earth	

Metazoa (35 phyla)

Traditional metazoan phylogeny: morphology (after Barnes 1987)

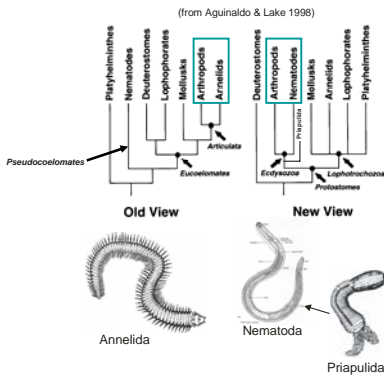


Revised metazoan phylogeny: 18S rDNA (after Aguinaldo et al. 1997, 1999)



- Non-morphological characters:**
- Gene sequences
 - nuclear (incl. RFLPs & AFLPs)
 - mitochondrial
 - Haemocyanin & hexamerin
 - Homeobox (HOX) gene expression
 - engrailed, distalless, wingless, nubbin, & apterous
 - Histones, ubiquitins, etc.

Summary of changes to phylogeny of Metazoa, based on nucleotide sequences of 18S rDNA (from Aguinaldo & Lake 1998)



Phylum Arthropoda
Metazoa

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"Panarthropoda"

Regular arthropods, plus:

Onychophora ("velvet worms")
Cambrian; ~200 species



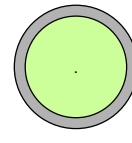
Tardigrada ("water bears")
Cambrian? >700 species



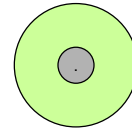
Arthropoda – "jointed foot"



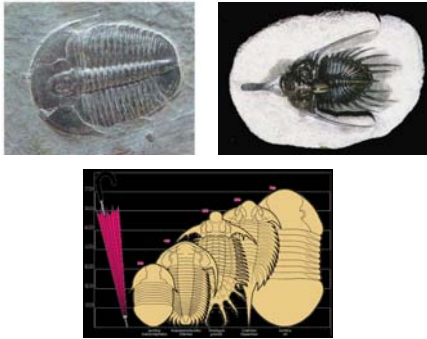
exoskeleton



endoskeleton



Arthropoda: Trilobitomorpha
~4000 species (Cambrian-Permian)



Arthropoda: Chelicerata

Pycnogonida (Sea Spiders) – Devonian-Present; ~1000 species



Arthropoda: Chelicerata, continued:

Euchelicerata: Merostomata

Eurypterida (Ordovician-Permian)
200 fossil species



Xiphosura (Cambrian-Present)
5 extant but many fossil species



Arthropoda: Chelicerata, continued:

Euchelicerata: Arachnida 1, the Scorpion clade

Opiliones (harvestmen, daddy longlegs)
5000 species



Scorpiones (scorpions)
1200 species; Silurian



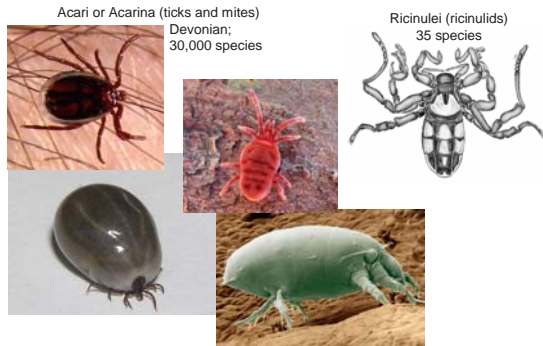
Pseudoscorpiones (pseudoscorpions)
2000 species



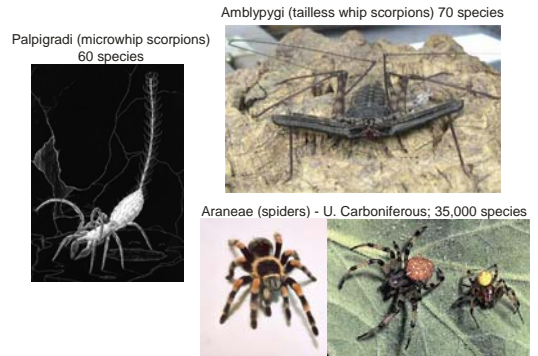
Solpugida (Solpugae) (sun spiders)
900 species



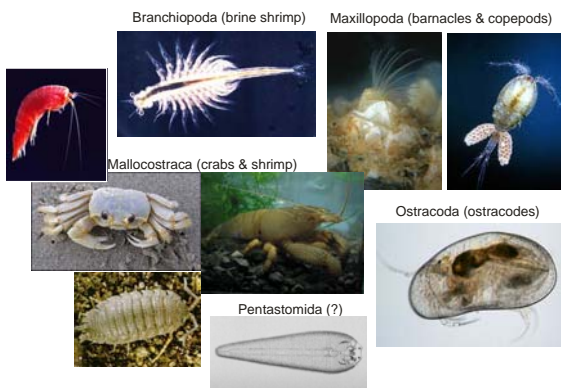
Arthropoda: Chelicerata, continued:
Euchelicerata: Arachnida 2, the Tick clade



