http://www.biltek.tubitak.gov.tr/bilgipaket/jeolojik/index.htm

Paleontology

Muhittin Görmüş

Department of Geology

Lecture 12

http://members.cox.net/jdmount/paleont.html

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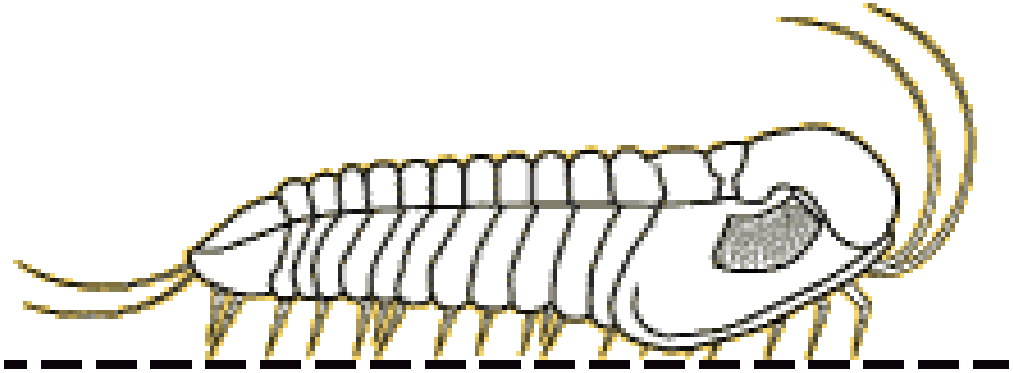
. . . the REAL rulers of the Earth. . .

ARTHROPODA

http://www.ucmp.berkeley.edu/arthropoda/arthropoda.html



http://www.trilobites.info/ordharpetida.htm

Arthropods are invertebrates with segmented bodies and jointed limbs. The limbs form part of an exoskeleton, which is mainly made of α-chitin, a derivative of glucose

Arthropods are members of the phylum **Arthropoda** (from Greek , "joint", and "leg", which together mean "jointed leg"), and include the insects, arachnids, and crustaceans. It also includes an extinction class Trilobita.

Arthropods are characterized by their jointed limbs and cuticles, which are mainly made of α-chitin; the cuticles of crustaceans are also biomineralized with calcium carbonate.

One of the most important invertebrate phyllum including 80.000 species.

Modified from http://en.wikipedia.org/wiki/Arthropod

Domain Eukarya
Kingdom Animalia
Phylum Arthropoda

Image below curtesy of Northwest Pests

http://www.sidwell.edu/us/science/vlb5/Labs/Classification_Lab/Eukarya/Animalia/Arthropoda/


Abtrichia antennata


starbellied spider
Acanthepeira stellata


starbellied spider
Acanthepeira stellata


Vespula germanica


red twin spot
Xanthorhoe ferrugata


oriental rat flea
Xenopsylla cheopis


Acanthocephala terminalis


smaller yellow ant
Acanthomyops claviger


smaller yellow ant
Acanthomyops claviger


Xylocopa

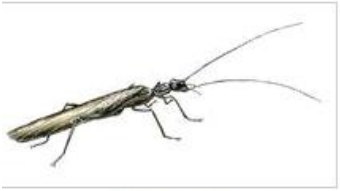

carpenter bee
Xylocopa virginica


Xylotrechus


Achaearanea


house spider
Achaearanea tepidariorum


Acherontia atropos


Zealeuctra claasseni


Zelus


Zelus


Acherontia atropos


Acherontia atropos


luna moth
Actias luna


Zelus


Zootermopsis laticeps


Zopherus chilensis


luna moth
Actias luna


Acyrthosiphon pisum


Adelpha bredowii


Zopherus chilensis


damselflies
Zygoptera


damselflies
Zygoptera

http://animaldiversity.ummz.umich.edu/site/accounts/pictures/Arthropoda.html

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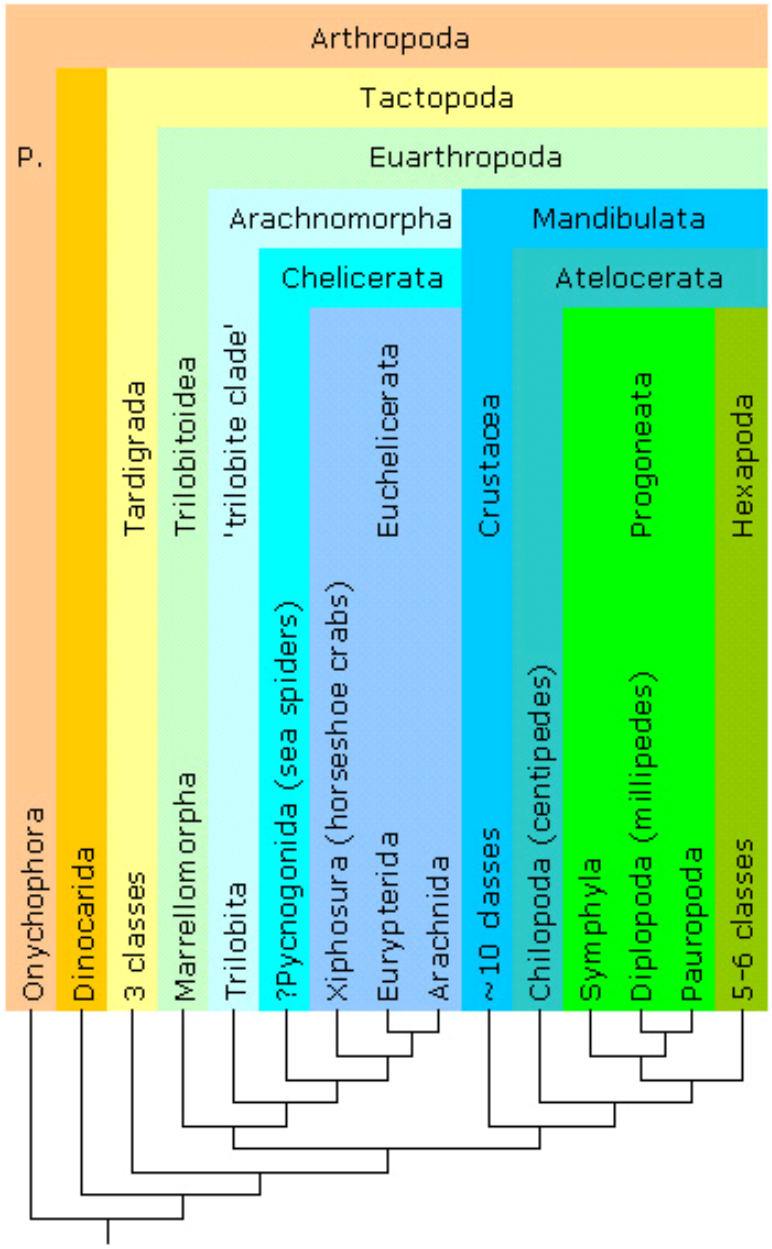
Classification

Phylum
Supersubphylum
Subphylum
Superclass
Class

Arthropoda

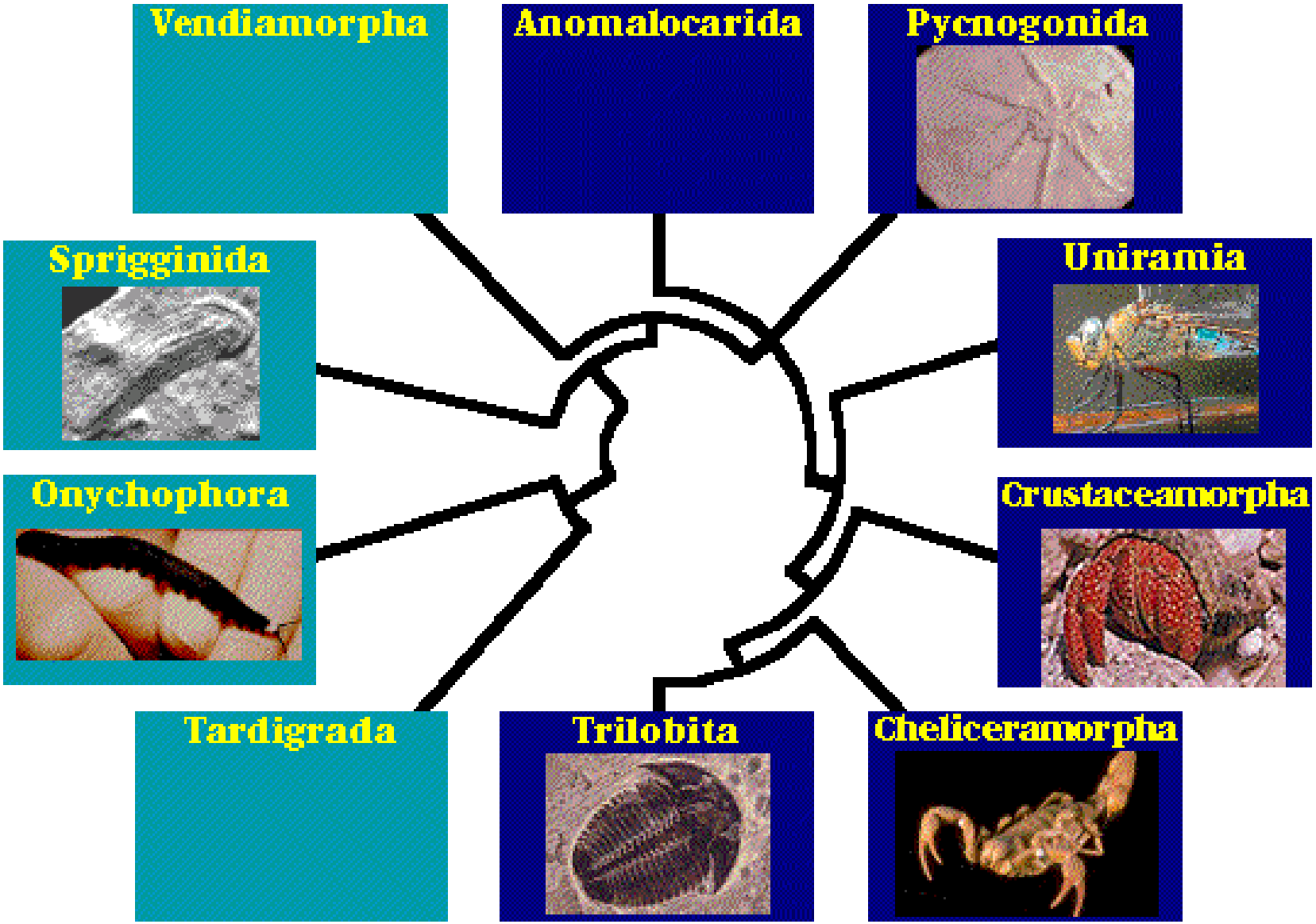
- Hexapoda (insects, springtails, diplurans, and proturans)
- Crustacea (crabs, lobsters, shrimp, isopods, water fleas, barnacles, etc.)
- Myriapoda
  - Pauropoda
  - Diplopoda (millipedes)
  - Chilopoda (centipedes)
  - Symphyla
- Chelicerata
  - Arachnida (spiders, mites, ticks, scorpions, etc.)
  - Eurypterida † (sea scorpions)
  - Xiphosura (horseshoe crabs)
  - Pycnogonida (sea spiders)
- Trilobites †

http://tolweb.org/Arthropoda



http://www.peripatus.gen.nz/
Taxa/Arthropoda/Index.html

Classification



http://www.ucmp.berkeley.edu/arthropoda/arthropodasy.html

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Trilobita

Domain Eukarya
Kingdom Animalia
Phylum Arthropoda
Class Trilobita

Image below courtesy UCMP Berkeley

http://www.sidwell.edu/us/science/vlb5/Labs/Classification_Lab/Eukarya/Animalia/Arthropoda/Trilobita/

- **Trilobites (meaning "three lobes") are a well-known fossil group of extinct marine arthropods. Trilobites form one of the earliest known groups of arthropods.**
- **Early Cambrian period to the end of the Permian**
- **When trilobites first appeared in the fossil record they were already highly diverse and geographically dispersed. Because trilobites had wide diversity and an easily fossilized exoskeleton that is made of chitin an extensive fossil record was left behind, with some 17,000 known species spanning Paleozoic time.**
- **The study of these fossils has facilitated important contributions to biostratigraphy, paleontology, and plate tectonics.**
- **Trilobites are often placed within the arthropod subphylum Schizoramia, although several alternative taxonomies are found in the literature.**
- **Trilobites had many life styles; some moved over the sea-bed as predators, scavengers or filter feeders and some swam, feeding on plankton.**

Modified from http://en.wikipedia.org/wiki/Arthropod

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Paleozoic

time

KAMBRİYEN DÖNEM

http://www.biltek.tubitak.gov.tr/bilgipaket/jeolojik/Fanerozoik/Paleozoik/Kambriyen/index.htm

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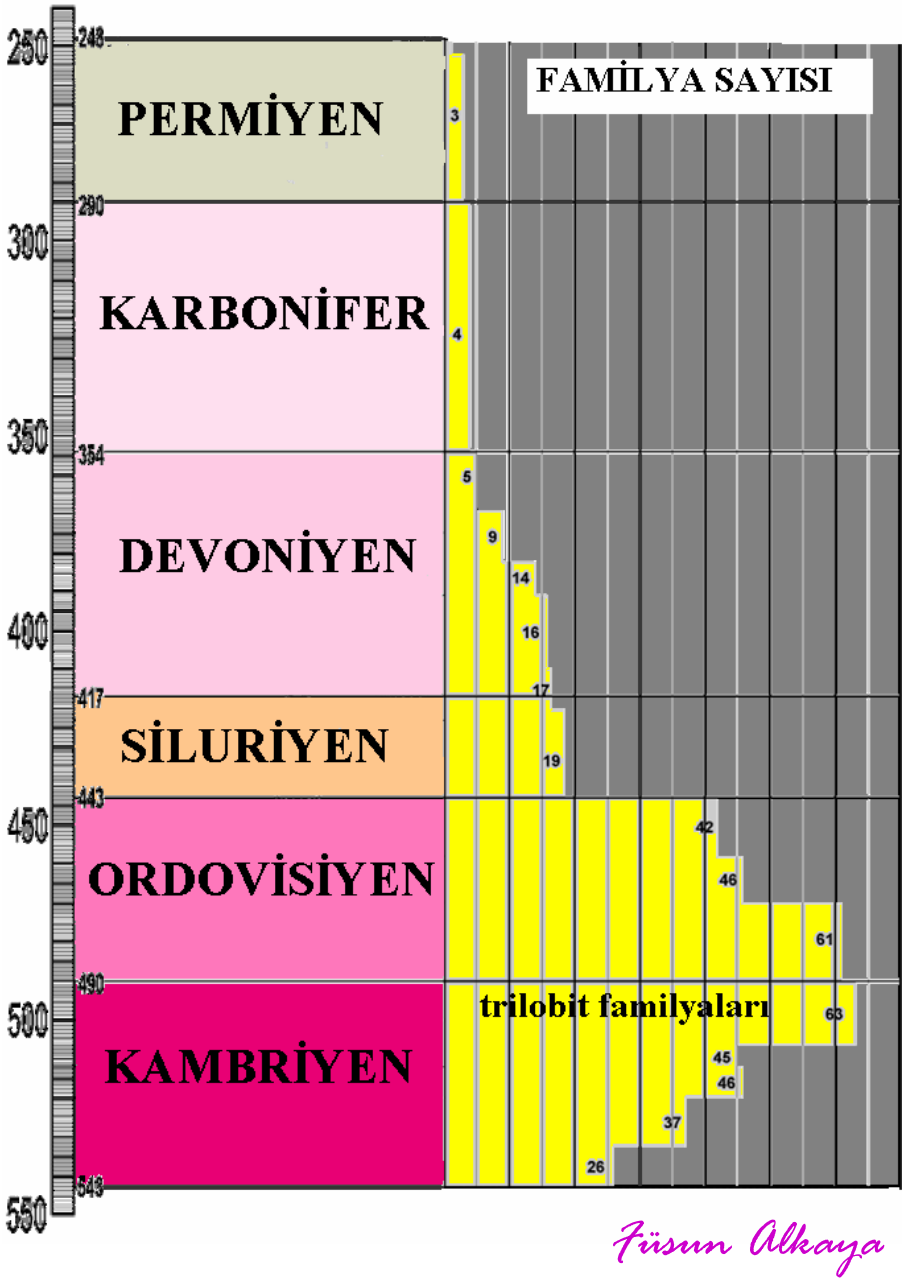

