EVOLUTIONRY TRENDS IN TRILOBITA

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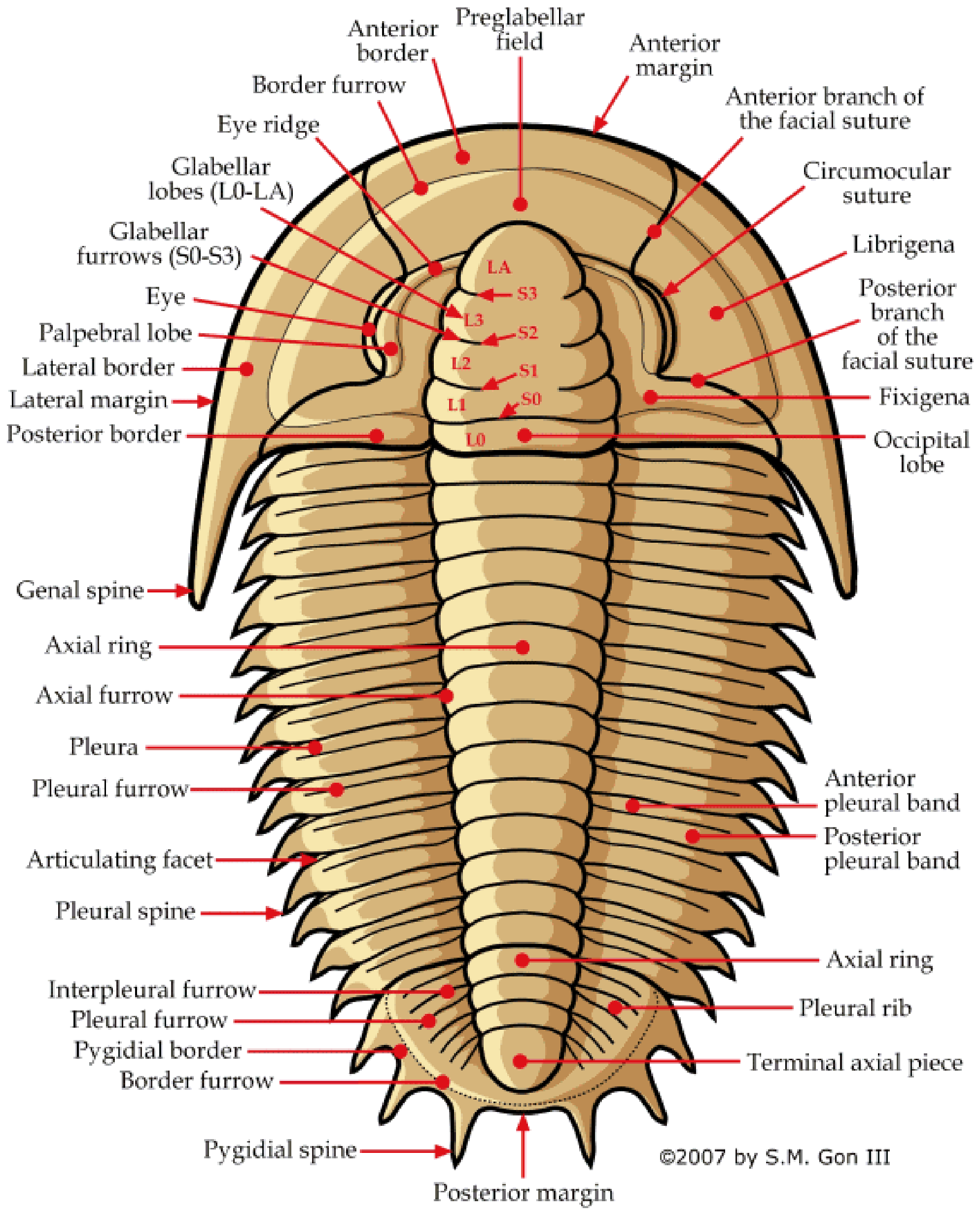
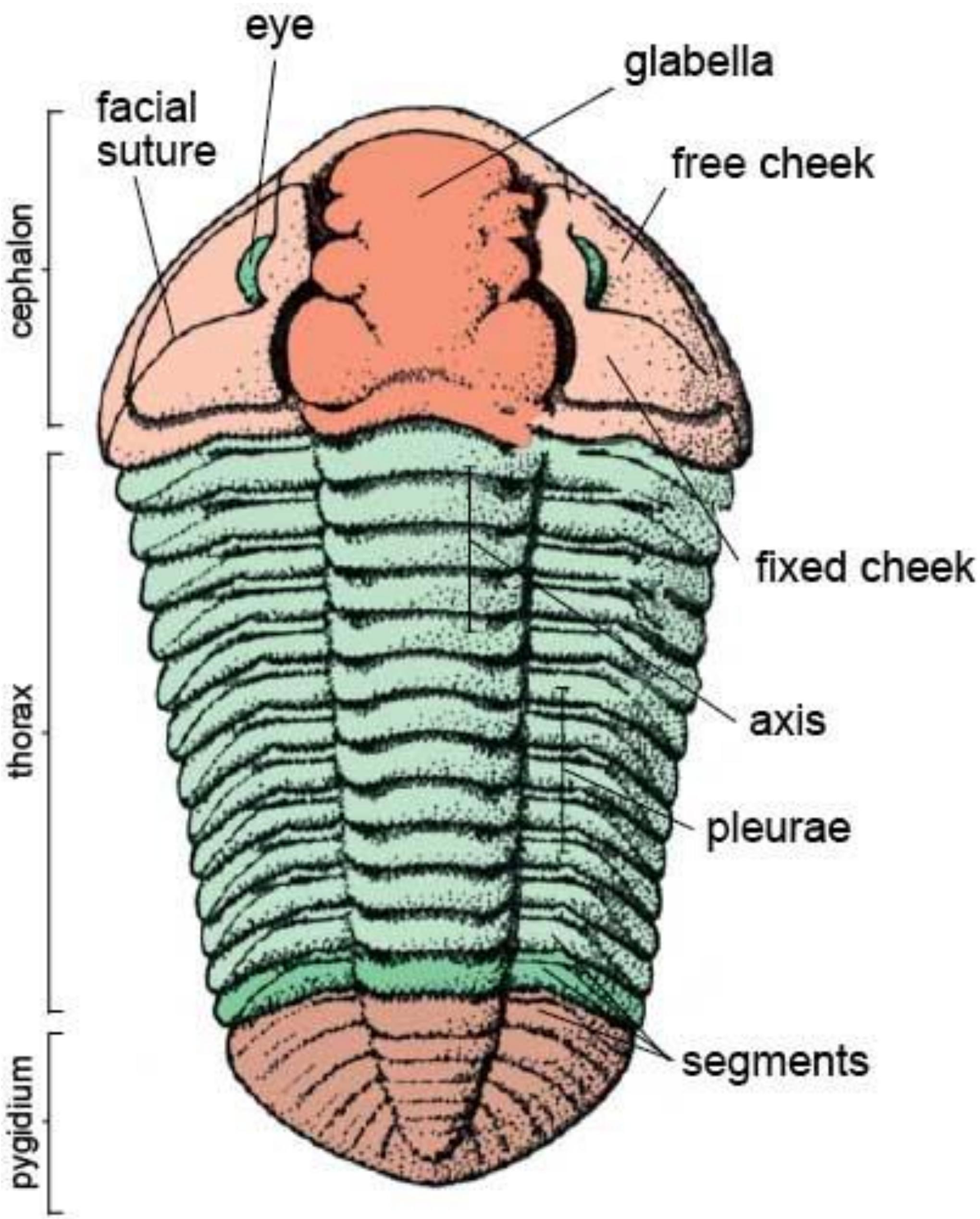


INTRODUCTION

- Trilobites are signature creatures of the Paleozoic Era, the first era to raise diversity of complex life forms.
- Trilobites were among the first of the arthropods, a phylum of hard-shelled creatures with multiple body segments and jointed legs that existed over 300 million years ago.
- The Trilobites are made up of nine orders, over 150 families, thousands of genera, and over 15,000 species.
- They were once one of the most successful of all animal groups and in certain fossil deposits, especially in the Cambrian, Ordovician, and Devonian periods, they were remarkably abundant.
- A prolonged decline then set in before they finally became extinct in the Permian Period, about 250 million years ago.
- They were exclusively marine but nurtured in all types of marine environments, and ranged in size from less than a centimeter to almost a meter.
- With such a diversity of species and sizes, the life styles of trilobites include planktonic, swimming, and crawling forms.
- They occupied a varied set of ecological roles, perhaps mostly as predators, detritivores, and scavengers.