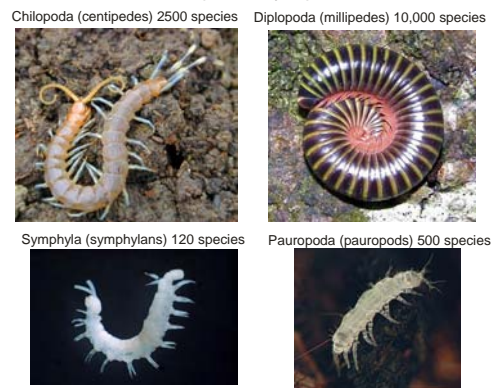
Arthropoda: Chelicerata, continued:
Euchelicerata: Arachnida 3, the Spider clade



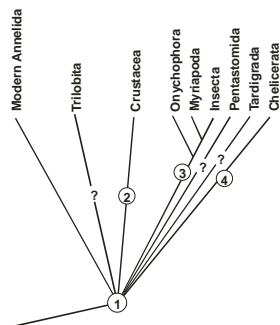
Arthropoda: Crustacea (>30,000 species)



Arthropoda: Myriapoda



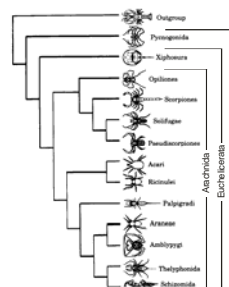
Annelid-Arthropod Relationships:
Polyphyletic Theory (Manton)



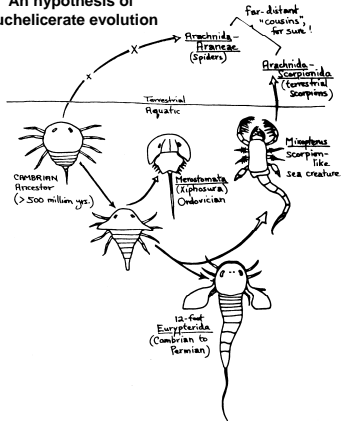
Phylogeny of the extant chelicerate orders

based on molecular (small and large ribosomal subunit DNA)
and morphological information (combined data)

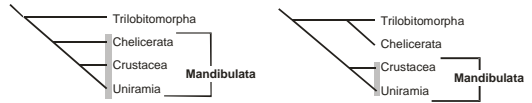
(after Wheeler & Hayashi 1998)



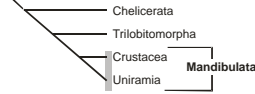
An hypothesis of Euchelicerate evolution



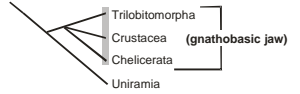
RELATIONSHIPS OF ARTHROPOD TAXA: EARLY HYPOTHESES
(In all schemes, Uniramia = Myriapoda + Hexapoda)



championed by SNODGRASS, e.g., 1938

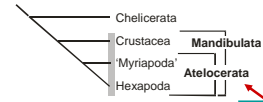


championed by MANTON, e.g., 1964

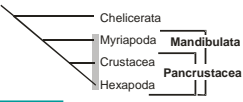


RELATIONSHIPS OF ARTHROPOD TAXA: CURRENT HYPOTHESES

Snodgrass, Weygoldt, Wägele, Wheeler et al.

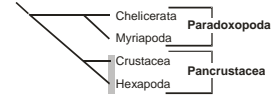


Zrzavý, Giribet et al.

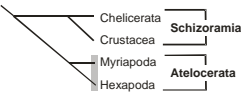


traditional views

Turbeville et al., Friedrich & Tautz, Mallatt et al.



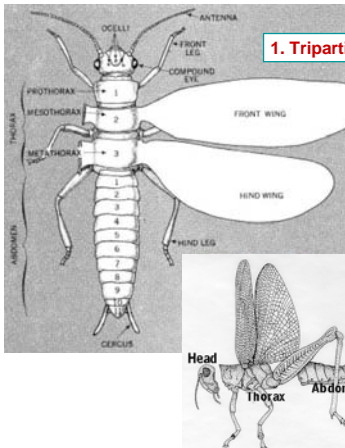
Cisne, Briggs et al., Budd



Note: Atelocerata = Tracheata = Uniramia (more or less)
Secondnote: Pancrustacea (Mallatt) = Tetraconata (Richter)

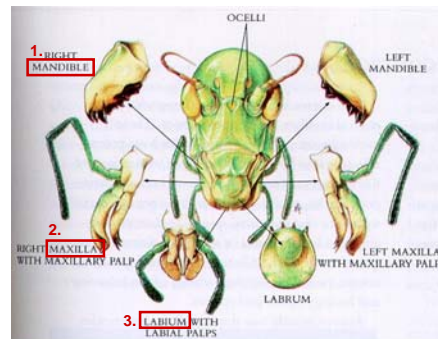
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				Mississippian	320
			Devonian	360	First amphibians
				Silurian	410
Ordovician	438	Fishes dominant			
	Cambrian	520	First land plants		
440		First trilobites			
Vendian	540	First organisms with shells			
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					First one-celled organisms
					Age of oldest rocks
					Origin of the earth

Insecta →
Arthropoda →
Metazoa →



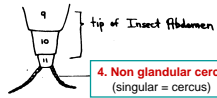
1. Tripartite Tagmosis

2. Trignathous, ectognathous mouthparts





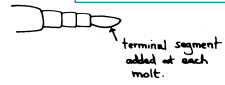
3. Antennae with no intrinsic muscles past the pedicel



4. Non glandular cerci: (singular = cercus)



5. No anamorphosis: (i.e., epimorphic development)



6. "Amniotic" Egg