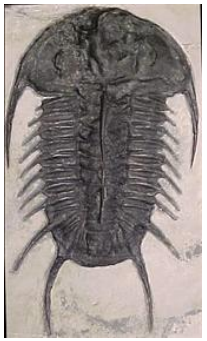

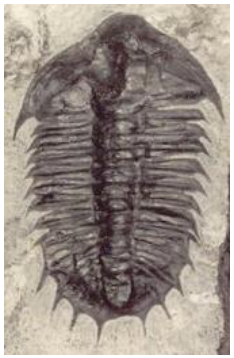

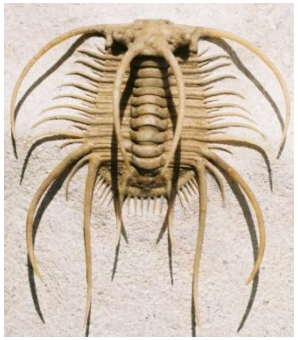

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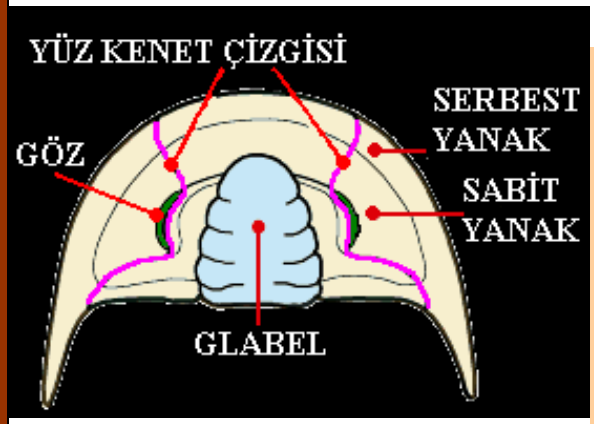
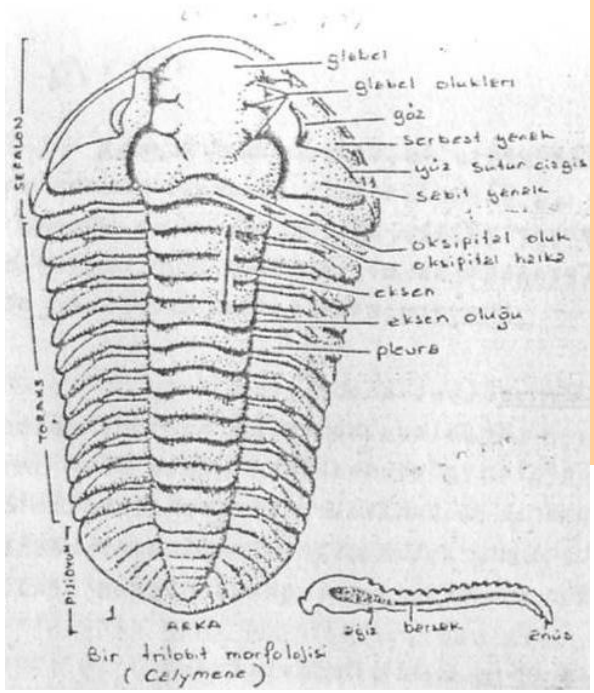
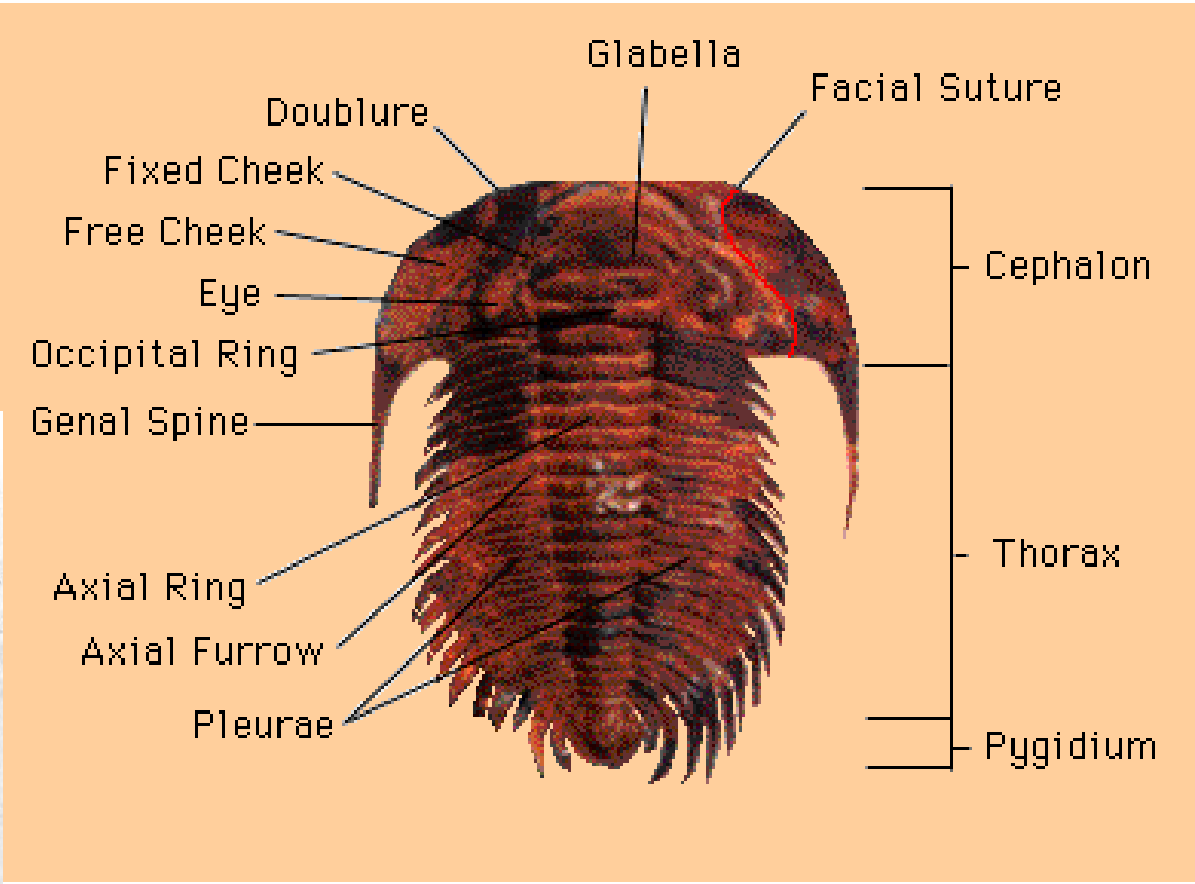
Body organisations & terms







http://www.brookes.ac.uk/geology/8361/1998/kirsty/morph.html#General

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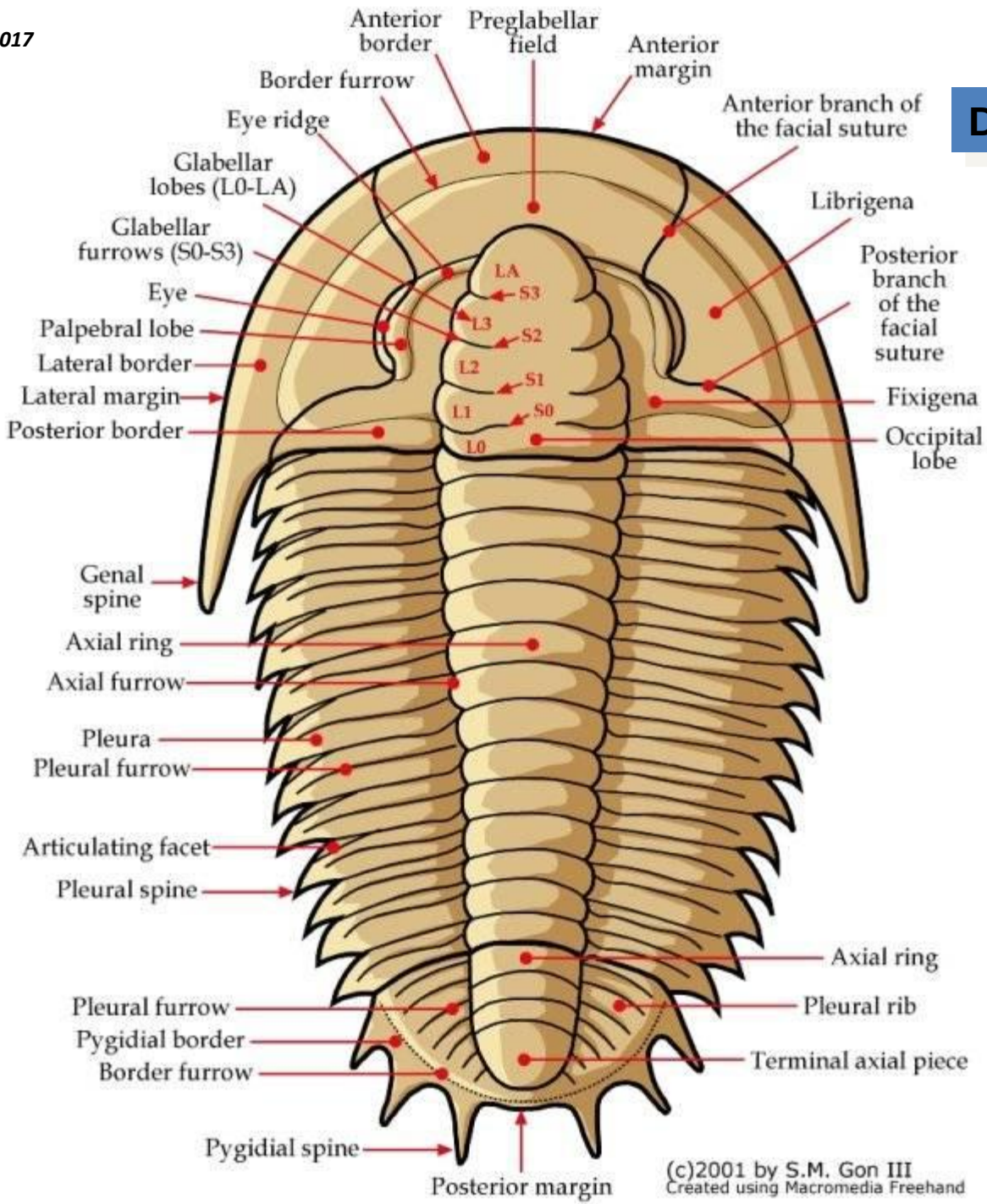
DORSAL VIEW



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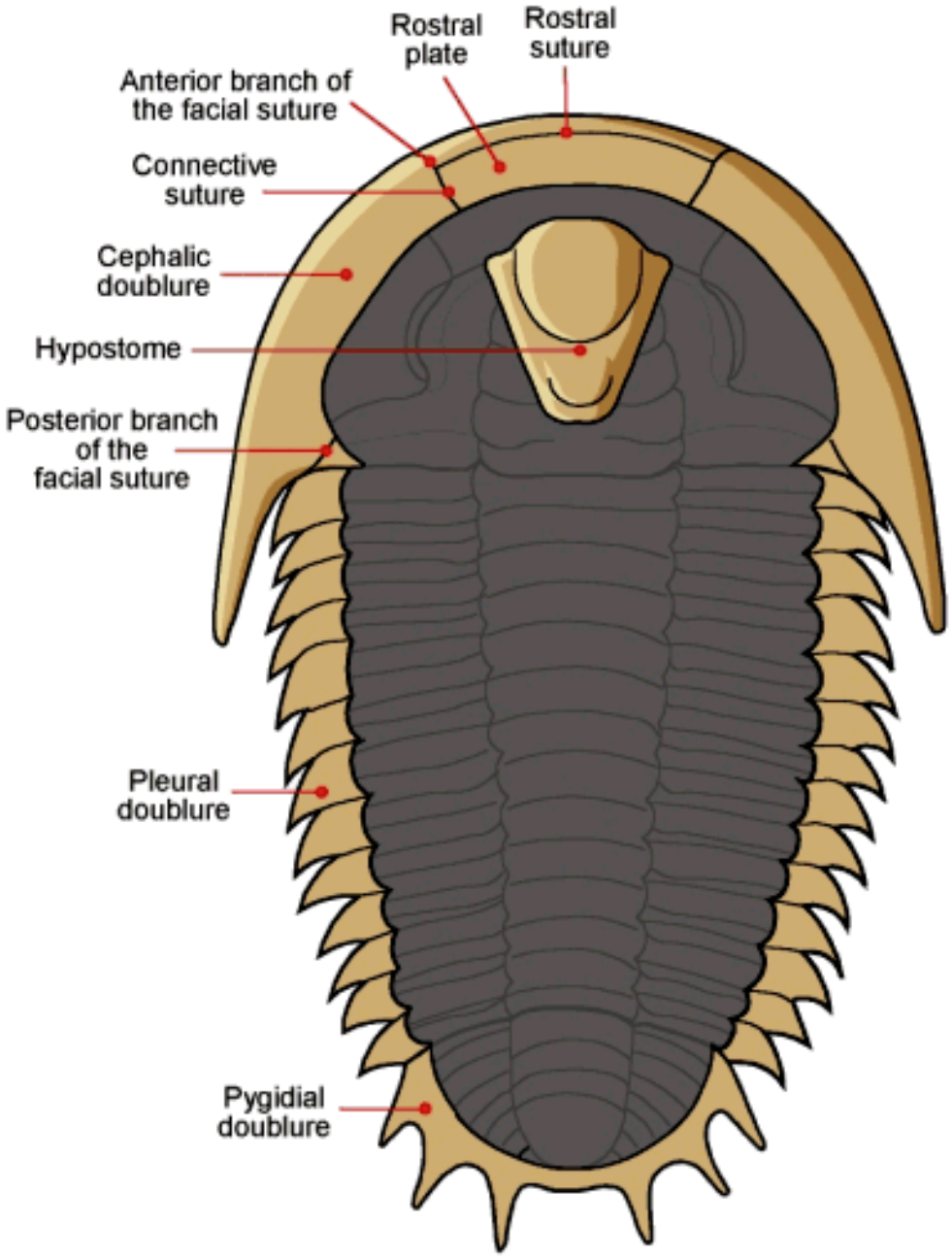

VENTRAL VIEW

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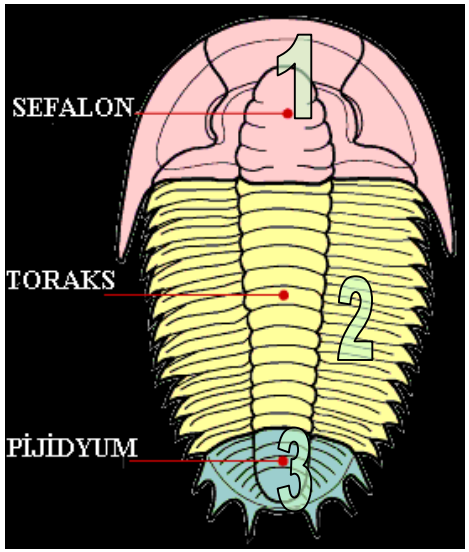
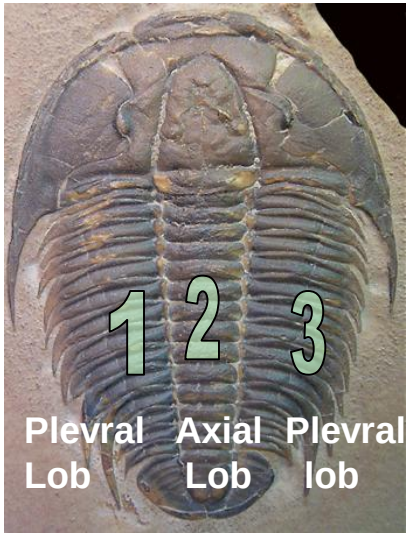
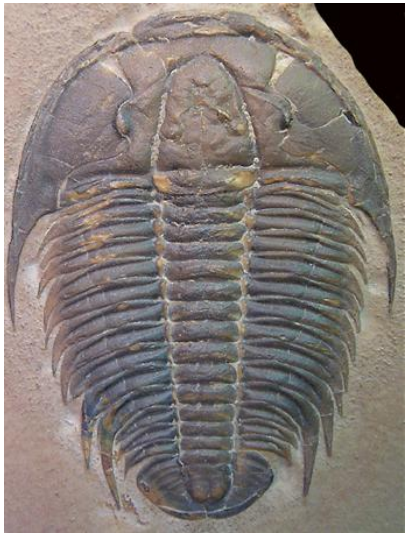
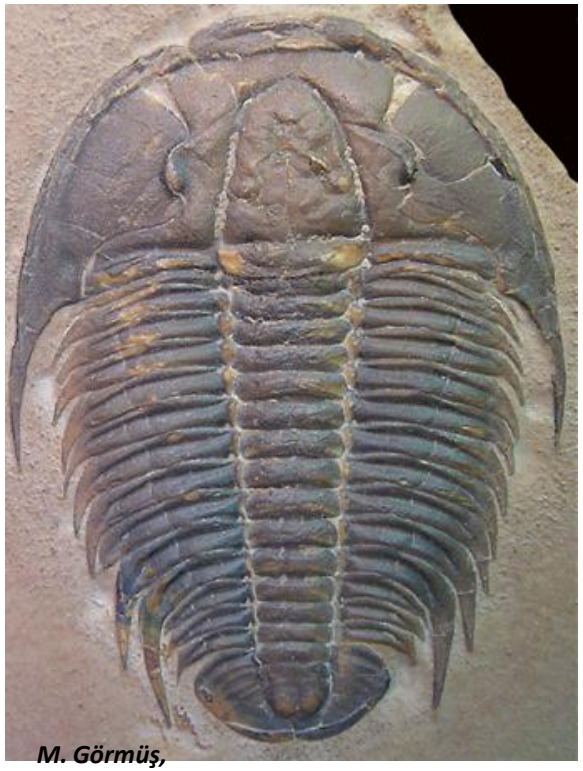
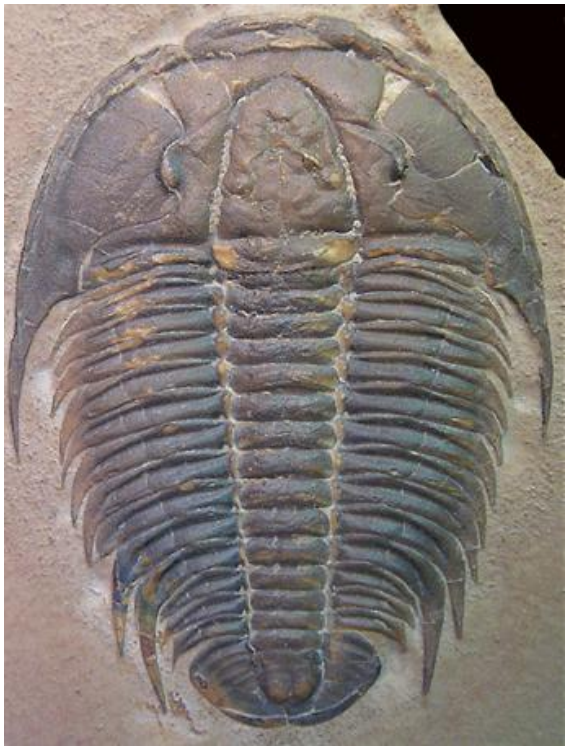
Three lobes