MORPHOLOGY OF TRILOBITA



CEPHALON

- The head shield composed of fused segments containing a sensory organs such as eyes, antennae as well as the mouth and a special ventral plate called the hypostome, thought to function as a mouthpart.
- The central region of the cephalon is termed as Glabella.

THORAX

- Comprised of a number of separate segments, usually of similar shape and varying somewhat in size with the posterior edge of the cephalon and the anterior edge of the pygidium, allowing the trilobite to bend, primarily upward and downward, and in many species, allowing the animal to enroll as a protective behavior.
- Each segment of the thorax bears a central axial lobe between two symmetrical pleural lobes.

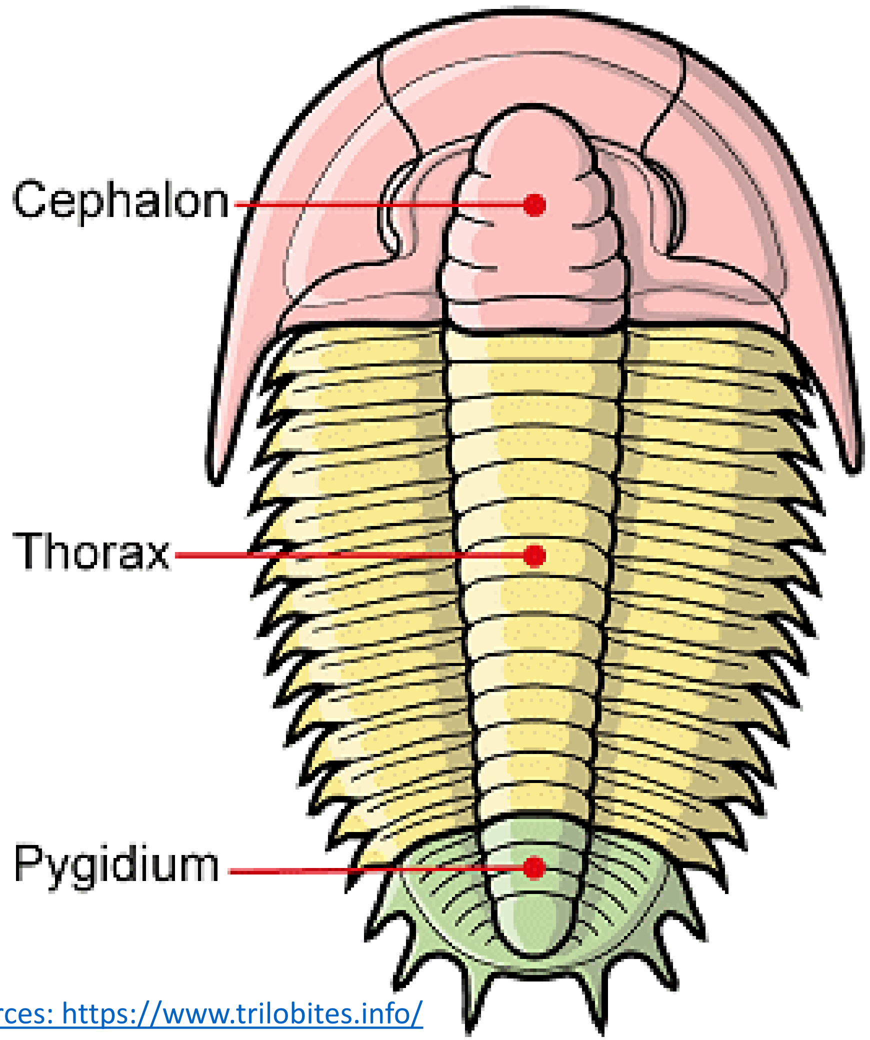
PYGIDIUM

- The tail section composed of a variable number of fused segments at the posterior end of a trilobite.
- Cephalon of a trilobite is normally wider than the thorax, but size can range from extremely small to larger than the cephalon.

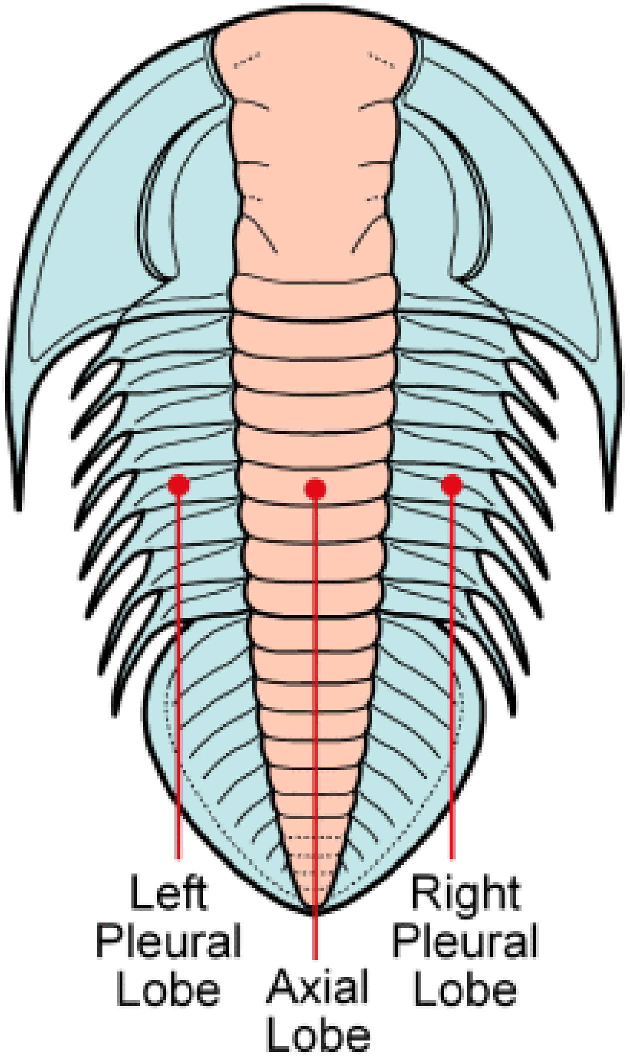
MORPHOLOGY OF TRILOBITA

- Trilobites are made up of three main body parts. It is separated from anterior to posterior into a Cephalon(head-shield), Thorax, and a tail-shield Pygidium(tail-shield).
- The cephalon, thorax and pygidium are all divided into segments.
- The segments of the cephalon and pygidium were fused, but those of the thorax were not, enabling the animal to roll into a ball to protect its relatively exposed ventral side in times of danger.
- The cheeks on either side of the glabella are usually separated from the rest of the cephalon by a facial suture into fixed cheeks and free cheeks on the outer edge of the cephalon.
- Some trilobites have spines originating at the genal angle, they are called genal spines.
- The soft parts of the trilobite animal were covered by an exoskeleton.
- The dorsal surface consisted of a hard, mineralized protective shield called a carapace; it is this part of exoskeleton, that is most commonly preserved as fossil record.
- The Ventral(lower) surface bore a pair of antennae and numerous pairs of jointed appendages that served as walking, swimming, feeding, and respiratory organs.
- The ventral surface, however, consisted of relatively soft tissue and rarely preserve.