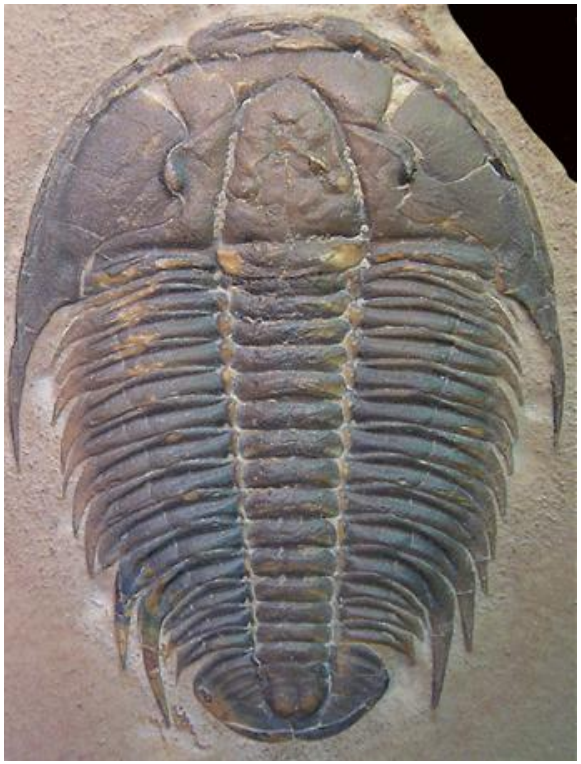












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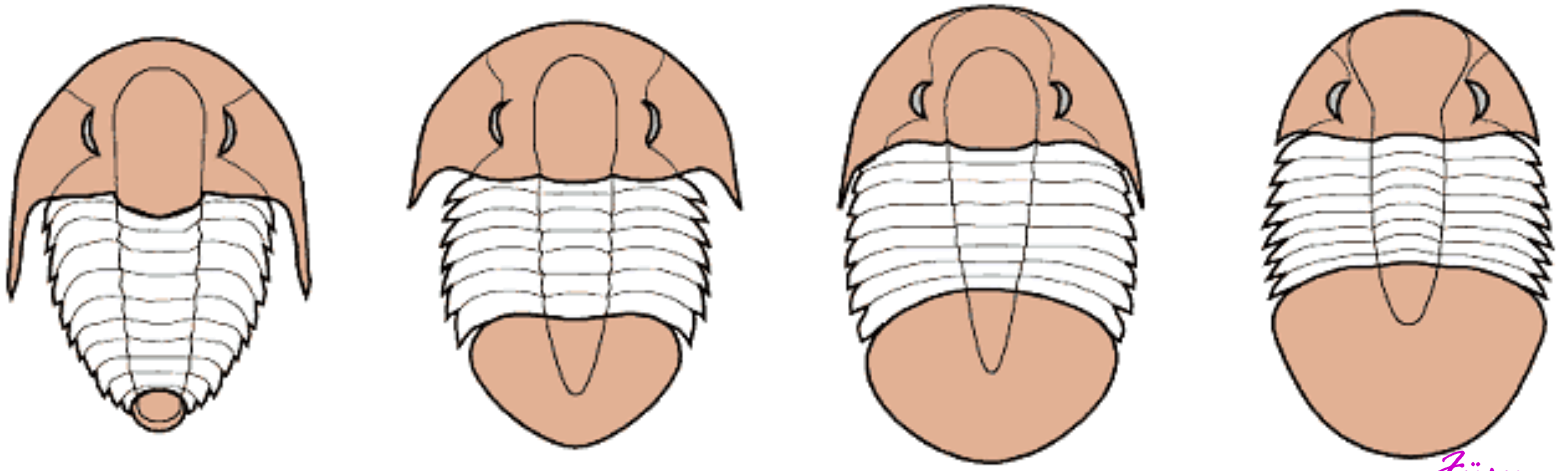
Ratio of cephelon to pygidium



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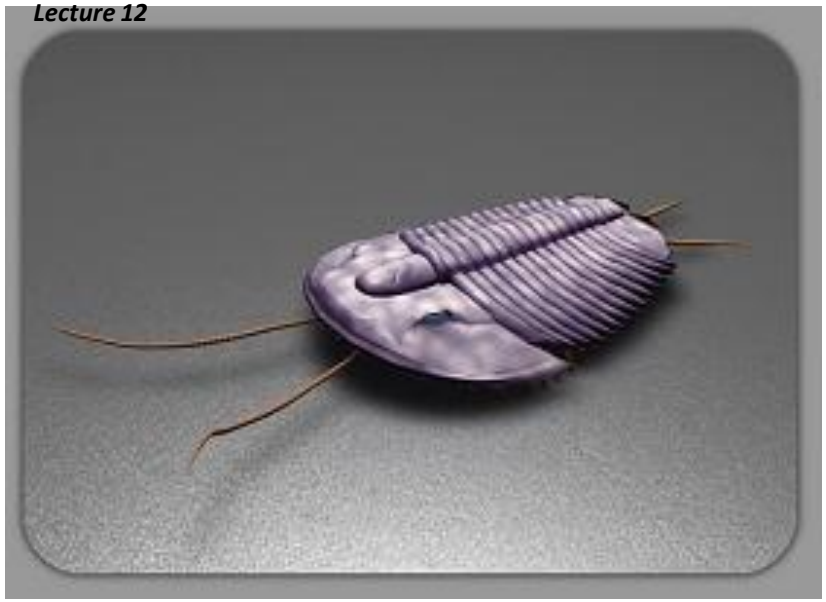
The folllowing has been taken into consideration for Trilobita classification.

Microfigos: Pijidiyum smaller than cephelon

Isofigos: Both equal in size

Macrofigos: Pijidiyum larger than cephelon

Terms



Dorsal view

Side view

Ventral view

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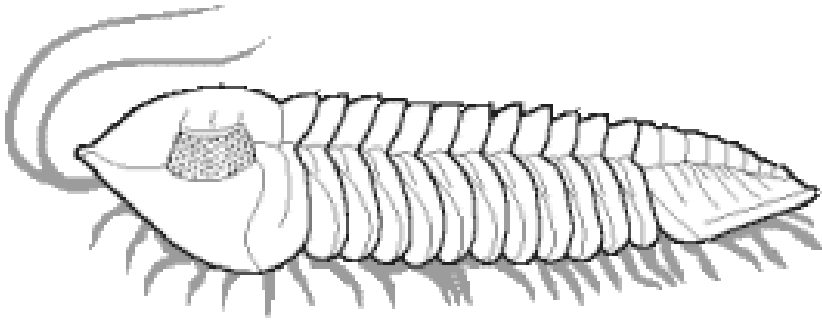

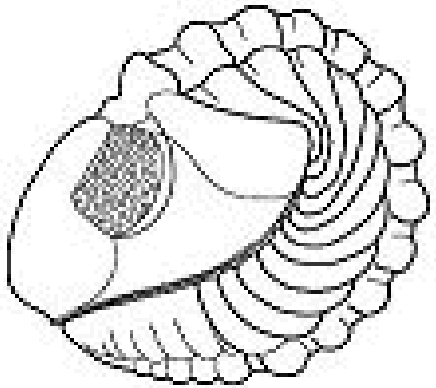


Legs made of chitin have not always been preserved in geological records.
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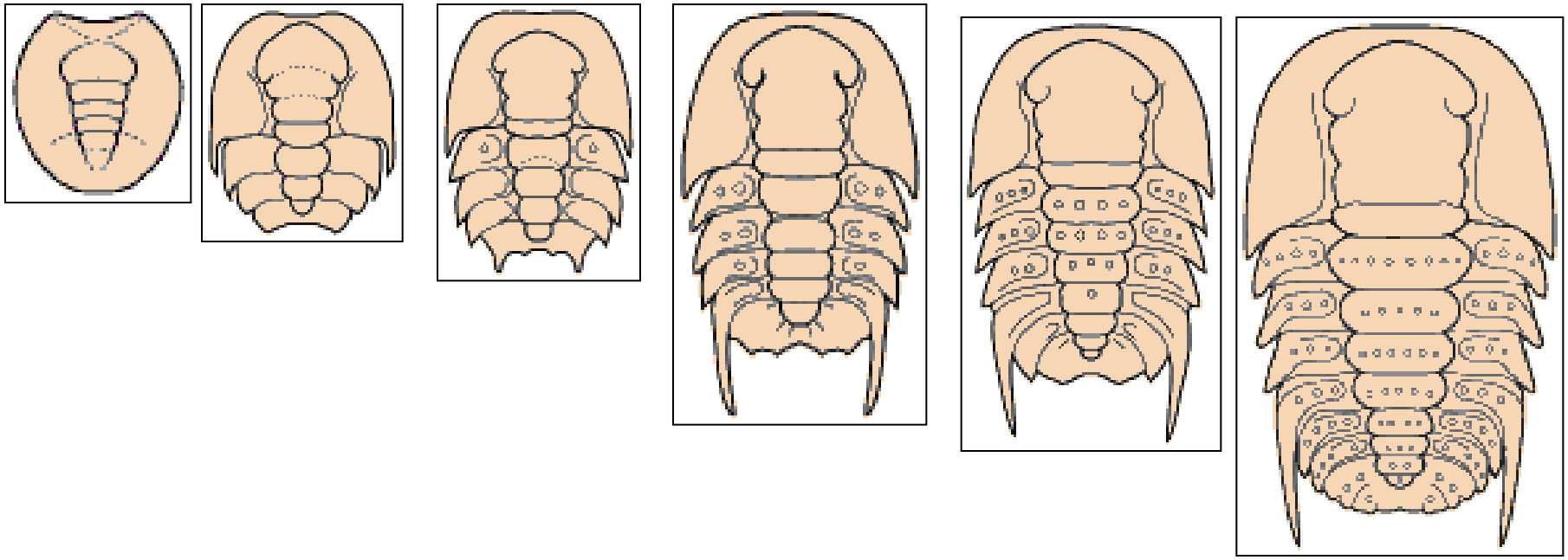
GROWTH



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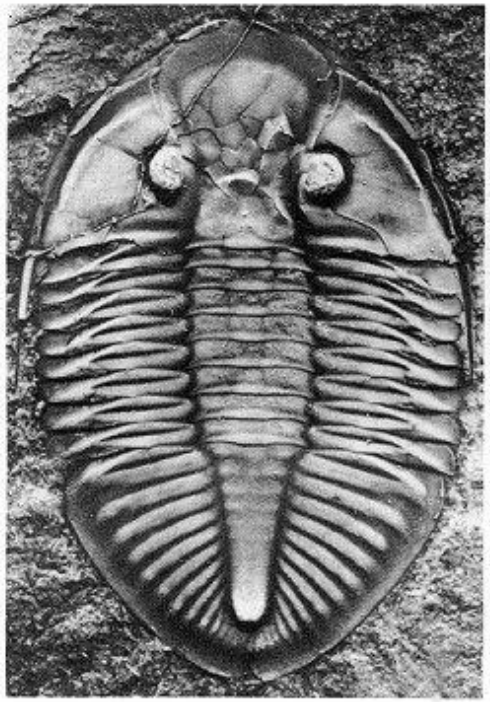
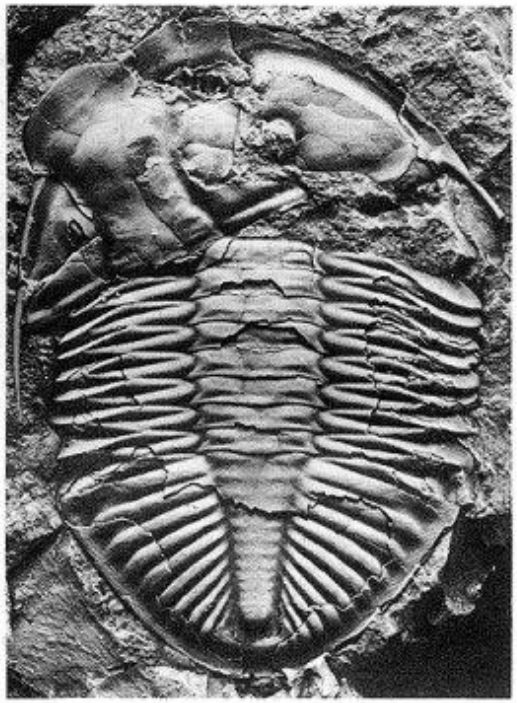
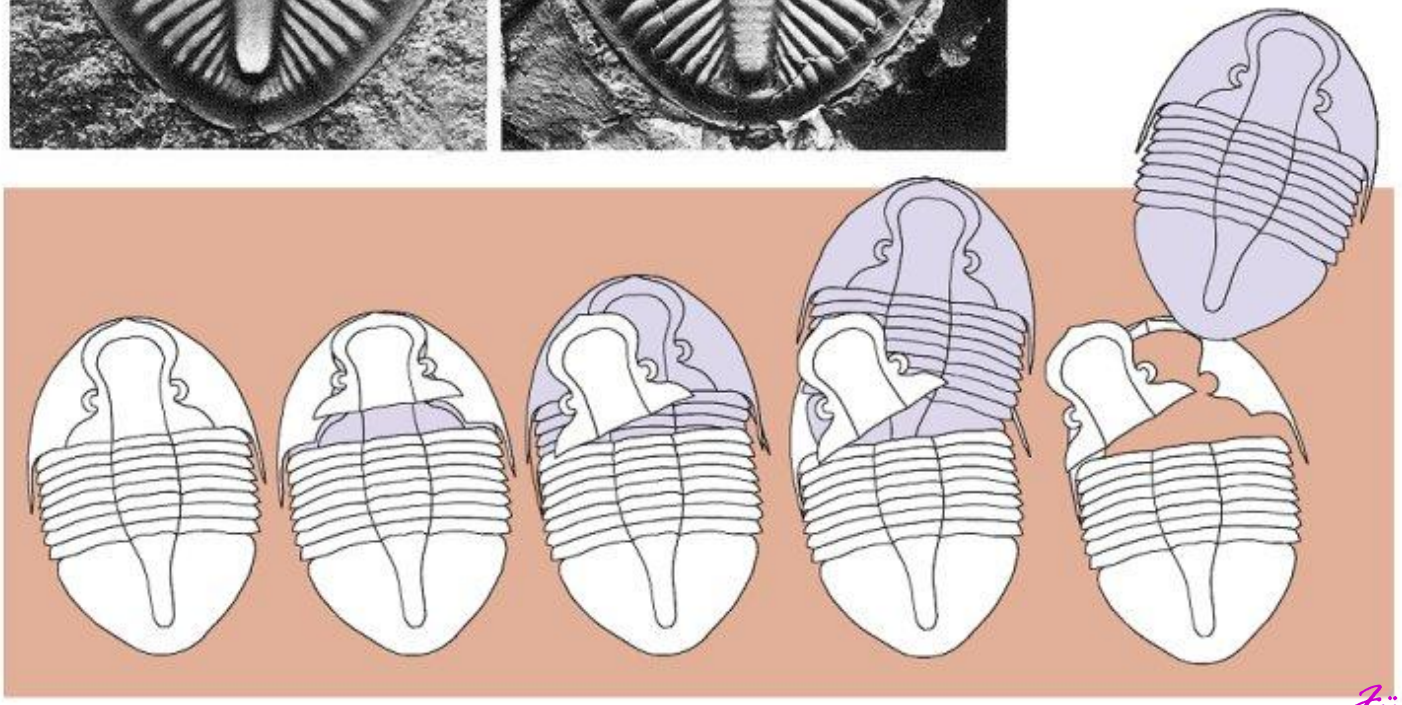
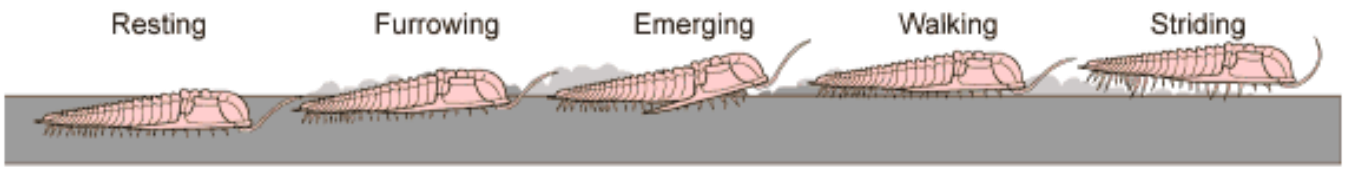




SKIN REPLACEMENT



TRACE FOSSILS RELATED TO TRILOBITA



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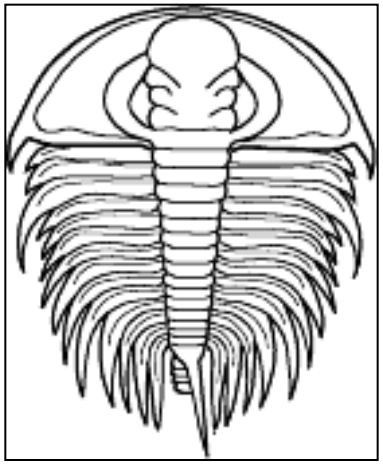
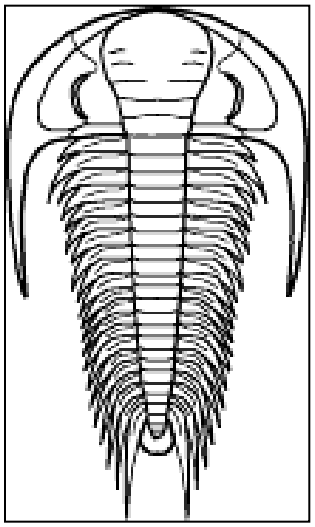
Class
Trilobita

Olenellus sp. Early Cambrian



Paradoxides sp. Middle Cambrian



Scientific Name	Paradoxides
Reference	Ernst Haeckel''s Kunstformen
Acknowledgements	Scan courtesy of Kurt Stüber
Specimen Condition	Fossil
ToL image Use	share with ToL partners
Attached to Group	Trilobites
image Type	Drawing/Painting
image Content	Specimen(s)
Title	Paradoxides.jpg

http://tolweb.org/Arthropoda

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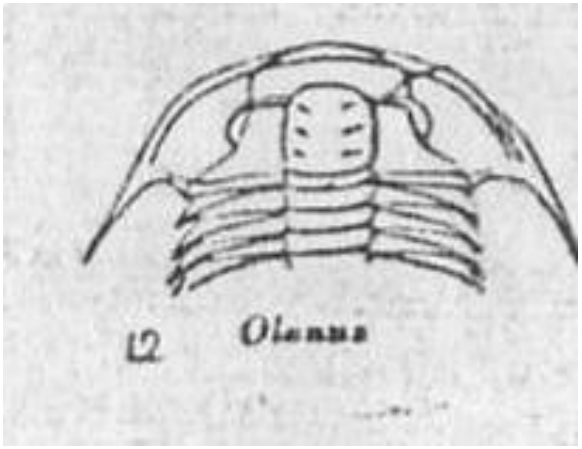
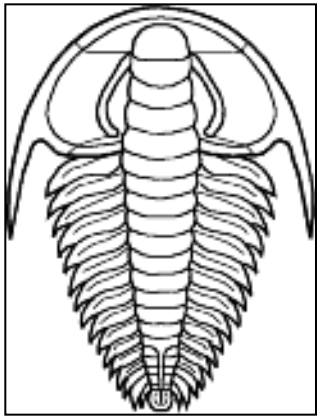
Class
Trilobita

Olenus sp. Late Cambrian



Redlichia sp. Early Cambrian



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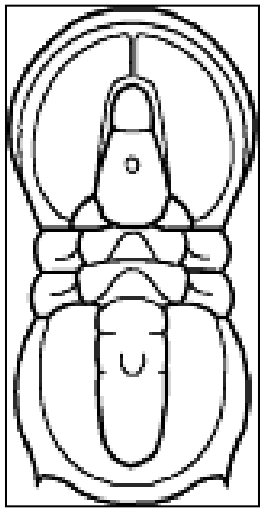
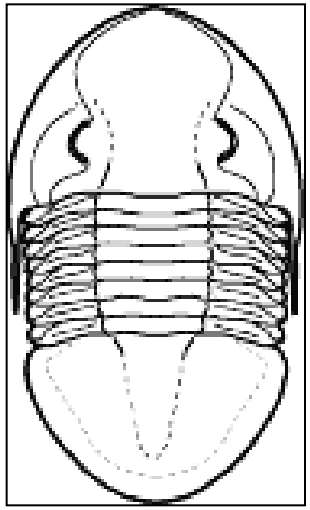
Class
Trilobita

Agnostus sp. Cambrian to Ordovician



Asaphus sp. Ordovician



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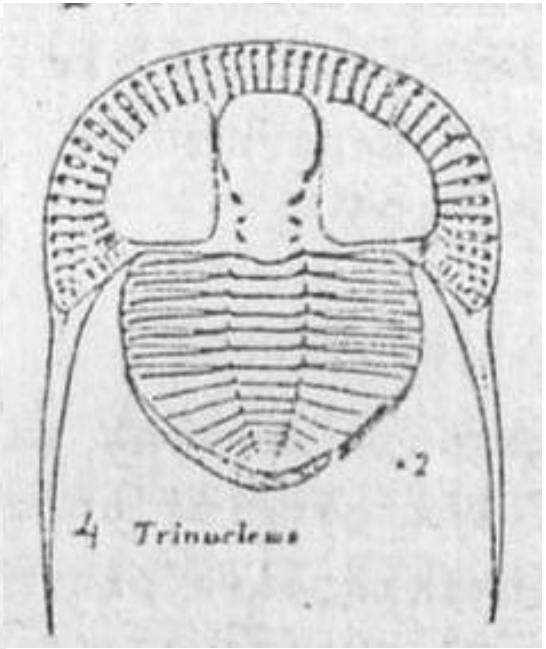
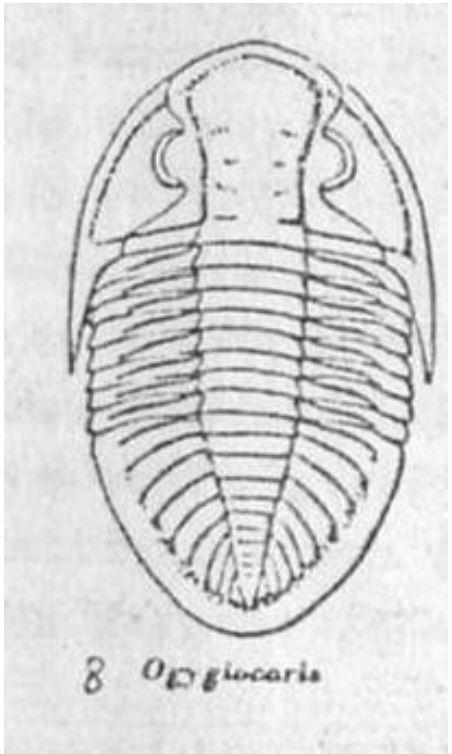
Class Trilobita





Illaenus Ordovician

Trinucleus Ord

Deiphon Sil

Dalmanites Sil-Early Dev.

Trimerus M. Sil. - M.Dev.

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Class Trilobita

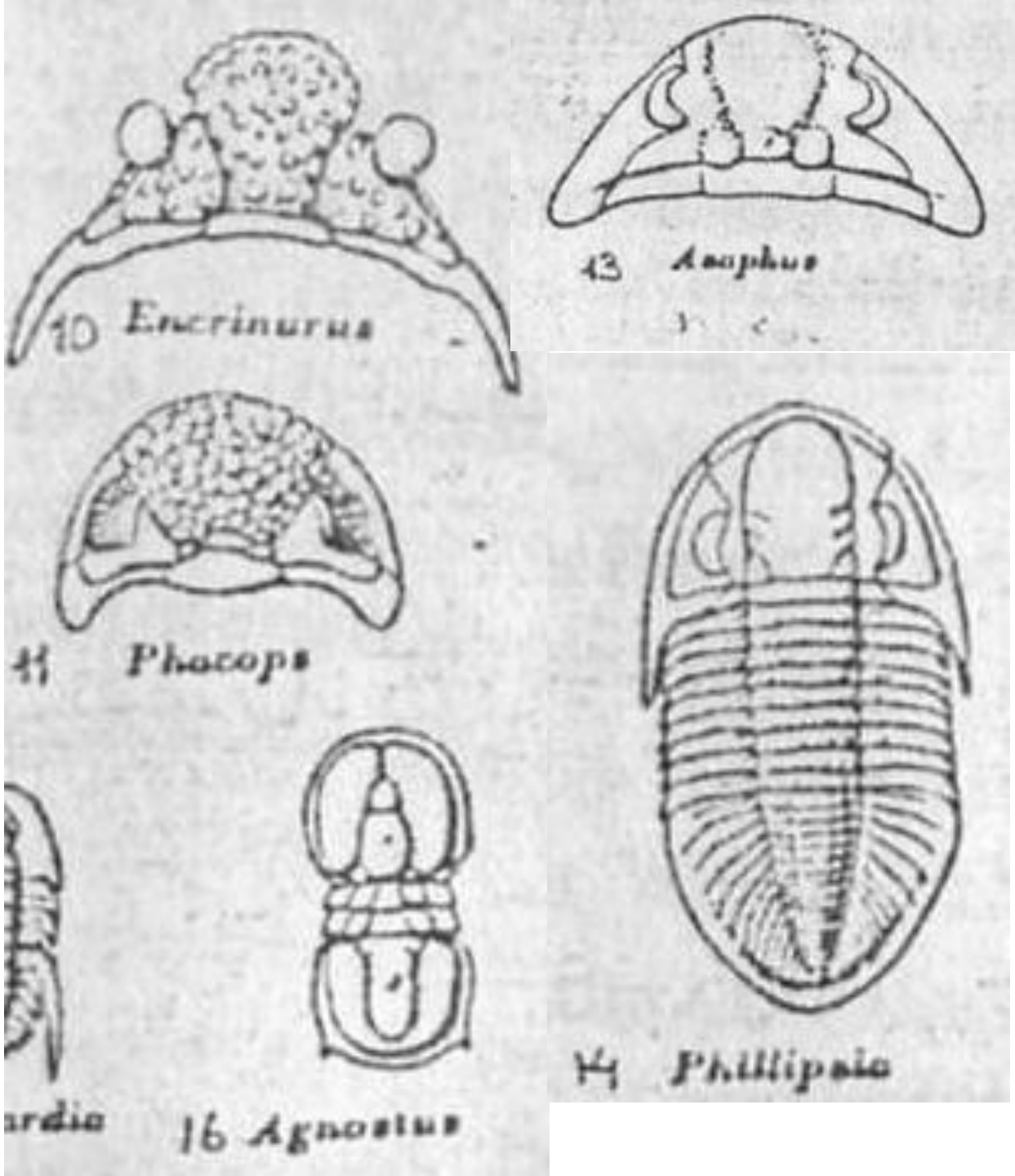
Encrinurus M.Ord.-Sil.

Phacops Sil-Dev.

Agnostus Late Camb.

Asaphus Early Ord.

Phillipsia Early Carb.



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(c) WWW.Trilobiten.de


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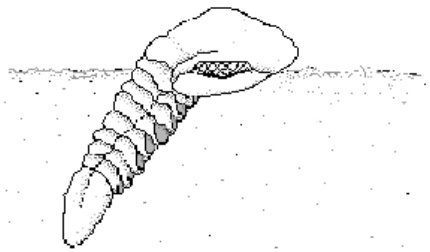
Infaunal filter feeders,
Epifaunal feeders off the organic matter resting on the sediment surface,
Swimming slowly through the deep waters,

Environmental indicators given by morphological structure:

Infaunal in Fine Substrate, Sedimentary suspension feeders:

The probable life position of the illaenid trilobite



Panderia megalophthalma

(Adapted from TRILOBITES, R. Levi-Setti)

Those trilobites which burrowed into the substrate developed a particular morphology e.g. a smooth exterior and a broad axial lobe. The smooth exterior would have allow a quick entry into the substrate with little friction, and the broad axial lobe allowed room for large appendage muscles needed to enable rapid burrowing. Large cephalons tend to be a characteristic of trilobites in this type of environment and these would have rested upon the surface with the rest of the body pointing downwards within the substrate.

Trilobites with highly convex exoskeletons have a body that cannot articulate, the body cannot move in the normal way with the head, but declines backwards. It is this adaptation which is a common denominator of trilobites from an infaunal environment, it is not suited to epifaunal crawling or swimming. Other features which may be seen include loss of eyes, development of genal spines, and miniaturization. e.g. illaenine *Bumastoides*. This trilobite seen to the right (*Bumastoides,* taken from PaleoPalace.com) did not have the ability to see, however this did not pose a problem as it was constantly submerged in the sea floor sediment.

Epifaunal Crawling or Swimming:

The species *Opipeuter* has an elongate body with reduced thoracic pleurae to give longitudinal flexibility, but it is its enormous eyes which enable all round vision which is its most prominent feature. In general this enlarged eye feature was common in swimming trilobites, it enabled a circular horizon field of view.

The lack of spines and the bulbous eyes would have made it impossible for this trilobite to have rested on the sea floor like other trilobites. It was most likely pelagic belonging to a benthonic group much like the amphipod *Hyperia* of modern day. The poorly streamlined shape indicates it was a slow swimmer.

The example seen to the right is *Flexicalymene.* Ordovician in age it comes from the Richmond Formation. Mt Orab, Ohio. The eyes are prominent upon the cephalon allowing good vision whilst crawling around on the sea bed and the enlarged glabella, possibly indicates (as discussed in the Morphology section) a reasonable sized stomach. The relatively large stomach size is not found within smaller infaunal trilobites, possibly due to the fact that the volumes of food consumed by them was substantially less than for these crawling swimming trilobites.

Another example is the agnostid trilobites which were small, blind, with two thoracic segments, a common indicator of a pelagic mode of life.

(Image taken from PaleoPalace.com, with permission)

http://www.brookes.ac.uk/geology/8361/1998/kirsty/evolu.html#Evolution

Swimming:

The bodies of swimming trilobites are narrower and the eyes are closer to the sides of the cephalon, than those of bottom dwelling trilobites. Swimming trilobites may have been predators, or they may have been "filter feeders" using special appendages to remove nutrients from the surrounding water.

Image taken from,
EXTINCTIONS fossil company web site.
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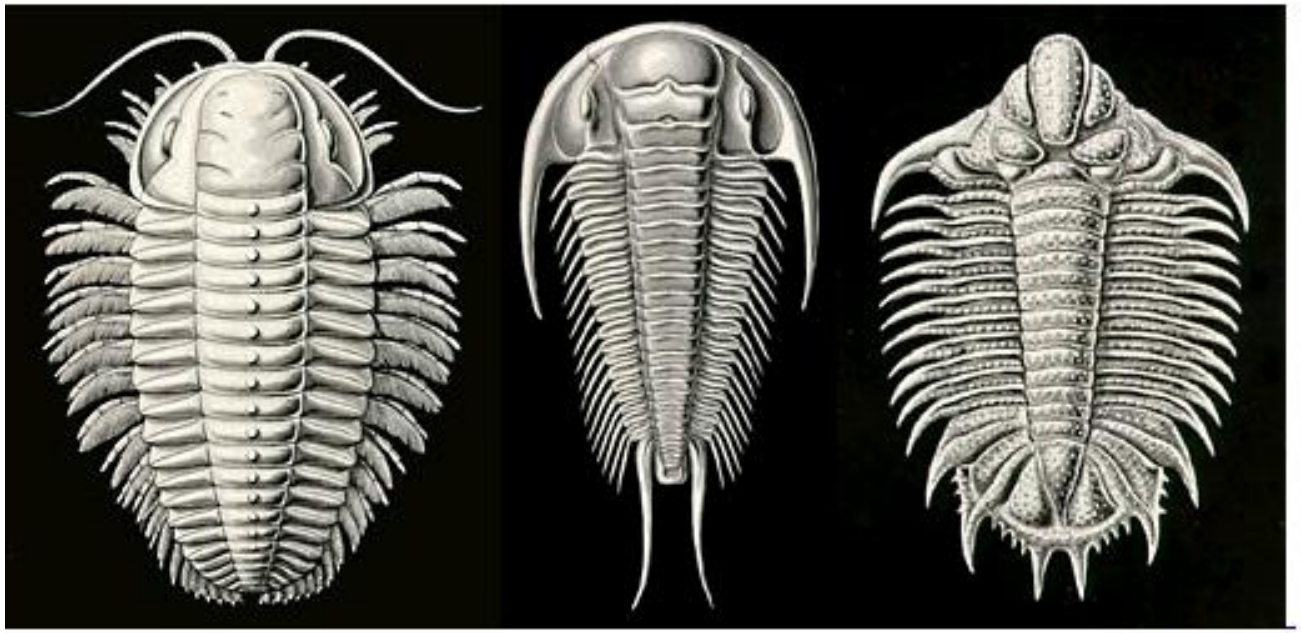
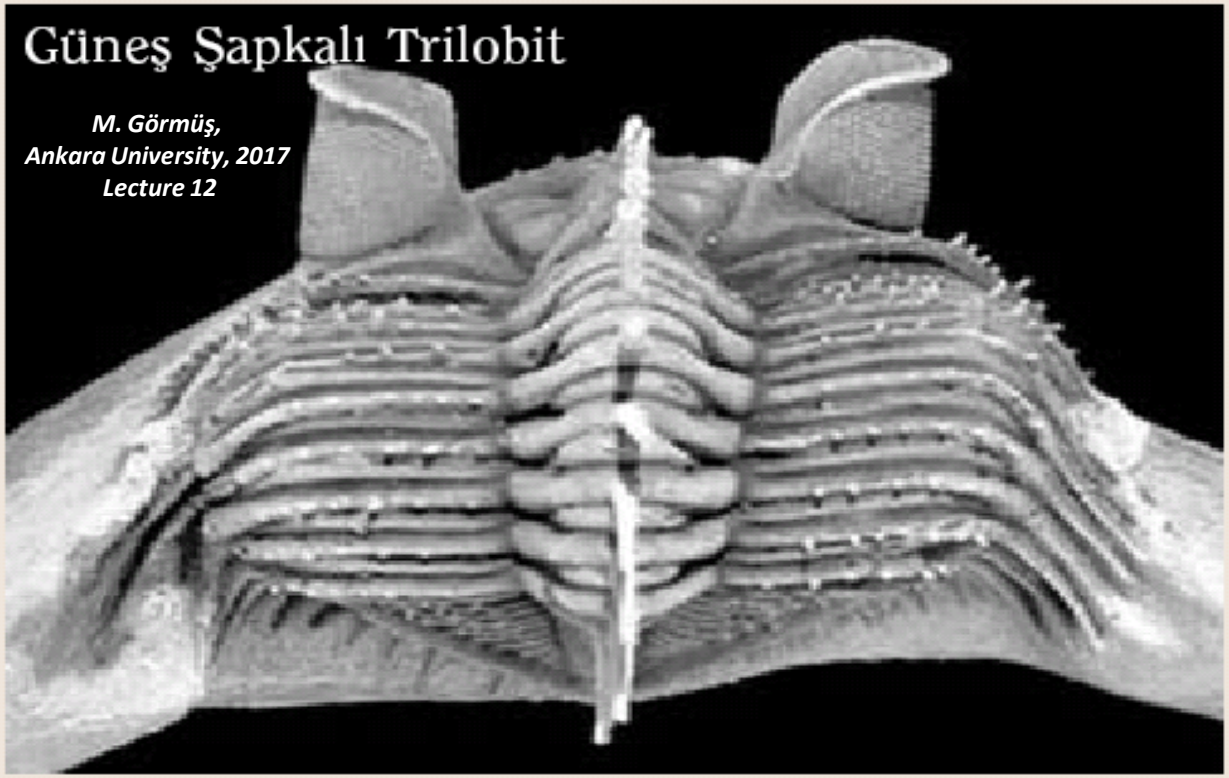
The odontopleurid *Selenopeltis* has been interpreted as an active swimmer which could also rest on the sea floor for short periods of time without sinking into the substrate due to the elongate genal spine and the presence of spines on each thoracic segment and the pygidium.

http://www.brookes.ac.uk/geology/8361/1998/kirsty/evolu.html#Evolution



http://tolweb.org/Arthropoda

Güneş Şapkalı Trilobit



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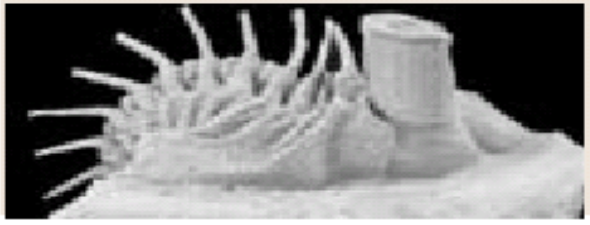
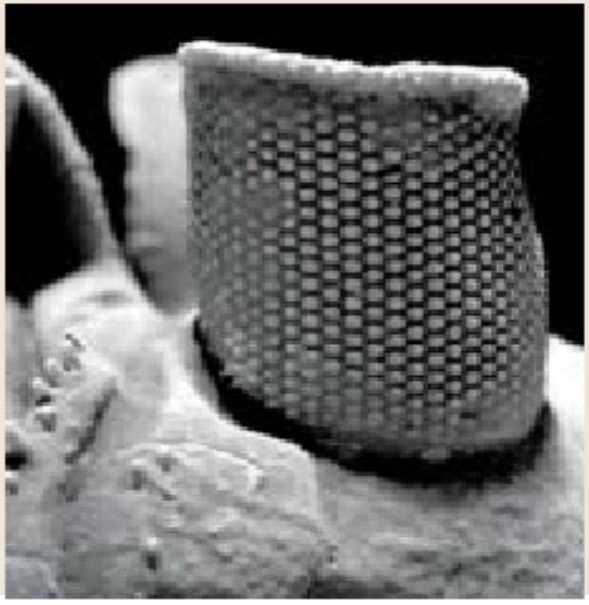
Bilimadamları, eski okyanuslarda daha iyi görebilmek için gözlerini ışıktan koruyan siperlikler geliştirmiş bir trilobit fosili bulduklarını açıkladılar. *Erbenochile erbeni* türünden olan ve 380 milyon yıl önce yaşadığı tahmin edilen hayvan, öteki trilobit türlerinden hayli farklı. Oxford Üniversitesi'nden Richard Fortey ile, Alberta Üniversitesi'nden (Kanada) Brian Chatterton, bu ilginç trilobiti, Fas'ta Devonyen döneme (günümüzden 417-354 milyon yıl önce) ait tortul kayalarda bulmuşlar. Trilobitler, aslında Kambriyen döneminde (günümüzden 545-495 milyon yıl öncesi) ortaya çıkmış ve ortama yaygın uyum göstermiş canlılar. Pek çok çeşitten çok sayıda fosillerine dünyanın her yerinde rastlanıyor. Ancak, iki araştırmacının bulduğu örnek, çok özel bir türe ait. Fosil üzerinde en çok dikkat çeken özellikler, son derece etkin savunma ve saldırı mekanizmaları. Hayvanın sırtındaki orta bölme üzerindeki dikenler, kendisini sürpriz saldırılara karşı korurken, olağanüstü gelişkin gözleri de daha iyi görmesini ve daha iyi beslenmesini sağlamış olmalı. Fosildeki gözler, bir kule gibi yükselen ve 360 derecelik görüş alanı sağlayan kompozit (bileşik) gözler. İki gözde, yukarıdan aşağıya 18'er sıra halinde dizilmiş toplam 560 kadar mercekten oluşuyor. Bu merceklerin önemli bir özelliği de, öteki trilobitlerde ve eski ya da modern bileşik göze sahip pek çok hayvanda görülenin aksine küre biçimli olmayıp, pencere camı gibi düz olmaları. Araştırmacılar, bu düz yapının mesafe ayarının iyi yapılmasında avantaj sağladığını vurguluyorlar. Gözlerin üzerini vizör gibi çepeçevre örten çıkıntının işleviyse, tepeden gelen günışığının, görüşü bozmasına engel olmak. "Tıpkı, insanların gözlerinin kamaşmaması ve daha iyi görebilmek için ellerini gözlerine siper etmeleri, ya da vizörlü şapkalar giymeleri gibi".