TRANSVERSE AND LONGITUDINAL DIVISIONS OF BODY

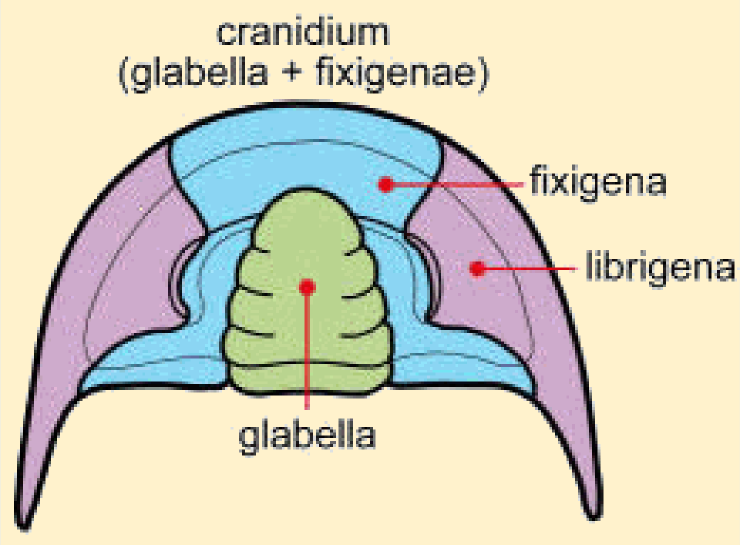


Sources: https://www.trilobites.info/

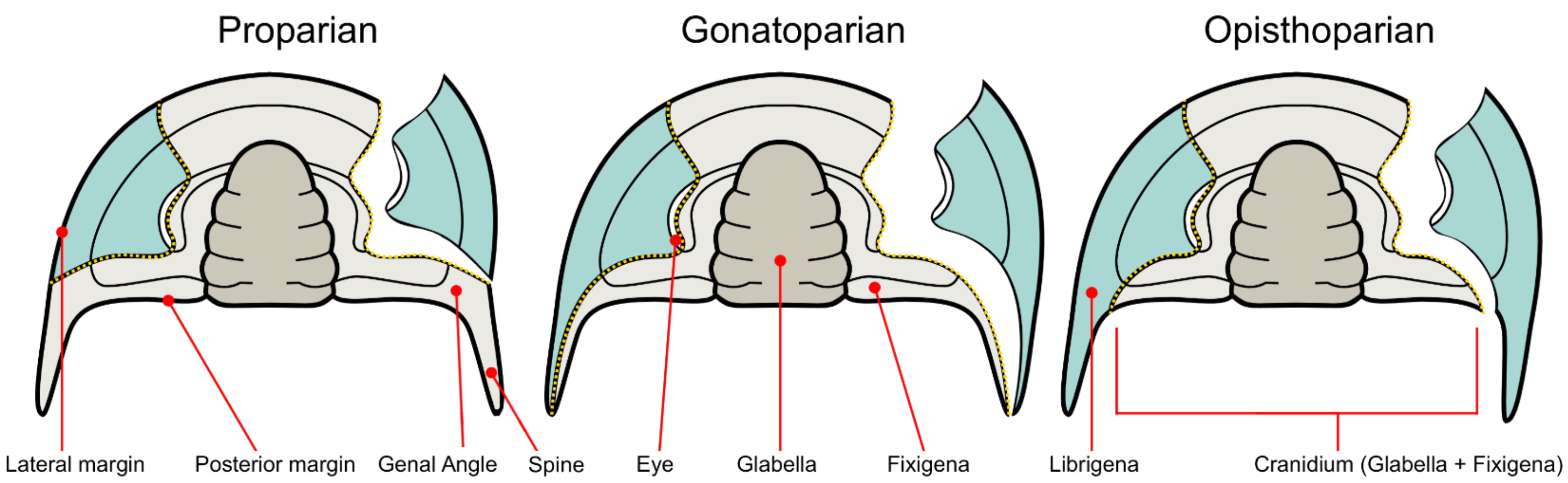


- The word 'trilobite' (three lobes) refers to the side-to-side partition, not the division into head, thorax and tail.
- The body of trilobite was dorso-ventrally flattened and two longitudinal lines divided the body into three lobes; axial part in the middle and two pleural parts on the sides.

CEPHALON AND TYPES OF FACIAL SUTURE

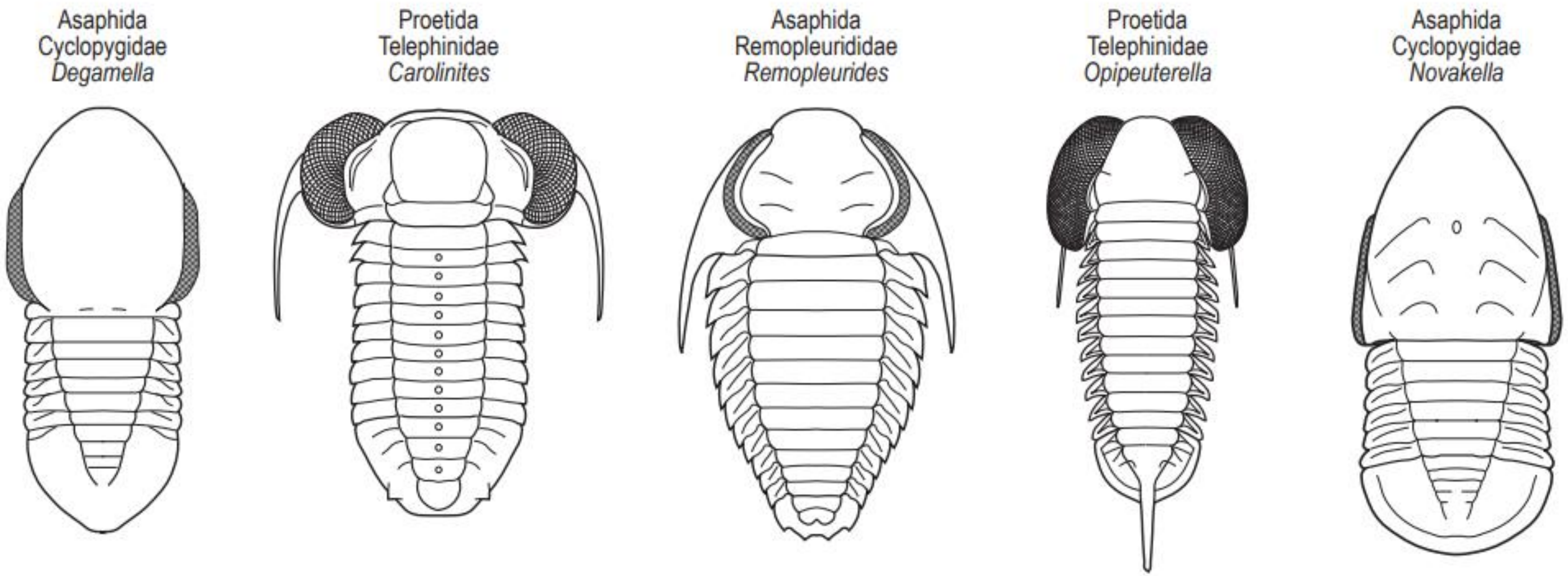


- GLABELLA: Axial portion of the cephalon is called the glabella.
- CHEEKS: Pleural lobes on each side of the glabella.
- LIBRIGENAE: Free cheeks often separate along the facial sutures
- CRANIDIUM: Combined glabella and fixigenae or "fixed cheeks“.



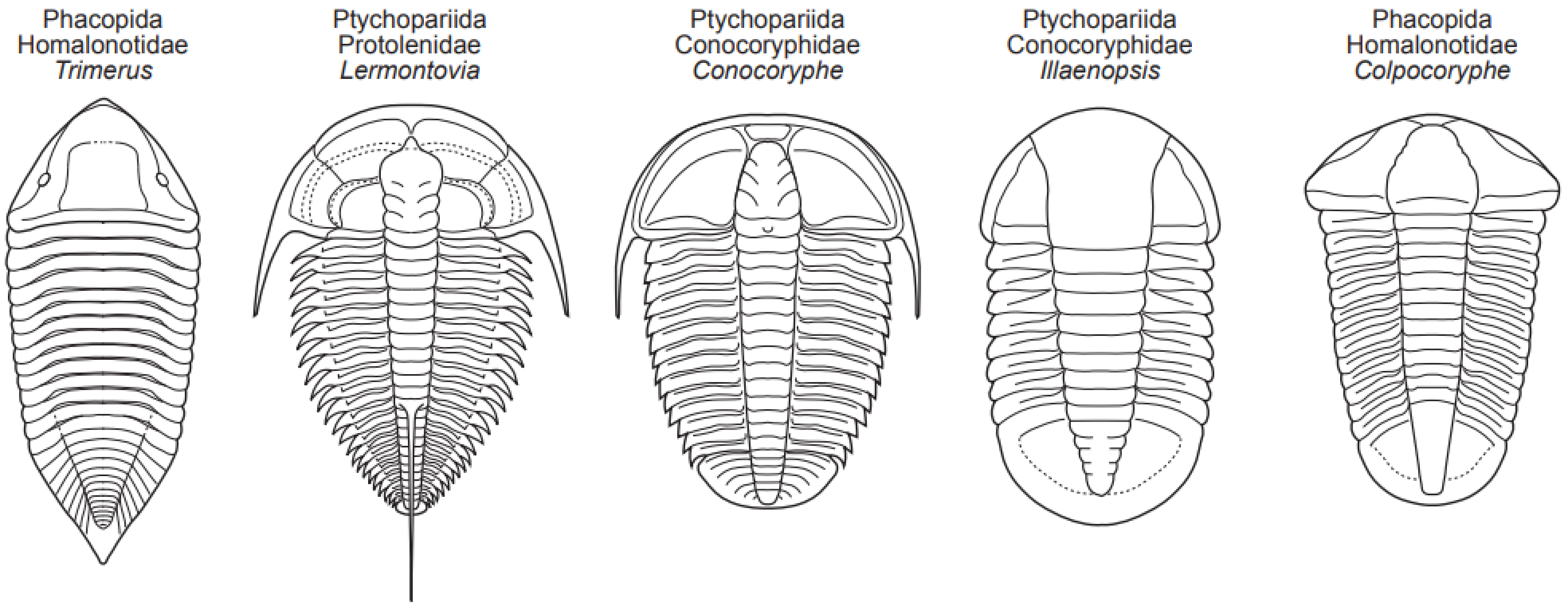
- Facial sutures normally run from somewhere along the anterior edge of the cephalon to the anterior edge of the eye, then around the edge of the eye, continuing from there to end at either the side or rear of the cephalon.
- The facial sutures determine the boundary between the cranidium (cephalon and fixed cheeks) and the librigena (free cheeks).

PELAGIC MORPHOLOGY



- There are a number of trilobites that have developed extremely large eyes and elongate, streamlined body shape associated with swimming in the photic water column.
- The paleogeography of some of these pelagic species suggests that their swimming abilities were good enough to spread in global oceanic distribution.

ATHELOPTIC MORPHOLOGY

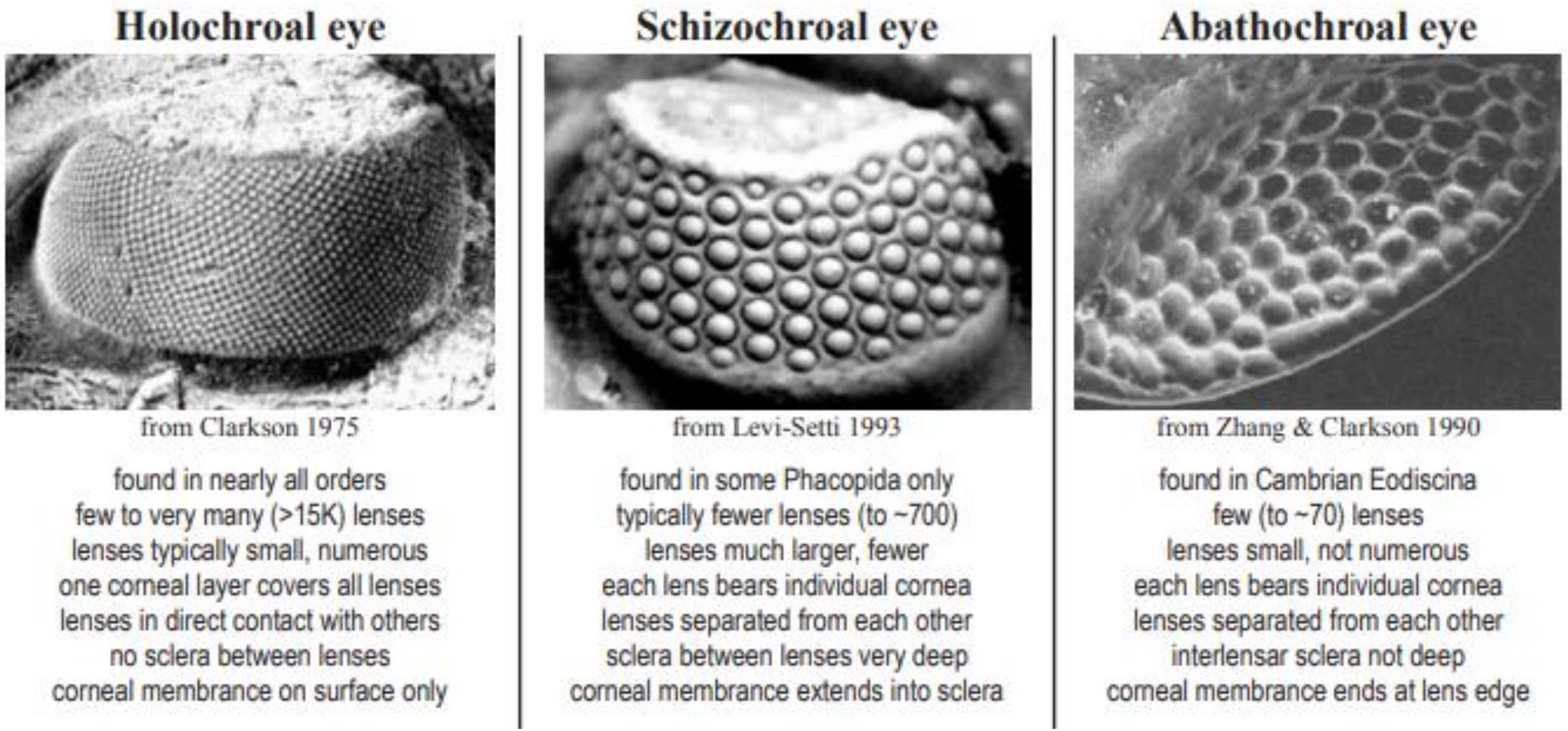


- Secondary reduction and loss of eyes is thought to be a trend among benthic species living in deep, poorly-lit or aphotic habitats.
- In these deep water biotopes, blind or nearly-blind trilobites are the dominant element.
- It is interesting to note that another trend of deep bottom habitat adaptation is an increase in the number of thoracic segments.

EYES OF TRILOBITA

- Eyes were positioned on the inner edge of the free cheek, adjacent to the fixed cheek.
- Trilobites had compound eyes, consisting of a number of separate lenses, number of lenses and the complexity of the eye structure varied widely.
- Some trilobites had large, convex compound eyes with a large number of lenses, giving them a wide field of view.
- Other trilobites had much smaller eyes, with fewer lenses, giving them a more limited view.
- Many trilobite eyes consisted simply of closely packed prisms of calcite, but in some later forms, such as Silurian-Devonian genus *Phacops*, the eyes had more complex lenses.
- *Phacops* may have been able to see an object clearly, and even estimate how far away it was.
- Most trilobites had eyes, although blind forms were also in existence.
- Blind trilobites may have burrowed and scavenged in mud on the sea-floor, or lived at great depth in the sea where there was no light.

TYPES OF EYES



- There are three acknowledged types of trilobite eyes: holochroal, schizochroal, and abathochroal.
- The first two are the major types, with the great majority of trilobites bearing holochroal eyes, and the distinctive schizochroal eye.