Science, 19 Eylül 2003



The 9 Orders of Trilobites (Class Trilobita)

Trilobite Order	Salient Distinguishing Characteristics of the Order	Appearance and Duration	Representative Trilobite
Agnostida	• Among the most primitive of trilobites, often lacking eyes • Length of a few mm and smaller • Similar cephalon and pygidium (isopygous)	Lower Cambrian to Upper Ordovician	
Redlichiida	• Among the most primitive of trilobites • Many thoracic segments • Spinocity usually limited to pleurae tips • Small pygidium	Lower Cambrian to Middle Cambrian	
Corynexochida	• Hypostomal attachment in common • Normally spinous, but Suborder Illaenina is typically effaced	Lower to Middle Cambrian	
Lichida	• Often elaborate and often highy spinous (making them highly sought)	Ordovician to Devonian	
Phacopida	• Particularly noted for detailed preservation of compound eyes • Typical deep furrows between thoracic segments • Typically not spinous	Lower Ordovician to Upper Devonian	
Proetida	• Among the last survivors before Trilobita faded away, and disappeared in the Permian extinction • Typically small with small spineless pygidium	Ordovician to Permian	
Asaphida	• Ubiquitous trilobite sharing distinct suture structure • Effacement of features common with typically large pygidium	Middle Cambrian to Lower Silurian	
Harpetida	• Presence of the broad semicircular to ovate brim • Lack of rostral plate	Upper Cambrian to Upper Devonian	
Ptychopariida	• Appeared early and persisted long, yielding much variability in form • Formerly included in what is now Order Harpetida	Lower Cambrian to Devonian	

http://www.fossilmuseum.net/Tree_of_Life/Phylum%20Arthropoda/ClassTrilobita.htm

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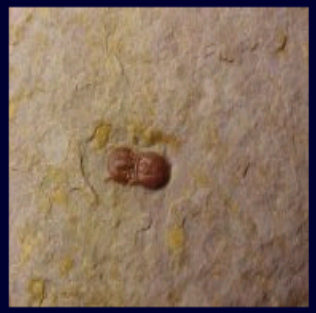
The trilobites of Order Agnostida appeared in the Lower Cambrian where they were diverse and ubiquitous, and declined to become rare in the Ordovician prior to their complete extinction by the end of the Ordovician. Among trilobites, they are so relatively unusual that some researchers have suggested, based on larval limb structure, that one of the two suborders, Agnostina, should not be included in Class Trilobita.

The agnostids are thought to have been plantonic, often lacked eyes, and mainly exhibited symmetry of cephalon and pygidium size, such that it may be hard to distinguish front from rear. There are two Suborders. Members of Suborder Agnostina have two segments between the cephalon and pygidium, and lack have sutures on the cephalon. In contrast, members of Suborder Eodiscina may have two or three body segments, and some have small eyes and proparian sutures that have a less rear-sloping angle that the genal angle.



Ptychagnostus michaeli
Family: Ptychagnostidae
Middle Cambrian
Millard County, Utah

Peronopsis segmenta
Family: Peronopsidae
Middle Cambrian
Millard County, Utah

Ptychagnostus atavus
Family: Ptychagnostidae
Middle Cambrian
Millard County, Utah

Ptychagnostus richmondensis
Family: Ptychagnostidae
Middle Cambrian
Millard County, Utah

Ptychagnostus akanthodes
Family: Ptychagnostidae
Middle Cambrian
Millard County, Utah

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Trilobite Order Agnostida Families:

Suborder Agnostina
Superfamily Agnostoidea
- Agnostidae
-- Subfamily Agnostinae
-- Subfamily Ammagnostinae
-- Subfamily Glyptagnostinae
- Ptychagnostidae
- Spinagnostidae
- Peronopsidae
- Doryagnostidae
- Peronopsidae
- Diplagnostidae
-- Subfamily Diplagnostinae
-- Subfamily Oidalagnostinae
-- Subfamily Pseudagnostinae
- Clavagnostidae
-- Subfamily Clavagnostinae
-- Subfamily Aspidagnostinae
- Metagnostidae
Superfamily (Equivocal)
- Sphaeragnostidae
Superfamily Condylopygoidea
- Condylopygidae
Suborder Eodiscina
Superfamily Eodiscoidea
- Tsunyidiscidae
- Hebediscidae
- Calodiscidae
- Weymouthiidae
- Yukoniidae
- Eodiscidae

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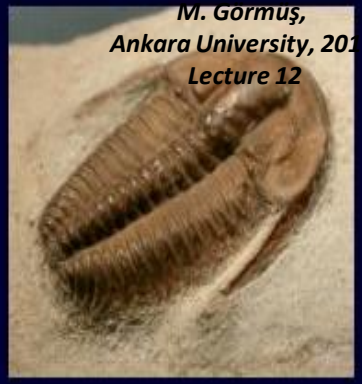

Bergeroniellus asiaticus
Redlichiida: Superfamily Redlichioidea; Family Redlichiidae
Lower Cambrian Botomian Stage
Sinsk Formation, Lena River, Russia

Peachella brevasina
Redlichiida: Superfamily Olenelloidea; Family Olenellidae; Subfamily Biceratopsinae
Late, Lower Cambrian
Cararra Formation, Nopah Range, Inyo County, California

Wanneria sp.
Redlichiida: Superfamily Suborder Olenellina
Family: Olenellidae; Subfamily: Wanneriinae
Lower Cambrian
Eager formation, Cranbrook Rifle Range, British Columbia, Canada

Olenellus gilberti
Redlichiida: Superfamily Suborder Olenellina
Family: Olenellidae; Subfamily: Olenellinae
Lower Cambrian
Pioche Shale, Lincoln County Nevada

Olenellus sp.
Suborder Olenellina
Superfamily Olenelloidea
Lower Cambrian
Eager formation, B.C., Canada

Fallotaspis sp
Family: Fallotaspidae
Cambrian
Zagora, Morocco

Xystridura saint-smithi
Superfamily Paradoxidoidea
Family Paradoxididae
Middle Cambrian
Mount Isa, Australia

Nevadia weeksi
Superfamily: Archaeaspididae
Family: Nevadiidae
Poleta Formation
Nevada

Trilobite Order Redlichiida
Families:
Suborder Olenellina
Superfamily Olenelloidea
- Olenellidae
-- Subfamily Olenellinae
-- Subfamily Biceratopsinae
-- Subfamily Bristoliinae
-- Subfamily Gabriellinae
-- Subfamily Laudoniinae
-- Subfamily Wanneriinae
- Holmiidae
-- Subfamily Holmiinae
-- Subfamily Callaviinae
Superfamily Fallotaspidoidea-
- Fallotaspididae
-- Subfamily Fallotaspidinae
-- Subfamily Daguinaspidinae
Archaeaspididae
- Judomiidae
- Neltneriidae
- Nevadiidae
Suborder Redlichiina
Superfamily Emuelloidea
- Emuellidae
Superfamily Redlichioidea
- Redlichiidae
-- Subfamily
-- Subfamily
-- Subfamily
-- Subfamily
-- Subfamily
- Dolerolenidae
-- Subfamily Doleroleninae
-- ?Subfamily Paramalungiinae
- Yinitidae
- Mayiellidae
- Gigantopygidae
-- Subfamily Gigantopyginae
-- Subfamily Yiliangellinae
-- Saukiandidae
-- Subfamily Saukiandinae
-- Subfamily Despujolsiinae
-- Subfamily Resseropinae
- Metadoxididae
- Abadiellidae
- Kueichowiidae
- Menneraspididae
- Redlichinidae
- Chengkouaspidae
Superfamily Paradoxidoidea
- Paradoxididae
- Centropleuridae
- Xystriduridae

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Olenoides nevadensis
(Rare)
Suborde
Family
Late, Lower Cambrian
Marjam Formation
Milliard County, Utah

Scabriscutellum furciferum
Suborder Illaenina
Hamar Laghdad Formation
Ofaten, Morocco

Kolihapeltis chlupaci hollardi
Suborder Illaenina
Laatchana, Morocco

Illaenus tauricornis
Ordovician
Suborder: Illaenina
Family: Illaenidae
Wolchow river, Russia

Address: http://www.fossilmuseum.net/Fossil_Galleries/UtahTrilobites/Olenoides%20nevadensis/Olenoides_navedensis.htm

Illaenus dalmani
Ordovician
Suborder: Illaenina
Family: Illaenidae
Wolchow river, Russia

Platyscutellum sp.
Family Thysanopeltidae
Devonian
Zerg, Morocco

Albertella cf longwelli
Family Zacanthoididae
Middle Cambrian
Nye County, Nevada

Trilobite Order Corynexochida
Families:

Suborder Corynexochina
Superfamily Corynexochoidea
- Amgaspididae
- Corynexochidae
- Cheiruroididae [now Oryctocephalidae]
- Chenghuiidae [Chengkouiidae]
- Dorypygidae
- Ogygopsidae [into Dorypygidae]
- Oryctocephalidae
- Dolichometopidae
- Edelsteinaspidae
- Jakutidae
- Zacanthoididae
- Dinesidae

Suborder Illaenina
Superfamily Illaenoidea
- Styginidae (Scutelluidae)
- Phillipsinellidae [into Styginidae]
- Illaenidae
- Panderidae
- Tsinaniidae

Suborder Leiostegiina
Superfamily Leiostegioidea
- Leiostegiidae
- Pagodiidae
- Kaolishaniidae
- Cheilocephalidae
- Lecanopygidae [Illaenuridae]
- Shirakellidae
- Ordosiidae

The Lichida trilobites are thought to have evolved from either Order Corynexochida or Order Redlichiida. While spines are widespread among many trilobite orders and species, the Lichida trilobites win the prize for the most elaborate, ornate, and possibly intimidating spines. The development of spines is commonly accepted as defense adaptation to ward off predators. An alternate hypotheses for the adaptive origin of trilobite spines is to use like snowshoes on a silty seafloor.

Hoplolichas tricuspidatus
Order Lichida
Superfamily Lichoidea
Family Lichidae
Ordovician
Wolchow river, Russia

Dicranurus monstrosus
Superfamily:
Odontopleuroidea;
Family Odontopleuridae
Lower Devonian
Alnif, Morocco

Hoplolichas plautini
Order Lichida
Superfamily Lichoidea
Family Lichidae
Ordovician
Wolchow River, Russia

Hoplolichas furcifer
Order Lichida
Superfamily Lichoidea
Family Lichidae
Ordovician
Wolchow River, Russia

Selenopeltis buchii
Order Lichida
Family Odontopleuridae
Ordovician
Erfoud, Morocco

Kettneraspis williamsi
Order Lichida, Family
Odontopleuridae
Lower Devonian
Haragan Formation

Arctinurus boltoni
Lichida Family Lichidae
Rochester Shale Formation,
Middleport, New York

Hoplolichas tricuspidatus
Order Lichida
Superfamily Lichoidea
Family Lichidae
Ordovician

Dicranurus hamatus
elegantus
Superfamily:
Odontopleuroidea;
Family: Odontopleuridae
Lower Devonian
Haragan Formation
Coal County, Oklahoma

Ceratonurus sp.
(2.3 inch - largest from
formation)
Superfamily:
Odontopleuroidea
Family: Odontopleuridae
Lower Devonian
Haragan Formation
Coal County, Oklahoma

Bug X
Lichida, Family Lichidae
Lower Devonian
Haragan Formation
Coal County, Oklahoma

Trilobite Order Lichida Families:
Suborder Lichina
Superfamily Lichoidea
- Lichidae
- Lichakephalidae
Superfamily Odontopleuroidea
- Odontopleuridae
- Odontopleuridae (was Selenopeltidae)
Superfamily Dameselloidea
- Damesellidae

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Trilobite Order Phacopida is large and diverse, comprising the related suborders Calymenina, Cheirurina, and Phacopina. Their grouping mainly derives from a shared and differentiating form during the early protaspid larval form period. The Phacopids likely appeared near the base of the Ordovician as Suborder Calymenina. The Calymenina share hypostomal characteristics with Order Ptychopariida, and Phacopida exhibits similar tuberculation with Lichida, confounding the Phacopids closest sister group.

Pliomera fisheri
Suborder Cheirurina
Family Pliomeridae
Middle Ordovician
Wolchow river, Russia

Coltraenia oufatenensis
Superfamily Acastoidea
Middle Devonian
Alnif, Morocco

Calymene clavicula
Family Calymenidae
Middle Silurian
Henryhouse Formation
Oklahoma

Cybele beletula
Family Encrinuridae
Lower Ordovician
Wolchow river, Russia

Chasmops praecurrens
Suborder Phacopina
Superfamily Phacopoidea
Family Pterygometopidae
Middle Ordovician
Wolchow river, Russia

Flexicalymene retrorsa
Family Calymenidae
Ordovician
Mount Orab, Ohio

Anacheirurs (Lehua sp.)
Family Cheiruridae
Ordovician
Tanssikhte, Zagora,
Morocco

Kainops raymondi
Family Phacopidae
Lower Devonian
Haragan Formation
Oklahoma

Phacops speculator
Family Phacopidae
Devonian
Alnif, Morocco

Phacops rana norwoodensis
Family Phacopidae
Devonian
Cedar Valley Formation,
Johnson County, Iowa

Crotalocephalina
(Crotalocephalus) gibbus
Family Cheiruridae
Devonian
Alnif, Morocco

Flexicalymene meeki
Family Calymenidae
Ordovician
Mount Orab, Ohio

Cybele bellatula
Suborder Cheirurina
Superfamily Cheiruroidea
Family Encrinuridae
Lower Ordovician
Wolchow river, Russia

Pseudocybele nasuta
Suborder Cheirurina
Superfamily Pilekiidae
Family Pliomeridae
Ordovician
Fillmore Formation
Millard County, Utah

Trilobite Order Phacopida
Families:

Suborder Calymenina
Superfamily Calymenoidea
- Calymenidae
- Pharostomatidae
- Homalonotidae
- Bavarillidae
- Carmonidae [not listed as family]
- Bathycheilidae

Suborder Phacopina
Superfamily Phacopoidea
- Phacopidae
- Pterygometopidae

Superfamily Dalmanitoidea
- Dalmanitidae
- Prosopiscidae
- Diaphanometopidae

Superfamily Acastoidea
- Acastidae
- Calmoniidae

Suborder Cheirurrina
Superfamily Cheiruroidea
- Cheiruridae
- Pliomeridae
- Pilekiidae
- Encrinuridae

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<u>Bathyurellus teretus</u>
Superfamily Bathyuroidea
Family Bathyuridae
Ordovician
Fillmore Formation, Millard County, Utah

<u>Comptonaspis swallowi</u>
Superfamily Proetoidea
Family Proetidae
Mississippian
Saline County, Missouri

<u>Comptonaspis swallowi</u>
Superfamily Aulacopleuroidea
Family Aulacopleuriidae
Silurian
Waldron Shale, Indiana

Trilobite Order Proetida Families:
Suborder Proetoidea
Superfamily Proetoidea
-Proetidae
-Tropidocoryphidae
Superfamily Aulacopleuroidea
- Aulacopleuridae
- Brachymetopidae
- Rorringtoniidae
Superfamily Bathyuroidea
- Bathyuridae
- Dimeropygidae
- Hystricuridae
- Toernquistiidae
- Lecanopygidae
- Holotrachelidae
- Telephinidae
- Sharyiidae

The most conspicuous morphological feature of the Asaphid trilobites is the smooth and isopygous (similar in size) cephalon and pygidium, an evolutionary adaptation believed to have helped the trilobite more easily burrow into sediment to achieve stealth. The Asaphids appeared in the Middle Cambrian and persisted to the Lower Silurian Order Asaphida comprises six Superfamilies: Anomocaroidea; Asaphoidea; Cyclopygoidea; Trinucleioidea; Dikelokephaloidea; and Remopleuridoidea listed at the bottom of this page. The oder contains a very large morphological diversity.