TRILOBITES ECOLOGY

Fossil Evidence	**Interpretation**	**Inferred Lifestyle or Behavior**
Reduced thorax and pygidium; smooth cephalon; downward projecting spines; occurs in many types of rocks	Light, streamlined body allows fast swimming. Spines prohibit effective movement on the sediment surface. Distribution controlled by water column characteristics rather than sediment characteristics.	Pelagic Lifestyle/Swimming
Smooth exterior, broad & flat axial lobe Larger muscle attachments	Reduce friction Stronger limb motions to move sediments	Burrowing
Eyes reduced or absent Whip-like pygidium Wide bodies, genal spines	Darker conditions, less need for keen eyesight, able to swim Added support for soupy substrate	Living in Deep Water
Well developed limbs, flexible hypostome, trilobite feeding traces, called *Cruziana*	Food passed anteriorly towards the mouth during the course of movement, flexible hypostome used as a scoop.	Particle Feeding
Unusual occipital angle, pitted fringe	Pits allow water to flow through cephalon from leg-generated currents	Filter Feeding
Rigid hypostome; hypostome with forked projections	Ability to process relatively large food particles	Predatory, feeding on soft bodied worms

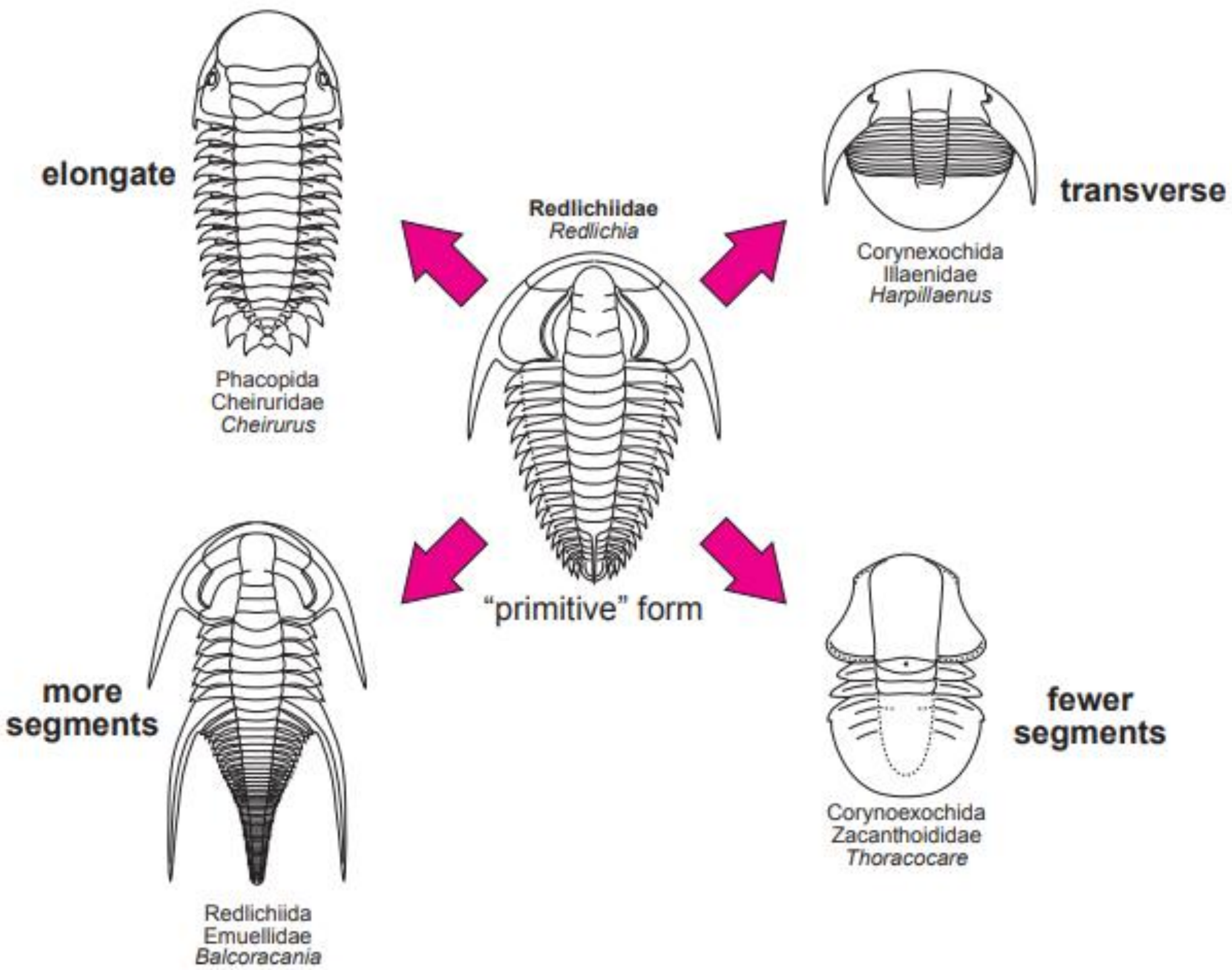
Sources: http://phylo.bio.ku.edu/fossil

PRINCIPAL EVOLUTIONARY TRENDS IN TRILOBITA

The abundant variety of body shapes and sizes indicate that trilobites occupied a variety of ecological niches. The principal evolutionary trends from primitive morphologies include the origin of several morphologies appeared independently within different major taxa.

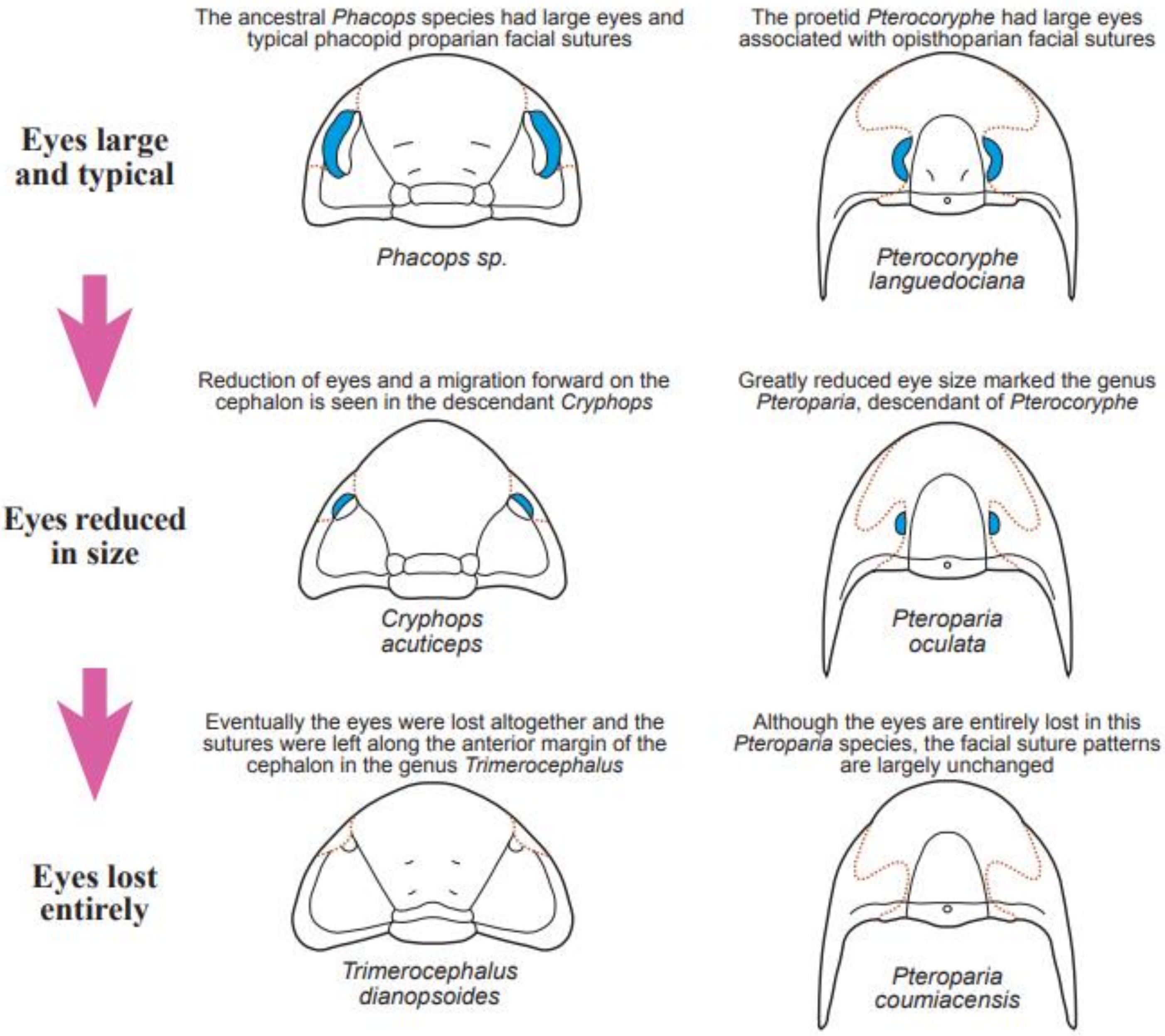
- Changes in the cephalon, variable size and shape of Glabella.
- Eye size reduction or miniaturization, variation in eyes types, position of eyes and facial sutures.
- Narrowing of the thorax, increasing or decreasing numbers of thoracic segments.
- Streamlined body shape.
- Increased size of pygidium, micropygous to macropygous.
- Extreme spinosity development in certain groups.
- Improvement in enrollment and articulation mechanisms.
- Hypostome specialization.
- Effacement, the loss of surface detail in the cephalon, pygidium, or the thoracic furrows, is also a common evolutionary trend.

EVOLUTIONARY TRENDS IN TRILOBITA



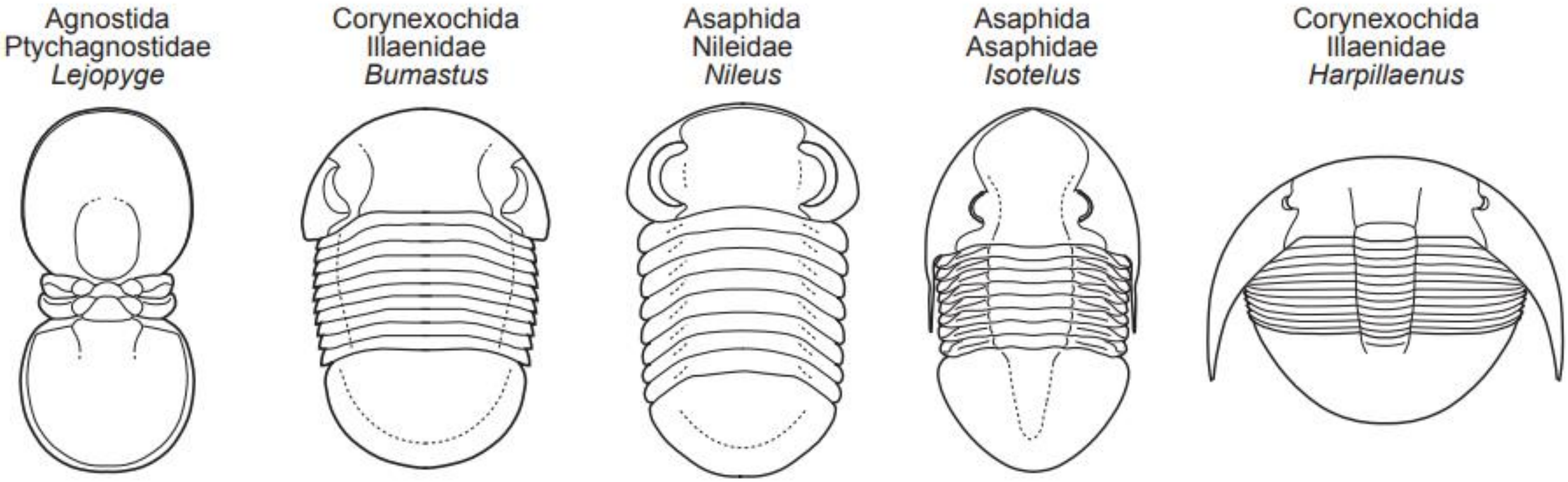
- Trilobites existed for almost 300 million years, there were many opportunities for diversification of morphology, starting from the primitive morphology such as Redlichia (shown in figure at center).
- This primitive morphotype had a small pygidium, well developed eye ridges, lobed glabella, several thoracic segments, and a rather flattened body form.
- Thoracic segments were reduced to as few as two or increased to over 60.
- Body shape was greatly elongated in some species, or transverse (widened) in others.
- Shapes and furrow patterns of the glabella, shape and placement of eyes and eye ridges also ranged widely.

EVOLUTIONARY LOSS OF EYES



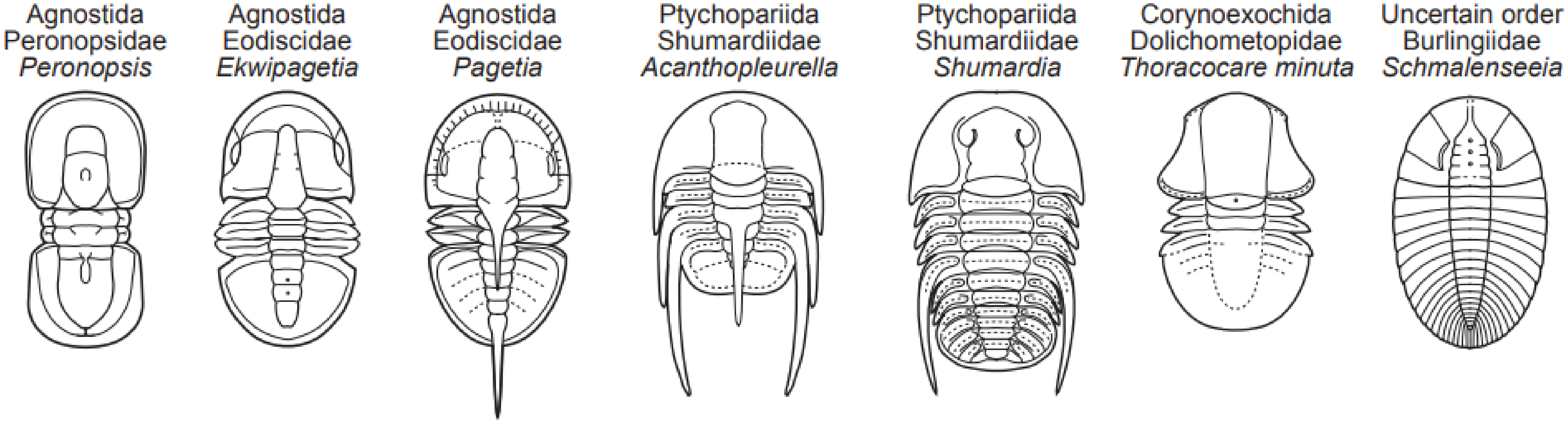
- Trilobites of deep-water benthic habitats where light was dim or lacking might have gradually lost their eyes, blind or nearly-blind trilobites were the dominant.
- Such eyeless trilobite assemblages are called Atheloptic.
- Devonian trilobites (in the figures) that started with ancestors bearing large, functional eyes.
- Eyes of a Phacopid clade were lost, and facial sutures associated with eyes were also reduced and marginalized.
- Proetid clade, eyes were also reduced and lost, but the basic facial suture pattern was retained. In the figures (after Fortey & Owens 1999), the eyes are shown in dark and the facial sutures as dashed lines.

EFFACEMENT: THE LOSS OF SURFACE DETAILS



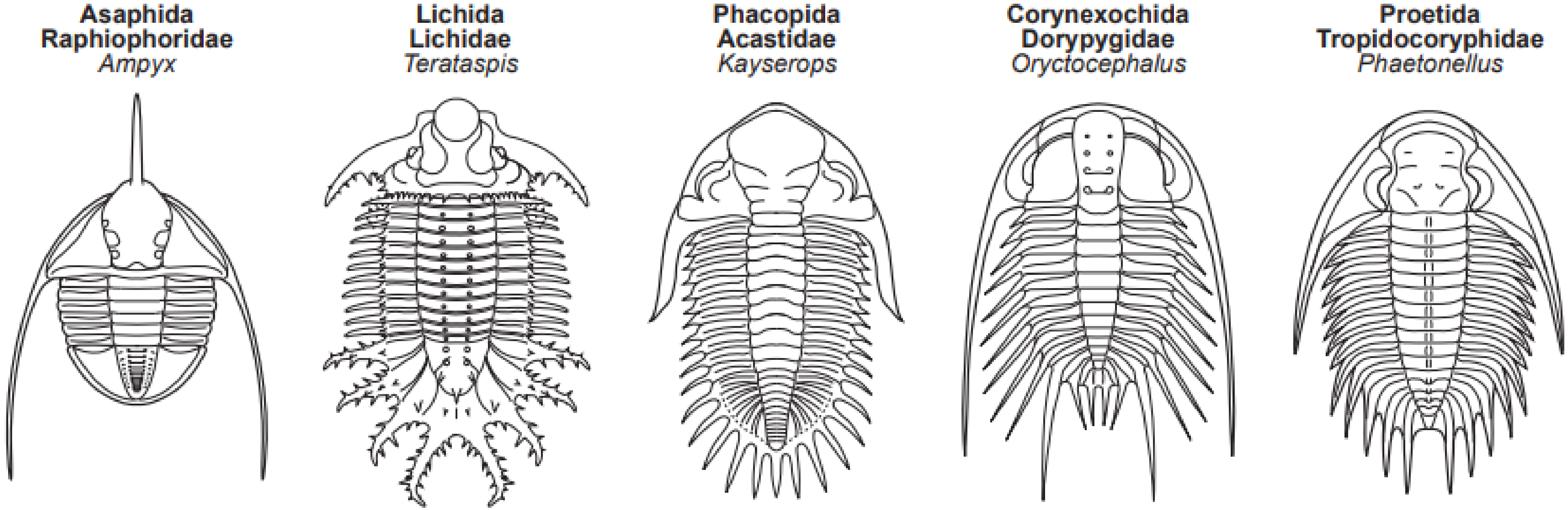
- In several trilobite orders, effacement of cephalic, pygidial, and even thoracic furrows is common.
- Effacement is an adaptation related to a burrowing lifestyle, but such effacement might also play a role in streamlining of pelagic.
- Effacement poses a problem for taxonomists since the loss of details (particularly of the glabella) can make the determination of phylogenetic relationships difficult.