Megistaspis triangularis
Superfamily Asaphoidea
Family Asaphidae
Lower Ordovician
Wolchow river, Russia

Asaphus cornutus
Superfamily Asaphoidea
Family Asaphidae
Middle Ordovician
Wolchov River, Russia

Asaphus kowalewskii
Superfamily Asaphoidea
Family Asaphidae
Middle Ordovician
Wolchow River, Russia

Nankinolithis sp.
Superfamily Trinucleoidea
Family Trinucleidae
Ordovician
El Kaid Errami, Morocco

Salterolithus caractaci
Superfamily Trinucleoidea
Family Trinucleidae
Upper Ordovician
Caradoc Series, Harnage (Shales) Formation, Welshpool, England

Isoteloides flexus (rare)
Superfamily Asaphoidea
Family Asaphidae
Ordovician
Fillmore Formation, Millard County, Utah

Paratrinucleus acervulosus
Family Trinucleidae
Upper Ordovician
Blacksburg, Virginia

Onnia superba
Death Assemblage
Superfamily Trinucleoidea
Family Trinucleidae
Middle Devonian
Blekos, Morocco

Pseudasaphus tecticaudatus
Middle Ordovician
Wolchow River, Russia

Homotelus florencevillensis
Family Asaphidae
Subfamily: Isotelinae
Upper Ordovician
Clayton County, Iowa

Lochodomas volborthi
Superfamily Trinucleoidea
Family Trinucleidae
Ordovician
Wolchow River, Russia

Ptyocephalus yersini
Superfamily: Asaphoidea
Family: Asaphidae
Subfamily: Ptyocephalinae
Ordovician
Fillmore Formation

Trilobite Order Asaphida Families:
Suborder Asaphina
Superfamily Anomocaroidea
- Anomocarellidae
- Anomocaridae
- Pterocephaliidae (includes Housiinae)
- Parabolinoididae
- Dikelokephalinidae [now Hungaiidae (Remopleuridoidea)]
- Aphelaspididae

Superfamily Asaphoidea
- Asaphidae
- Ceratopygidae

Superfamily Dikelokephaloidea
- Dikelokephalidae
- Andrarinidae
- Saukiidae
- Ptychaspididae
- Eurekiidae
- Loganellidae [now Idahoiidae (Remopleuridoidea)]

Superfamily Remopleuridioidea
- Remopleurididae
- Kainellidae [now Remopleurididae]
- Opipeuteridae [now Telephinidae (Order Proetida)]
- Bohemillidae
- Auritamiidae
- Idahoiidae
- Hungaiidae

Superfamily Cyclopygoidea
- Cyclopygidae
- Taihungshaniidae
- Nileidae

Superfamily Trinucleioidea
- Trinucleidae
- Dionididae (=Tongxinaspididae) (?)
- Orometopidae [into Alsataspididae]
- Raphiophoridae
- Alsataspididae
- Liostracinidae

Superfamily Uncertain
- Rhyssometopidae (includes - - Mapaniidae, Plectriferidae)
- Monkaspididae

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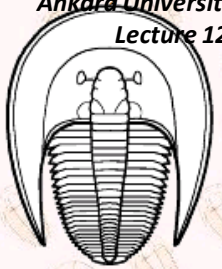
ORDER HARPETIDA

Harpes

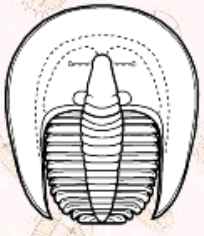


(click on images for pictorial guide)

Entomaspis

Introduction: Recently split from the Ptychopariida (Ebach & McNamara 2002), easily distinguished by marginal sutures and lack of rostral plate, as well as the presence of the "harpetid brim."
Cephalon: semicircular to ovate; fringe inclined, consisting of vaulted inner genal roll, which is convex or flat, and an outer bilaminar brim, either flat, convex or concave, extending posteriorly to long, flat genal prolongations; facial sutures marginal, in Entomaspididae involving the eyes, but with anterior and posterior sections running close together toward otherwise marginal sutures; glabella convex, narrowing forwards, with 1 to 3 pairs of furrows, posterior pair isolating triangular basal lobes; occipital ring convex; alae typically present; preglabellar field broad, sloping down to flat or upwardly concave border; eyes commonly reduced to prominent tubercles, centrally located on genae, strong eye ridges present; external surface of cephalon may be tuberculose or granulose.
Thorax: with 12 or (frequently) more segments, pleurae flattened, with broad axial furrows.
Pygidium: subtriangular, elongate to short.
Families: Entomaspididae, Harpetidae, Harpididae (=Loganopeltidae).
Occurrence: Upper Cambrian to Late Devonian (Frasnian).
Genera: Entomaspididae: *Entomaspis (=Hypothetica)*
Harpetidae: *Arraphus, Bohemoharpes (=Declivoharpes; =Ungulohar pes), Bowmania, Brachyhipposiderus, Conococheaguea, Dolichoharpes, Dubhglasina (=Australoharpes; =Sinoharpes), Eoharpes (/Harpina), Eotrinucleus, Harpes (=Helioharpes; =Reticuloharpes), Heterocaryon, Hibbertia (/Platyharpes; =Harpesoides; =Metaharpes; =Paraharpes; =Thorslundops; =Wegelinia), Kathrynia, Kielania (=Lowtheria), Lioharpes (=Fritchaspis), Paleoharpes, Scotoharpes (=Aristoharpes; =Selenoharpes).*
Harpididae: *Chencunia, Dictyocephalites, Fissocephalus, Harmidas, Harmidoides, Kitatella, Loganopeltis, Loganopeltoides, Metaharmides, Paraharpides, Pscemiaspis.*

Eoharpes



ADDITIONAL CLASSIFICATION NOTES FOR H
Fortey (1990) points out that two of the diagnostic charac
Ebach & McNamara (2002) point out that all members of
defined as Ptychopariida. Consequently, they raised Harpe
Fortey erected the Librostoma (1990) to act as a high-lev
suborders. As Proetida, Asaphida, and now Harpetida are
the shared Ptychopariida ancestry.
A note on the name Harpidae: Harpidae was once used as
with the use of the same name for a family of extant mollus
family. In 1987 Harpetidae Hawle & Corda 1847 and Ha
1436 of the ICZN.
For information on the ontogeny of Harpetida, see Dr. Ru

Beu, A.G. 1971. Cassidae and Harpidae: Two family grou
Nomenclature 28:564-86.
Ebach, M.C. & K.J. McNamara. 2002. a systematic rev
21:135-67.
Fortey, R.A. 1990. Ontogeny, hypostome atachment and

Harpes perradiatus)
Harpetida Gallery
A small gallery of images from the web

click this image for pictorial guide

ORDER PTYCHOPARIIDA

Introduction: A large, heterogenous order, classification problematic, with specialized offshoots that are hard to frame within a general diagnosis.
Cephalon: typically with opisthoparian facial sutures, with gently forward-tapering simple glabella bearing a broad, rounded front, usually with 3 pairs of rather narrow parallel glabellar furrows; natant hypostome.
Thorax: typically large with 8+ thoracic segments.
Pygidium: quite variable, but typically with a small pygidium bearing a border (Cambrian) or a larger pygidium with or without border (post-Cambrian).
Occurrence: Lower Cambrian to Upper Ordovician.
Suborders: Ptychopariina, Olenina, (formerly also including Harpina, which is now a full Order Harpetida).

Suborder Ptychopariina

Introduction: Primitive Ptychopariida, a large and extremely varied group.
Cephalon: glabella usually tapering with 3 pairs of glabellar furrows, sutures typically opisthoparian (but some proparian, and blind forms marginal); anterior sutures usually convergent to slightly divergent, posterior sections moderately to highly divergent; eyes usually present, medial, and near glabella; usually blade-like genal spines present.
Thorax: generally long, relative to pygidium.
Pygidium: variable, but typically smaller than thorax.
Superfamilies: Ellipsocephaloidea, Ptychparioidea (see below)
Families: (listing those for which suborder assignment is uncertain) Ityophoridae, Catillicephalidae, Raymondinidae, Avoninidae, Plethopeltidae.

Superfamily Ellipsocephaloidea

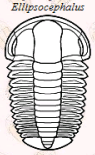
Cephalon: glabella tapering forward, or subparallel or slightly expanding forward; up to 5 pairs of lateral furrows, eye ridges present.
Thorax: generally 12-16 thoracic segments.
Pygidium: small, unremarkable.
Families and Genera: Agraulidae: *Agasella, Agaso, Agraulos (/Arion; /Arionius; =/Arionides /Arionellus; =Agrauloides), Batenoides, Chittidilla (=Diandongaspidella /Diandongaspis), Chondroparia, Clemenella, Conagraulos, Elankaspis, Lenagraulos, Litavkaspis, Metagraulos, Micragraulos, Mungvongia, Parachittidilla (=Amurticephalus), Paragraulos, Paraplesiagraulos, Phymaspis, Plesiagraulos, Poriagraulos, Proampyx, Protochittidilla, Pseudoeteraspis, Pseudoplesiagraulos, Qiannanagraulos, Shahaspis, Skreiaspis, Stembergaspis, Taiganella, Tetragonocephalus, Tholus, Tianjingshania, Veragraulos, Wutaishania.*

Aldonaiidae: *Aldonaia, Granutaspis, Ideria, Perissopyge, Planaspis, Pumilina, Repinaspis, Tuvanella (=Eleganolimba), Tuvanellus, Volonellus.*

Bigotinidae: *Bigotina, Bigotinella, Bigotinops, Bulaiaspis, Hupetina, Neobigotina, Ouijjania, Pruvostina, Serrania.*

Chengkouiidae: *Acanthomicmacca (=Chengkouia; =Jaskovitchella; =Myopsomicmacca), Bidjinella, Changyangia, Micmacca, Turkestanella, Wenganella, Xiuqiella, Zacanthellina, Zhenbaspis (=Yankongia; =Zhenxiongaspis).*

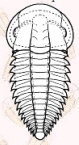
Ellipsocephaloidea
Ellipsocephalidae
Ellipsocephalus



Ellipsocephalidae: *Acadolenus, Alueva, Antatlasia, Argunaspis, Asiatella, Bergeroniaspis, Bergeroniellus, Blayacina, Brevitermierella (=Paratermierella), Cambrunicornia, Catadoxides, Charaulaspis, Chorbusulina, Comluella, Culmenaspis, Ellipsocephalus (=Germaropyge), Ellipsostrenua, Glabrella, Hamatolenus, Hupeolenus, Issafeniella, Kadyella, Kameschkoviella, Kijanella, Kingaspidoides (=Elatius), Kingaspis (=Mesetaia), Krolina, Kymataspis, Latikingaspis, Latouchia, Latuzella, Lermontovia, Limataceps, Limouolenus, Lotzeia, Lusatiops (= Jalonella), Mohicana, Myopsolenus (=Collyrolenus), Myopsostrenua, Nelegeria, Olekmaspis, Ornamentaspis, Orodes, Ourikaia, Paramicmacca, Paraprotolenella, Pauliceps, Planolimbus, Protagraulos, Protaldonaia, Protolenella, Protolenus (/Bergeronia; =Matthewlenus), Pruvostinoides, Pseudoasiatella, Pseudokadyella, Pseudolenus, Pseudoprotolenella, Ptychoparopsis (=Berabichia), Rinconia, Sailycaspis, Sectigena, Strenuaeva (=Hindermeyeria), Strenuella, Tadakoustia, Termieraspis, Termierella, Thoralaspis, Timnaella, Triangulaspis (=Acutaspis; =Angustaeva; =Plenudiscus; =Triangullina), Yeshanaspis.*

Lermontovia

Yunnanocephalidae
Yunnanocephalus



Estaingiidae: *Alanisia, Chulanolenus, Coreolenus, Eomalungia, Estaingia (=Hsuaspis, =Pseudichangia; =Zhuxiella; =Sematiscus; =Strenax), Hupeia, Ichangia, Longmenshania, Longxianaspis, Madianaspis, Mundocephalina, Ningxiaspis, Olekinanellus, Paraichangia, Pararaia (=Proichangia; =Tannuolaspis), Protolenoides, Shangsiaspis, Shifangia, Shiqihepsis, Sichuanolenus, Subeia, Szechuanolenus, Yinshanaspis.*

Palaeolenidae: *Alataurus, Bajangoliaspis, Enammocephalus, Ferralsia, Gigoutella, Hybrocephalus, Hoffetella, Latipalaeolenus, Megapalaeolenus, Palaeolenella, Palaeolenides, Palaeolenus, Resimopsis, Schistocephalus, Torgaschina, Ulakhanella, Validaspis.*

Yunnanocephalidae: *Elicicola, Luaspis, Pensacola, Wangzishia, Wenganlenus, Yunnanocephalus (/Pseudoptychoparia).*

Superfamily Ptychparioidea

Cephalon: typically with well-defined border, glabella tapering forward, preglabellar field present, opisthoparian sutures, natant hypostome, and genal spines; but exceptions include eyeless forms (Conocoryphidae), proparian forms (Norwoodiidae), rounded genal angles and gonatoparian sutures (Menomoniidae).
Thorax: typically 12-17 segments.
Pygidium: typically micropygous, transverse, pleural field nearly flat, with distinct pleural grooves; but exceptionally isopygous (*e.g.*, some Asaphiscidae, Cooselidae).
Families and Genera: Acrocephalitidae HUPE, 1953
Acrocephalella, Acrocephalinella, Acrocephalites (=Acantholenus), Acrodirotes, Afghancephalites, Asturiaspis, Brutaspis, Cermataspis, Decus, Diceratocephalina, Elatilimbus, Ijacephalus, Kepisis, Mansiella, Pseudacrocephalaspina, Siligerites, Toxotina, Trifonella.

Alokistocaridae: *Alokistocare (=Pseudoalokistocare), Alokistocarella, Alokistocaropsis, Altiocculus, Amecephalina, Amecephaloides, Amecephalus (=Strotocephalus), Annamitia, Arcadiaspis, Arellanella, Atopiaspis, Beldirella, Binella, Bythicheilus, Chancia, Chanciaopsis, Danzhaiaspis, Diaoyaspis, Ehmania, Ehmaniella (=Anomalocephalus; =Clappaspis), Elrathia, Elrathiella (=Coelaspis; =Glossocoryphus), Eokaotaia, Erdoradites, Furia, Ganovexopyge (/Scottia), Huochengella, Inglefieldia, Jenkinsonia, Kailiella, Kaotaia, Katunicare, Kistocare, Langqia, Lenacare, Nelgakia, Parapachyaspis, Parehmania (=Mcnairia; =Rowia; =Thompsonaspis), Pedinocephalina, Peregrinaspis, Plesiamecephalus, Proehmaniella, Proveedoria, Pseudomexicella, Schopfaspis, Trachycheilus, Tympanuella, Utaspis.*

Ptychparioidea
Alokistocaridae
Elrathia

Antagmidae: *Antagmella, Antagmus, Bagradia, Bicella, Bilimbataia, Cambrophatictor, Crassifimbra, Cyphambon, Erzishania (=Oreisator), Houmengia, Katunia, Lennontoviella, Longshania, Luaspides, Mantoushania, Onchocephalina, Onchocephalus (=Litocodia), Paraantagmus, Periomma, Plesioperiomma, Shilengshuia, Sombrerella, Wanbeiaspis, Xiangqianaspis, Xiaofangshangia, Xiaomajiella, Yuehsienszella.*

Asaphiscidae: *Anomocarellius, Asaphiscus, Blainia, Blainiopsis, Blountiella, Blountina, Canotiana (=Williamsina), Cinnella, ?Conoides, Dunderburgella, Edithiella, Eoasaphiscus* HAJRULLINA, *Eokaninia (/Kaniniella* SIVOV), *Eoproetus, Erbenia, Eteraspis, Iniotoma, Kaninia (/Kaniniella* SIVOV; *=Dolgaia), Kaniniella* KOBAYASHI, *Lioparia (/Lorentzia, /Pseudoliostracina; =Emmrichella; =Liaoyangaspis), Luyanhaoaspis (/Luaspis* PENG et al., 1995), *Mindycrusta, Paraorlovia, Vega, Verkholenella.*

Menomoniidae
Menomonia

Atopidae: *Atopina, Atops (=Ivshiniellus), ?Avalonia, Pseudatops.*

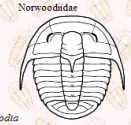
Bolaspididae: *Acrocephalops, Bolaspidaspis, Bolaspis, Eldoradia, Rawlinsella.*

Cedariidae: *Bonneterrina (=Holstonia; =Piedmontia), Carinamala, Cedaria, Cedarina, Henadoparia, Jimachongia, Vernaculina.*

Changshaniidae: *Benxiella, Changshania (=Metachangshania; =Prochangshania), Changshanocephalus, Kazelia (=Kazellina), Mecophyrs, Narinosa, Parachangshania, Paramenomonia, Paraqingshuiheella (=Qingshuiheella), Pseudowentsuia, Suribongia, Wentsuia.*

Conocoryphidae: *Bailiaspis, Bailiella (=Liaotungia; =Liocephalus; =Tangshihella), Cainatops (=Comucoryphe), Conocoryphe (/ Conocephalites; =Conocephalus; =Couloumania), Ctenocephalus, Elyx (/Eryx), Hartella, Parabailiella, Tchaiaspis.*

Norwoodiidae



Conokephalinidae: *Buitella, Catuniella, Conokephalina (=Lobocephalina; =Ruzickaia/Lobocephalus), Gorskia, Maspakites, Meisteraspis, Meisterella, Miranda, Oirotella, Suludella, Westergaardella.*

Crepicephalidae: *Bagongshania, Beikuangaspis, Cayupania, Coosella (=Wilsonella), Coosia, Coosina, Coosinoides, Crepicephalina (=Mesocrepicephalus), Crepicephalus, Hsuchuangia, Idioura, Kasatchaspis, Neimonggolaspis, Perforina, Pseudocrepicephalus, Sinocoosella, Sinocrepicephalus, Sneedvillia, Temnoura (=Asteromajia), Tetraceroura, Uncaspis, Zaozhuangaspis.*

Norwoodia

Diceratocephalidae: *Anopocodia, Aulacodigma, Cyclolorenzella, Diceratocephalus, Fenghuangella (=Cyclolorenzellina), Hwangjuella, Jiangnania, Tangshihlingia, Tholifrons (=Paraphoreotropsis), Torifera, Xiangia.*

Elviniidae: *Chariocephalus, Dartonaspis, Drumaspis, Dunderbergia, Dytremacephalus, Elburgia, Elvinaspis, Elvinia (=Moosia), Elviniella, Elvinioides, Elyaspis, Enshia, Irvingella (=Irvingellina; =Parairvingella; =Komaspis), Jessievillia, Kujandina, Maladioides, Maladiopsis, Megadundabergia, Metisaspina, Onchopeltis, Paraenshia, Parakomaspis, Pesaia, Protemnites (=Prismenaspis), Pseudomaladioides, Pseudosaukia, Qingshuihella, Schmidtaspis, Yunlingia.*

Tricrepicephalidae

Eulomidae: *Acrocephalaspina, Altaiaspis, ?Amzasskiella (=Trip lacephalus), Archaeuloma, Baikadamaspis, Bilacunaspis, Butyrinia, Crucicephalus, Dolgeuloma (/Rosovaspis/ Pseudoacrocephalites* ROSOVA), *Duplora, Euduplora, Euloma (=Calymenopsis), Guizhoucephalina, Iveria, Karataspis, Ketyna (=Kujandaspis), Lateuloma, Limpeina, Loparella, Lopeuloma, Luyanhaoia, Miaeuloma, ?Natmus, Pareulorna (=Gansucephalina), Pesaina, Plecteuloma, Probilacunaspis, Proteuloma (=Mioeuloma), Pseudoacrocephalites* MAKSIMOVA, *Sanduspis, Spineuloma, Stigmatoa.*

Tricrepicephalus

Ignotogregatidae: *Ignotogregatus.*

Inouyiidae: *Catinouyia, Eoinouyia, Huainania, Inouyia, Parahuainania, Parainouyia, Parajialaopsis, Parawuania, Plesiowuania, Proinouyia, Pseudinouyia.*

Isocolidae: *Cyphoniscus, Effnaspis, Hanzhongaspis, Holdenia (/Tiresias), Isocolus (/Astyages), Kielanella, Liangshanocephalus, Paratiresias, Pradesia, Pseudopetigurus, Taimyraspis, Thoralocolus, Triarthroides.*

Conocoryphidae
Conocoryphe

Kingstoniidae: *Acheilus CLARK, Ankoura, Blountia (=Homodictya; =Protillaenus; =Stenocombus), Brachyaspidion (/Brachyaspis MILLER, 1936), Bynumia, Bynumina, Calvipelta, Cielancha (/Harrisia; =Bynumiella), Ithycephalus, Kingstonella, Kingstonia (=Ucebia), Kingstonioides, Komaspidella (=Buttsina; =Ataktaspis), Larifugula, Maryvillia, Pugionicauda, Saonella, Shuizuia, Wanwanaspis, Wanwanoglobus, Yanzhuangia.*

Lisaniidae: *Dazhuia, Eoshcngia (=Baojingia), Extrania, Klimaxocephalus, Lisania (=Aojia), Megalisania, Metalisania, Paralisaniella, Paraojia, Parashengia, Platylisania, Quandraspis, Redlichaspis (=Lisaniella), Rinella, Shengia, Xichuania.*

Llanoaspididae: *Amquia, Arcuolimbus, Deiracephalus (/Asteraspis), Genevievella (=Placoscma; = Nixonella; =Torridella), Llanoaspidella, Llanoaspis, Metisaspis, Nahanniccphalus, Paracedaria (/Pilgrimia), Rogersvillia, Sacha, Stenelymus, Tagenarella.*

Marjumiidae
Modocia

Lonchocephalidae: *Amiaspis, Bolaspidellus, Calymenidius, Caulaspina, Caulaspis, Durinia, Glaphyraspis (=Raaschella), Graciella, Hawkinsaspis (/Hawkinsia), Interalia, Kuraspis, Kuraspoides, Lazarenkiura, Letniites, Lonchocephalus (=Bucksella), Monosulcatina, Neoglaphyraspis, Nordia, Olegaspis, Prolonchocephalus, Pseudotalbotina, Quebecaspis, Raaschellina, Talbotina, Terranovella, Trymataspis, Weeksina.*

Lorenzellidae: *Damiaoaspis, Eujinnania, Inouyops, Inoyellaspis, Jiangjunshania, Lonchinouyia, Lorenzella, Paralorenzangella (/ Paralorenzella* Q.Z. ZHANG), *Paralorenzella* LUO, *Paraporilorenzella, Porilorenzella (=Jinnania), Pseudolorenzella, Ptyctolorenzella, Zhongweia.*

Mapaniidae: *Angsiduoa, Hualongia, Mapania, Mapanopsis, Metanomocarella, Paramapania, Pseudomapania, Quitacetra, Quitalia.*

Marjumiidae: *Anemocephalops, Crepichilella, Glyphopeltis, Holmdalia, Ithyektyphus, Lecanopleura, Loulania, Marjumia, Modocia (=Armonia; =Metisia; =Perioura; =Semnocephalus), Nasocephalus, Nericella, Nericia, Pearylandia, Petruninaspis, Schyilaspis, Shickshockia, Syspacheilus.*

Menomoniidae: *Balderia, Biaverta, Bolaspidella (= Deissella; =Howellaspis), Bridgeia, Coenaspis, Coenaspoides, Deltophthalmus, Dresbachia, Hysteropleura (=Apedopyanus), Josina, Knechtelia, Menomonia (=Densonella/Millardia), Tavsenia, Verditerrina.*

M. Görmüş,
Ankara University, 2017
Lecture 12

Mapaniidae: *Angsiduoa, Hualongia, Mapania, Mapanopsis, Metanomocarella, Paramapania, Pseudomapania, Quitacetra, Quitalia.*

Marjumiidae: *Anemocephalops, Crepichilella, Glyphopeltis, Holmdalia, Ithyektyphus, Lecanopleura, Loulania, Marjumia, Modocia (=Armonia; =Metisia; =Perioura; =Semnocephalus), Nasocephalus, Nericella, Nericia, Pearylandia, Petruniaspis, Schyilaspis, Shickshockia, Syspacheilus.*

Menomoniidae: *Balderia, Biaverta, Bolaspidella (= Deisszella; =Howellaspis), Bridgeia, Coenaspis, Coenaspoides, Deltophthalmus, Dresbachia, Hysteropleura (=Apedopyanus), Josina, Knechtelia, Menomonia (=Densonella/Millardia), Tavsenia, Verditerrina.*

Nepeidae: *Ascionepea, Ferenepea, Folliceps, Loxonepea, Nepea, Penarosa (=Trinepea).*

Norwoodiidae: *Cedaraspis, Garbiella, Hardyoides (=Norwoodina), Holcacephalus, Levisaspis, Norwoodella, Norwoodia (=Whitfieldina), Paranorwoodia, Xenocheilos.*

Papyriaspididae: *Badainjaranaspis, Metapianaspis, Papyriaspis, Pianaspis, Prohedinaspis, Prohedinia (=Tosotychia), Sanduhedinaspis, Wandelella, Wangcunia, Wudangia.*

Phylacteridae: *Aphelotoxon (=Ponumia), Cliffia, Drabia, Phylacterus (=Liostracinoides), Westonaspis.*

Proasaphiscidae: *Acanthocephalus Alomataspis, Chelidonocephalus, Dananzhuangaspis, Daopingia, Deltocephalus, Derikaspis, Dignaceps, Eoasaphiscellus (/Eoasaphiscus* LU & YUAN), *Eymekops (=Kolpura), Farsia, Gangdeeria, Gloria, Grandioculus (/Megalophthalmus; =Honania), Guankouia, Hadraspis, Hatangia, Heukkyoella, Holanshania, Honanaspis, Hsiaoshia, Huaibeia, Hundwarella (=Anomocaraspis), Huojiangaspis, Iranochresterus, Iranoleesia (/Irania; =Michaspis; =Heyelingella), Itcheriella, Jiangsuaspis, Jiangscuephalus, Jiangsua, Jiubaspis, Jixianella (/Jixiania), Koptura (=Parakoptura), Kopungiella, Kutsingocephalus, Leichuangia, Lioparella (=Zhuozishania), Lultangshanaspis, Luonanocephalus, Manchuriella, Maotunia, Memmatella, Miaobanpoia, Paofeniellus, Paragangdeeria, Parazhongtiaoshanaspis, Plectrocrania, Plesigangdeeria, Proasaphiscina, Proasaphiscus, Pseudanomocarina, Pseudonericella, Raduginella, Severina, Shanxiella, Shuangshania, Stella, Sudanomocarina, Szeaspis (=Spitiaspis), Tankhella, Tengfengia, Teratokoptura, Tylotaspis, Ulania, Urjungaspis, Wutaishanaspis, Xiangshania, Xinglongia, Yanshania, Yujinia, Zhaishania, Zhongtiaoshanaspis.*

Ptychopariidae: *Achlysopsis, Altikolia, Altitudella, Amecephalites, Asthenopsis, Austinvillia, Balangcunaspis, Bashania, Bathyholcus, Bathyocos, Billingsaspis, Binodaspis (=Xilingxia), Blairella, Bolaspidina, Brunswickia, Bulkuraspis, Caborcella, Callidaspina, Callidaspis, Cathayanella, Champlainia, Chengshanaspis, Chinghisicus, Chunghwaella, Conopolus, Dananzhuangia, Deltina, Deuposiella (=Tongshania), Elrathina, Entsyna, Eodouposiella, Eokochiaspis, Esoptychoparia, Esopsecia, Eurostina, Finecrestia, Gaotanaspis, Gaphuraspis, Gedongaspis, Guznia (=Ellotia; =Yilangaspis), Hadrocephalites, Hadrolaspedon, Hamptonella, Hejinaspis, Hemicricomatopus, Hewenia, Holasaphus, Horbuskia, Illtydiaspis, Jangudaspis, Jialaopsis, Jianchangia, Jinaoshania, Jumenia, Kermanella, Kochaspis (/Palaeocrepicephalus), Kochiella (=Eiffelaspis), Kochiellina, Kochina, Kounamkites, Kummingaspis (=Benxiaspis), Lamimurus, Laoyingshania, Lianglangshania, Loriella, Luguoia, Lucella, Lyriaspis, Majiangia, Manailina, Meitania, Metisella, Mexicella, Monanocephalus, Mopanshania, Mrassina, Mufushania, Nangaocephalus, Nangaoia, Nangaos, Nanogia, Nassovia, Nelsonia, Neokochina, Nyella, Olenekina, Onchocephalites, Ontoella, Orienturus, Orlovia, Orloviella, Pachyaspidella, Pachyaspis, Palmeraspis, Panacus, Paraeosoptychoparia, Paragunnia, Paramecephalus (=Parahiolites), Paraperiomma, Paraplagiura, Parapoulsenia, Parashuiyuella, Paraziboaspis, Perimetopus, Periommella, Piazella, Pingluaspis, Piochaspis, Plagiura (=Ruichengella; =Plagiurella), Pokrovskayaspis, Poulsenella, Poulsenia, Poulseniella, Probowmania, Probowmaniella (=Proshantungaspis), Probowmanops, Proliostracus, Prometaitania, ?Protohedinia, Pseudoliostracus, Psilostracus, Ptychoparella (=Eoptychoparia; =Syspacephalus; =Elrathma), Ptychoparia (=Agraulopsis; =Ptychoparioides), Qiaotouaspis, Qingshuiheia, Reedus, Regina, Regius, Runnania, Salankanaspis, Sanhuangshania, Sanwania, Schistometopus, Semisphaerocephalus, Seriaspis, Shanganella, Shantungaspis, Shuiyuella, Sinoptychoparia, Spencella, Spencia*

Prometaitania, ?Protohedinia, Pseudoliostracus, Psilostracus, Ptychoparella (=Eoptychoparia; =Syspacephalus; =Elrathma), Ptychoparia (=Agraulopsis; =Ptychoparioides), Qiaotouaspis, Qingshuiheia, Reedus, Regina, Regius, Runnania, Salankanaspis, Sanhuangshania, Sanwania, Schistometopus, Semisphaerocephalus, Seriaspis, Shanganella, Shantungaspis, Shuiyuella, Sinoptychoparia, Spencella, Spencia (=Stauroholcus), Stoecklinia, Sujaraspis, Suluktella, Taijiangia, Taniaspidella, ?Townleyella, Trachyostracus, Trigonyangaspis (/Trigonaspis), Tukalandaspis, ?Ulrichaspis, Variopelta, Vermontella, Vica, Volocephalina, Wanhuaia, Weijiaspis, Wuhaina, Xiangshanaspis, Xingrenaspis (=Spitella; = Danzhaina; =Wuxunaspis), Yaoyiayuella, Yohoaspis, Yuknessaspis, Ziboaspidella, Ziboaspis.

Shumardiidae: *Acantholeurella, Changchowilla, Conophrys, Elaphraella, Eoshumardia, Gaoloupingia, Koldinioidia (=Akoldinioidia), Kuruktagaspis, Kweichowilla, Leioshumardia, Leofforteyia, Liriamnica, Parashumardia, Puanocephalus, Shumardia, Shumardoella (/Shumardella), Shumardops, Stigmametopus, Tarimella (=Yinganaspis), Thomondia, Trianguraspis.*

Solenopleuridae: *Abakanopleura, Acanthometopus, Acrocephalaspis, Aiaiaspis, Aidarella, Aikhaliella, Albansia, Aldanaspis, Badulesia, Bigraunilella, Bijelina, Braintreella, Canotaspis, Catasolenopleura, Changgingia (=Austrosinia), Colliceps, Conicephalus, Crusoia, Daldynaspis, Datongites, Denaspis, Eilura, Ejinaspis, Erratojincella, Foveatella, Gonzaloia, Gushanaspis, Herse (/Solenopleurina; =Parasolenopleura* WESTERGARD), *Huzhuia, Hyperoparia, Jiagouia, Jincella, Kabuqiia, Kaipingella, Karagandoides, Keguinia, Lashushania, Levisia, Lingyuanaspis, Liosolenopleura, Maiaspis, Manublesia, Markhaspis, Mataninella, Menocephalites (=Parataitzuia), Minupeltis, Mukrania, Munija, Neoacrocephalites, Neosolenopleurella, Nilegna, Ninaspis, Notocoryphe, Paracrocephalites (/Arctaspis), Paramenocephalites (=Solenoparina), Parasolenoparia, Parasoloplеurena (/Parasolenopleura* POLETAEVA), *Parayabeia, Pardailhania, Perneraspis (/Pernieria), Pinghuia, Plesiolenoparia, Proavus, Protrachoparia, Pseudosolenoparia, Reilloleura, Rimouskia, Rna, Sao (=Acanthocnemis; =Acanthogramma, =Critbias; =Endogramma; =Exmeacnemis; =Goniacanthus; =Micropyge; =Monadina; =Monadella; =Selenosema; =Staurogmus; =Tetracnemis), Shanghaiaspis, Solopleura, Solenoparia, Solenoparops, Solenopleura, Solenopleurella, Solenopleuropsis, Squarrosoella, Suyougouia, Tabalqueia, Tangwangzhaia, Tjungiella, Trachoparia, Usumuniaspis, Velieuxia, Wafangdiania, Xianfengia, Tabeia.*

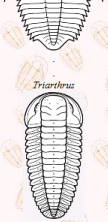
Tricrepicephalidae: *Erediaspis, Meteoraspis (=Greylockia; = Coleopachys), Prometeoraspis, Tricrepicephalus (/Paracrepicephalus).*

Utiidae: *Amginouyia, Antagmopleura (=Poljakovia), Chondragrautina, Chondagraulos, Okunevaella, Utia.*

Wuaniidae: *Eotaitzuia, Houmaia, Inouyella, Jixianaspis, Latilorenzella (=Wuania), Lophodesella, Megagraulos, Pseudosolenopleura, Rencunia, Ruichengaspis, Wuanoides, Wuhushania, Yunmengshania.*

Suborder Olenina

Cephalon: with narrow border, opisthoparian sutures (exceptionally proparian), genal angle rounded or spined, glabella tapering forward with simple, sigmoid, or bifurcate furrows (furrows absent in some forms); librigenae yoked (fused by a narrow strip of cephalic doublure), or rarely, separated by anterior median suture; eyes small to medium, usually with distinct eye ridges.
Thorax: 9-24 segments.
Pygidium: micropygous to subisopygous, with or without marginal spines.
Other: typically with extremely thin cuticle.
Family: Olenidae (subfamilies Leptoplastinae, Oleninae, Triarthrinae, Pelturinae).
Genera: Olenidae: *Acerocare, Acerocarina (/Cyclognathus), Aciculolenus, Anaximander, Angelina (=Keidelaspis), Apoplanias, Asilluchus, Baikonuraspis, Balnibarbi, Bienvillia (=Diatemnus; =Mendoparabolina), Boeckaspis (/Boeckia* BROGGER; *=Sphaerophthalmella), Bondarevites, Bulbolenus, Chekiangaspis, Cloacaspis, Ctenopyge, Cyclognathina, Danarcus, Desmetia, Eoctenopyge, Euonchonotina, Eurycare, Granitzia, Hancrania, Helieranella, Highgatella, Huangshiaspis, Hunanolenus, Hypermecaspis (=Spitzbergaspis), Inkouia (=Agalatus), Isidrella, Jujuyaspis (=Alimbetaspis), Leiobienvillia, Leptoplastides (=Andesaspis; =Beltella; =Chunkingaspis; =Parabolinopsis; =Rampartaspis), Leptoplastus, Leurostega, Magnomma, Mesoctenopyge, Moxomia, Neoolenus, Neoparabolina, Nericiaspis, Olenus (=Simulolenus), Orkekeia, Parabolina (/Odontopyge), Parabolinella, Parabolinina, Parabolinites, Paraolenus, Paraplicatolina, Peltocare, Peltura (/Anthes; =Anopocare), Pelturina, Plicatolina, Plicatolinella, Porterfieldia, Prohedinella, Protopeltura, Psilocara, Remizites, Rhodonaspis, Saltaspis, Shihuigouia, Shaerophthalmus, Svalbardites, Talbotinella, Triarthrus (/Brongniartia* EATON), *?Ullaspis, Westergaardia (=Sphaerophthalmoides), Westergaardites, Wujiajiania.*



Uncertain Suborder or Polyphyletic Families:

Avoniniidae: *Avonina, Wongia.*

Catillicephalidae: *Acheilops, Agelagma (?=Paradistazeris), Buttsia, Buttsiella, Catillicephala (/Cephalocoelia), Catillicephalites, Coephalocoeliaspis, Cryptoderaspis, Distazeris, Galeaspis, Lajishanaspis, Madaracephalus, Matania, Onchonotellus (=Onchonotina; =Guotangia; =Seletella), Onchonotopsis, Onchonotus, Pemphigaspis (=Hallaspis), Peracheilus (=Acheilus* RAYMOND), *Qilianshania, Stenochilina, Theodenisia (/Denisia; =Calculites; =Mannschreekia), Triarthropsis, Tumidulaspis, Tuojiangella, Urbanaspis, Waergangia, Welleraspis (=Avonaspis), Yukonaspis.*

Ityophoridae: *Frognaspis, Ityophorus.*

Plethopeltidae: *Arapahoia (=Hesperaspis), Exigua (=Brassicicephalus), Koldinia, Koldiniella, Kuljumbina, Lampropeltis, Leiocoryphe, Meniscocoryphe, Notaiella, Plethopeltides, Plethopeltis (=Plethometopus; =Enontioura), Plethopeltoides (=Kulyumbopeltis), Poriplethopeltis, Pseudokoldinella, Semicyclocephalus, Stenopilus, Strotocephala, Tolstotchichaspis.*

ADDITIONAL CLASSIFICATION NOTES FOR PTYCHOPARIIDA:
This order is certainly most problematic. Defined largely by combinations of primitive character states (such as tapering glabella, preglabellar field, natant hypostome, small, furrowed pygidium, and subdued exoskeletal sculturing), the fate of the Ptychopariida may be to slowly dwindle as groups such as the Proetida, Asaphida, and Harpetida are defined via their shared derived characters and extracted from the Ptychopariid clade.
The origins of the Ptychopariida and other Early Cambrian trilobite lineages have been explored recently by Jell (2003) who noted that at least two major lineages arose independently in different parts of the Early Cambrian world out of Fallotaspidae (the earliest trilobite family, a member of Redlichiida) to produce taxa that are now referred to as members of Ellipsocephaloidea (generally recognized as the earliest of the Ptychopariida). In addition, another lineage gives rise to Anomocaridae (primitive Asaphida) and Proasaphiscidae (primitive Ptychopacioidea). This would make the Ptychopariida polyphyletic, and throws a complicaton into the origins of the Asaphida. Jell also questions the primacy of the conterminant hypostomal state, suggesting that the earliest trilobites were natant, and that both facial sutures and the conterminant condition arose independently in several lines. The "Librostome Orders" (Ptychopariida, Asaphida, Proetida, Harpetida, and possibly the Phacopida), have sister taxa within the Ptychopariida, making it a paraphyletic unit. The problem is exacerbated by the inadequate diagnoses of the constituent families; even the well-accepted clades within Ptychopariida, such as the Olenidae, are united by few shared derived characters, and, as in the Asaphida, there are primitive representatives lacking some of the derived states, and advanced representatives that have secondarily lost them.