MINIATURIZATION



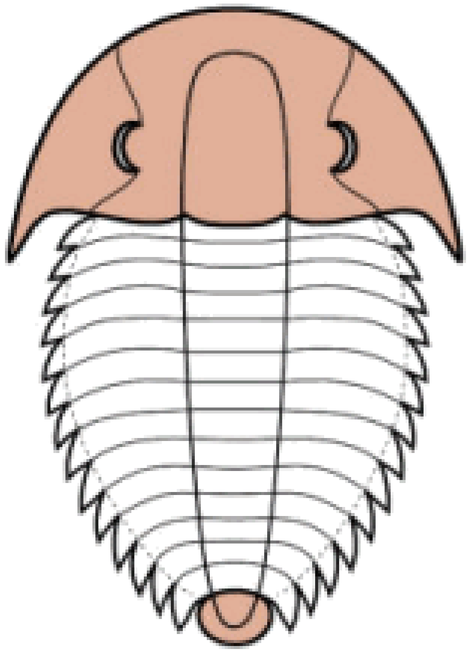
- Reduction in size is seen in several trilobite species.
- Numerous microhabitats of complex marine systems, and the correlation of size with rapid maturity are causes suggested for evolution of small sizes.
- When this reduction is due to progenesis (arrested development) the trilobites may also display a reduction in the number of thoracic segments.

SPINOSITY

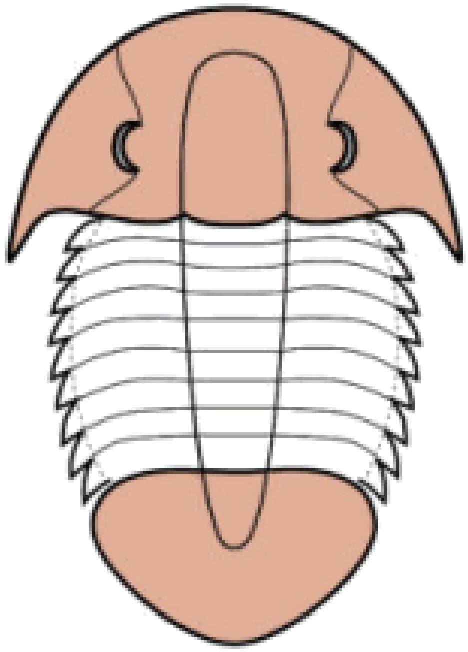


- Increase in spinosity is observed in a wide variety of trilobite species.
- The development of spines is normally considered as defensive adaptation.
- Spinosity as a stabilization structures on a loose silty and flotation or slow swimming also included as evolutionary hypothesis.
- Spines may originate from any part of the exoskeleton, particularly the margins.

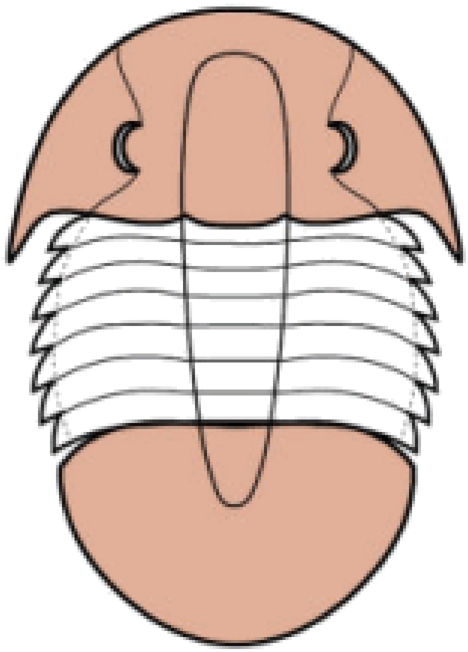
RELATIVE SIZES BETWEEN CEPHALON AND PYGIDIUM



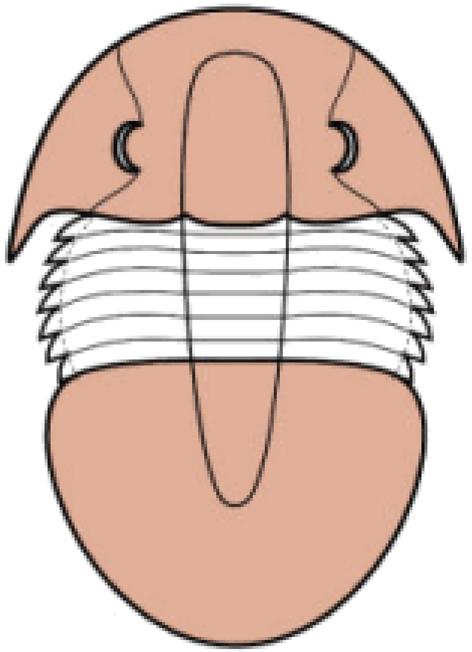
MICROPYGOUS
{Pygidium far more
smaller than Cephalon}