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The process of clarifying the Ptychopariida is hampered by lack of complete specimens, lack of sufficient ontogenetic data, lack of hypostome characters, *etc*. It will take much effort and some fortuitous breakthroughs in both data and analysis to deal with the Ptychopariida. There are a number of families and genera that are considered part of the Ptychopariida, but for which additional detail is difficult to ascertain:
For a review of information dealing with ontogeny of Ptychopariida, see Dr. Rudy Lerosey-Aubril's page on larvae and trilobite orders: Ptychopariida.

The genera listed here are from Jell & Adrain 2003.

Fortey, R. A. Trilobite systematics: the last 75 years. *J. of Paleontology*. 75(6):1141-51.
Jell, P.A. 2003. Phylogeny of Early Cambrina trilobites. *Special Papers in Palaeontology* 70:45-57.
Jell, P.A. & J.M. Adrain. 2003 Available generic names for trilobites. Memoirs of the Queensland Museum 48(2):331-553

Want more than line drawings?

Ptychopariida Gallery
A small gallery of images from the web

M. Görmüş,
Ankara University, 2017
Lecture 12

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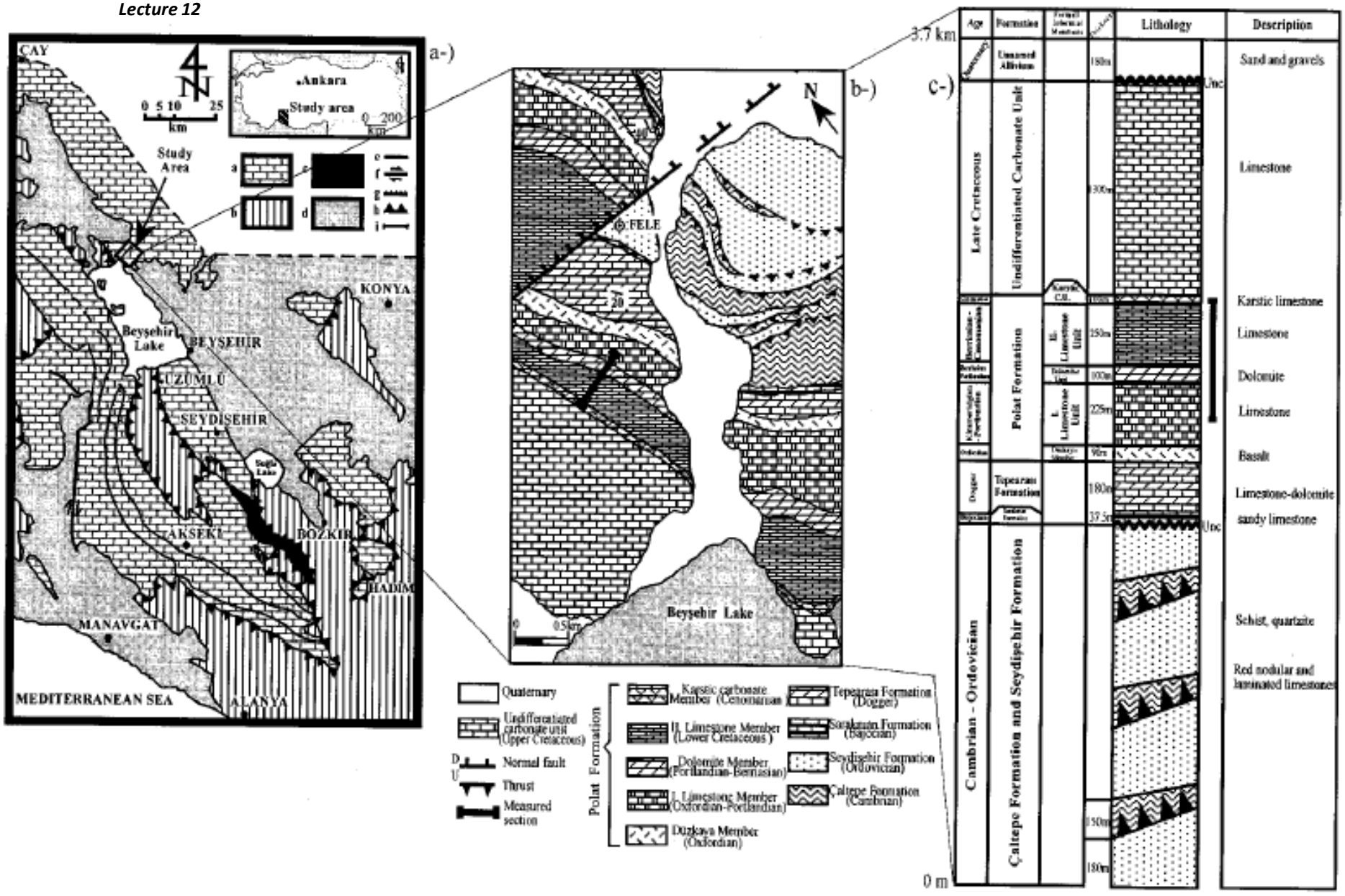

Yılmaz, 1999

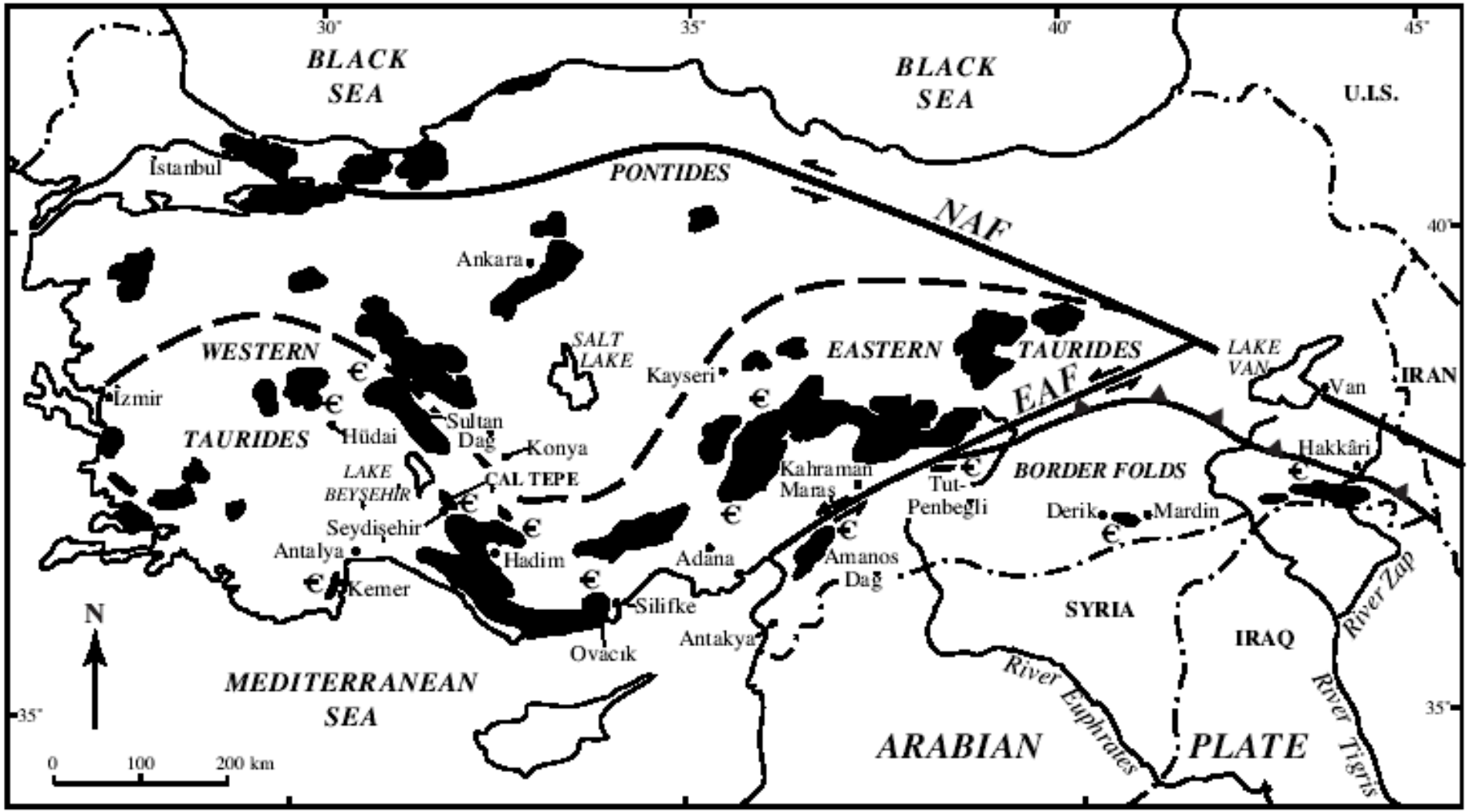

Figure 1. Outline map of Turkey, showing location of principal place-names cited in the text. Regional tectonic units after Ketin (1966) and Gutnic *et al.* (1979); black areas denote Palaeozoic (undivided) outcrops (after Dean 1975, and Gutnic *et al.* 1979), compiled and modified from maps of the General Directorate of Mineral Research and Exploration of Turkey (= MTA). Those which include Cambrian rocks are marked by the letter ∈. EAF = East Anatolian Fault, NAF = North Anatolian Fault.

Dean, 2005

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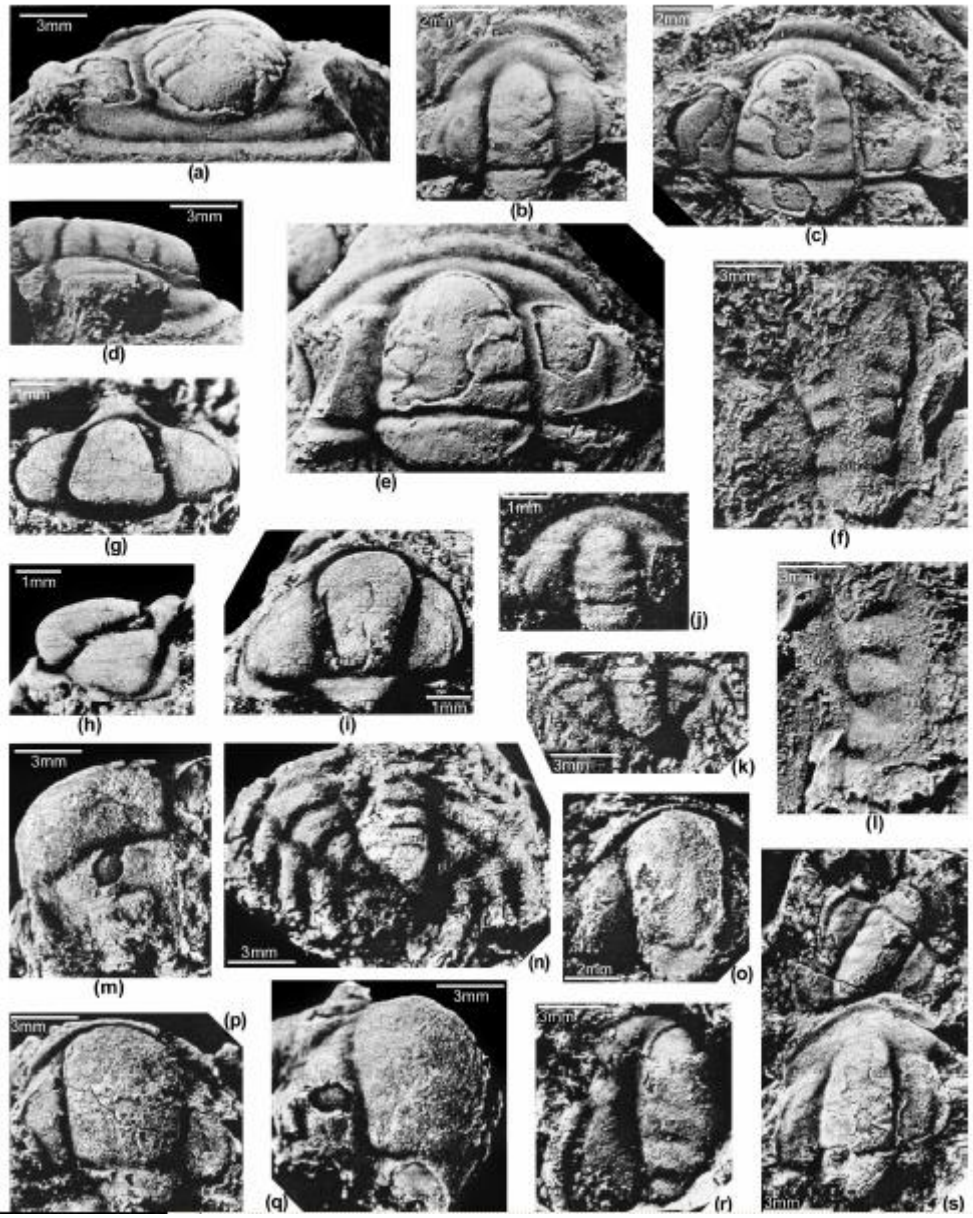

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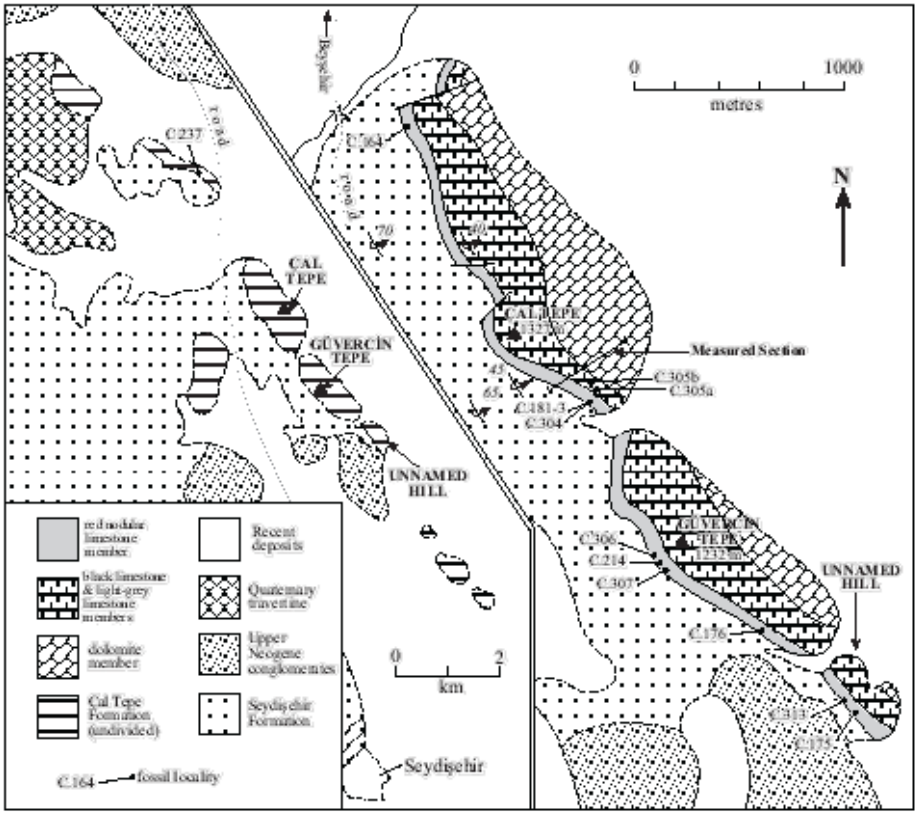

Figure 2. Geological map (after Monod *in* Dean & Monod 1970; Monod 1977) of the Çal Tepe and adjacent hills, 8 km north of Seydişehir.

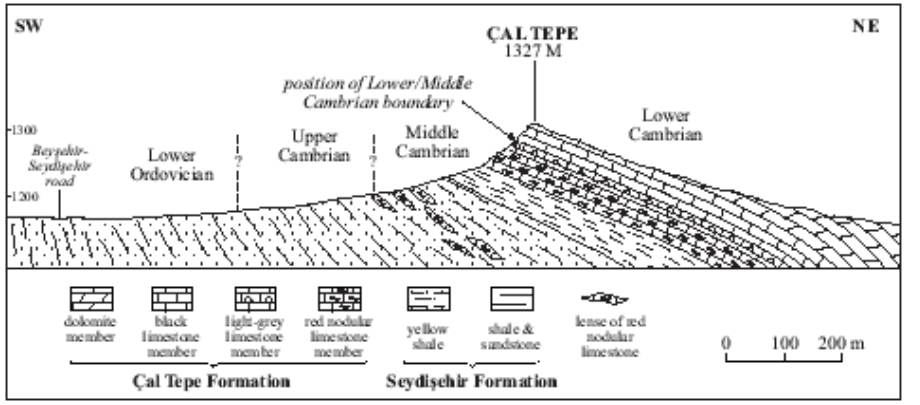

Figure 3. SW–NE cross-section through the inverted succession at the Çal Tepe (after Dean & Monod 1970, Figure 4; see also Monod 1977, and Monod *in* Gutnic *et al.* 1979, p. 49).