SUBISOPYGOUS
{Pygidium subequal
to Cephalon}

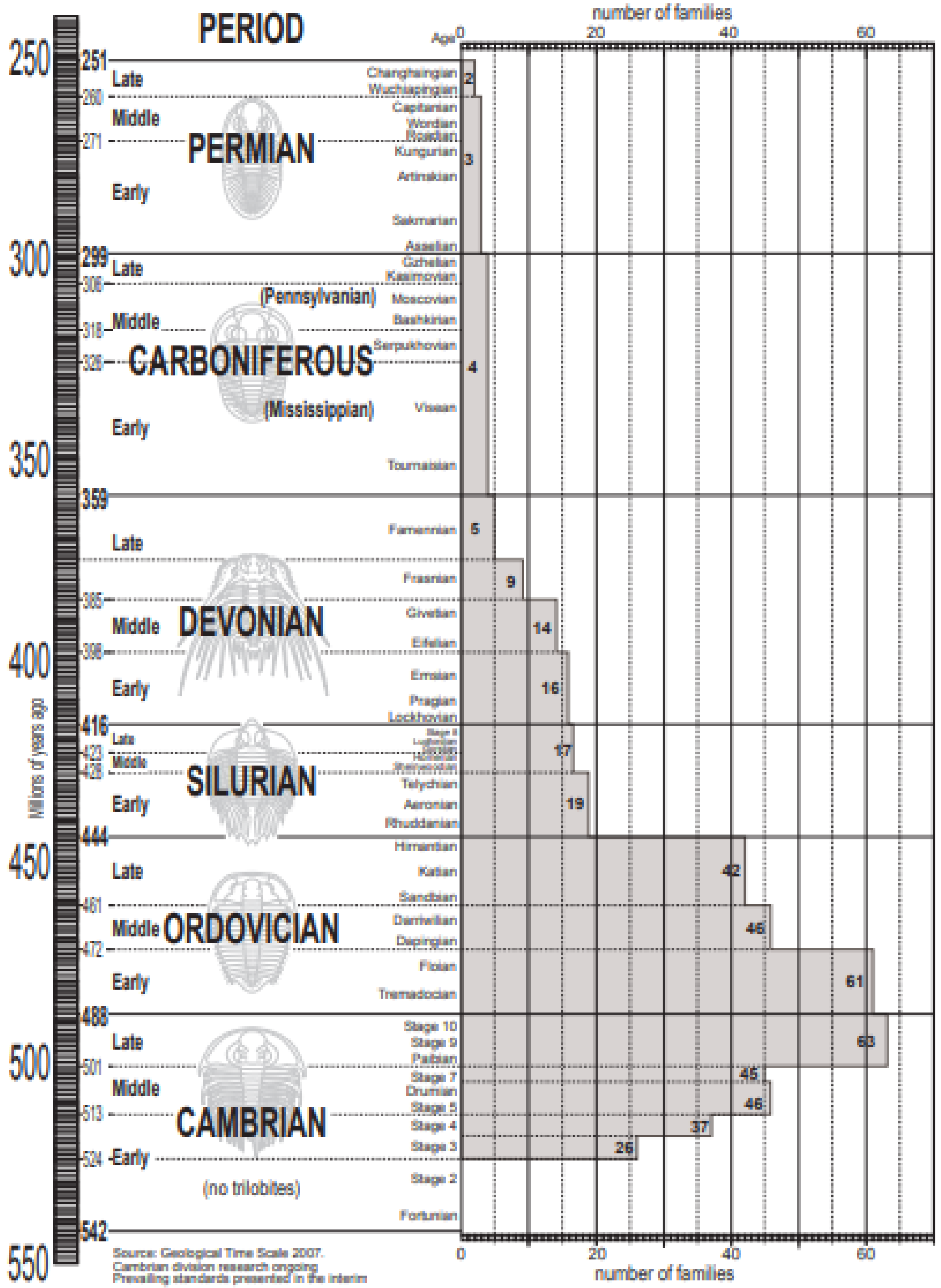


ISOPYGOUS
{Pygidium equal
to Cephalon}



MACROPYGOUS
{Pygidium larger
than Cephalon}

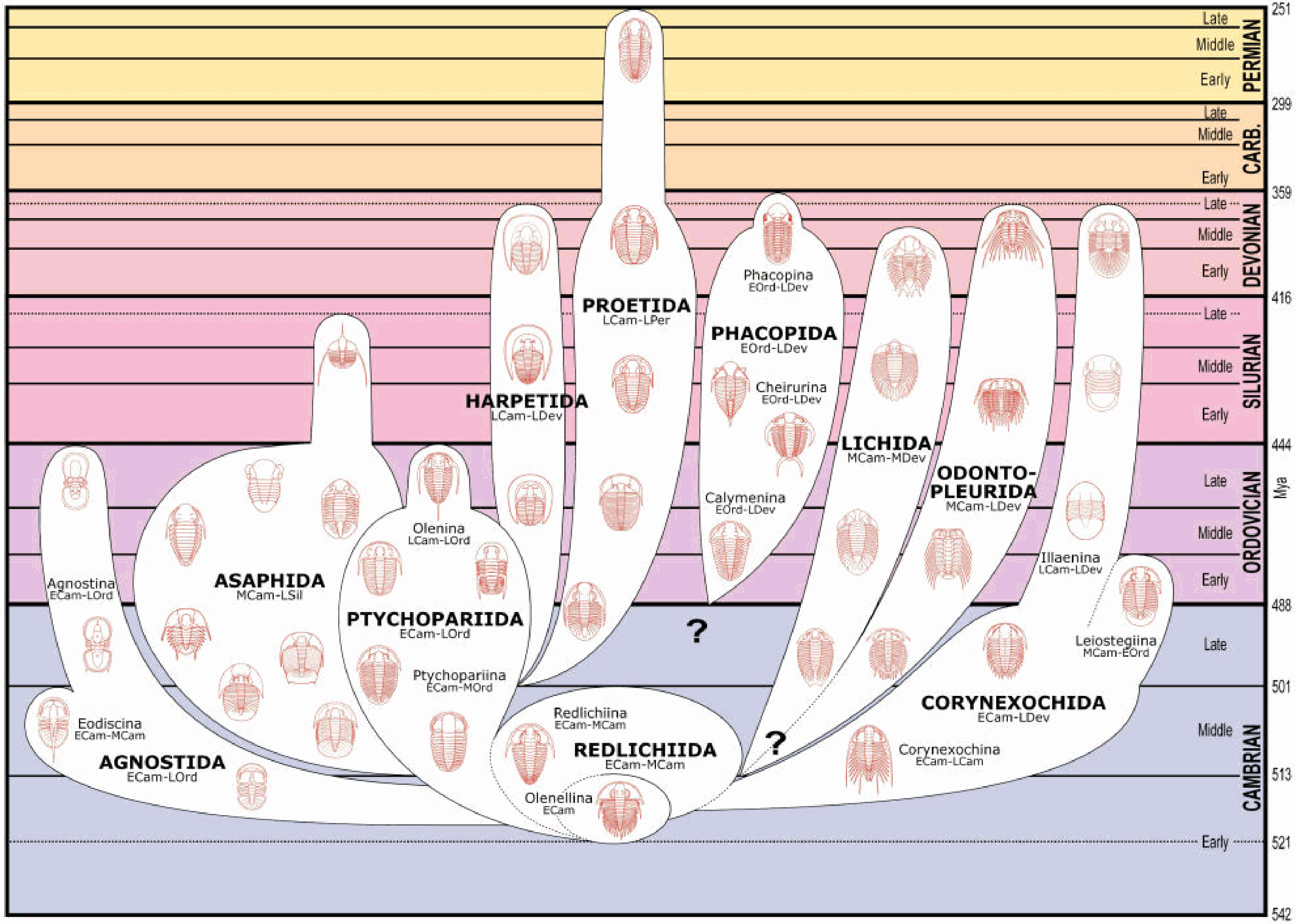
- There are four general categories of pygidium relative size, shown above.
- Pygidium can range from extremely small to larger than the cephalon.
- Cephalon of a trilobite is normally wider than the thorax.



FAMILY DIVERSITY OVER THE PALEOZOIC ERA

- Trilobites are one of the signature organism of the Paleozoic Era, appearing in the early Cambrian.
- Their peak diversity was in the early Paleozoic, and they began a general decline in the upper Paleozoic, despite bursts of adaptive radiations in the Ordovician, Silurian, and Devonian periods.
- The greatest numbers of trilobite species occurred during the Cambrian and Ordovician periods.
- Toward the end of the Devonian most of the families and orders of trilobites were gone.
- There were much fewer species in the lone surviving, order Proetida in the carboniferous and Permian periods.
- By that time, they had dwindled to two families (Proetidae and Brachymetopidae, both in the order Proetida) and had long ceased to be a prominent feature of the marine biota.
- Trilobites ended with the mass extinction event of Permian end period.
- They have persisted for nearly 300 million years is a testimony to the successful design and adaptability of trilobites.
- The chart indicates changes in the diversity of the Trilobita over the periods of the Paleozoic Era, based on figure in the *Treatise of Invertebrate Paleontology(1997)* modified.

ORDERS AND THEIR RELATIONSHIP THROUGH THE GEOLOGIC TIME



- The chart above gives an indication of the relationships of the trilobite orders, and their extent over geological time.
- The Cambrian origin and proliferation of trilobites is very apparent, as well as the loss of the orders Agnostida, Ptychopariida, and Asaphida in the Ordovician,
- The loss of the majority of remaining orders in the late Devonian, and the final extinction of the class in the Permian.
- The Ordovician extinction event is particularly apparent.

GEOLOGICAL SIGNIFICANCES OF TRILOBITA

- Geologists use trilobites to understand Biosratigraphy, Paleogeography, Palaeoecology, and Palaeotectonics, of Palaeozoic era.
- Palaeobathymetry, marine palaeoenvironmental analysis to reconstruct the global ocean-continent distribution and the positions of palaeoshorelines of lower Palaeozoic era.
- Relative dating and stratigraphical correlation of sedimentary rock successions, especially in rock formations of Cambrian and early Ordovician age.
- *Paradoxides*, for example, occurs in rocks in England, Newfoundland, Sweden, Spain and Siberia, and shows that these rocks are all of the same, Middle Cambrian age.
- Other stratigraphically useful trilobites include species of *Merlinia* in the lower Ordovician and *Calymene* in the Silurian.

REFERENCES AND FOR THE FURTHER STUDY

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