

# Insect Evolution



Fossil photographs with permission by David Kohls. Accessed online Sept 2009. <http://paleobiology.si.edu/greenRiver/insectPhotos.html>

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# Objectives

- Describe the four successive stages of insect evolution.
- Define ametabolous, hemimetabolous and holometabolous, and the similar terms regarding wing development.
- Describe the theories of insect wing evolution.



Newly molted Odonate alongside its larval skin.

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# Introduction



Beetle fossil



Hemipteran fossil

You may wonder, "What kinds of fossils could entomologists find that might show them how insects gradually evolved?"  
Also, "How can insect fossils be found? Insects are so tiny!"

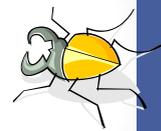
Believe it or not, there are insect fossils-- quite a few of them.

<http://paleobiology.si.edu/greenRiver/insectPhotos.html>  
(Click to view slide show of fossil insects.)

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# Fossil Record

ERA	PERIOD	APPROXIMATE TIME BOUNDARIES	LIFE FORMS ORIGINATING
MESOZOIC		136,000,000	Primates - Flowering Plants
		195,000,000	Birds
		225,000,000	Dinosaurs-Mammals
PALEOZOIC	CARBONIFEROUS	280,000,000	Reptiles
		320,000,000	Fern Forests
		345,000,000	Vascular Land Plants
		395,000,000	Amphibians - Insects
		430,000,000	Fish - Cordates
		500,000,000	Shellfish - Trilobites
		570,000,000	



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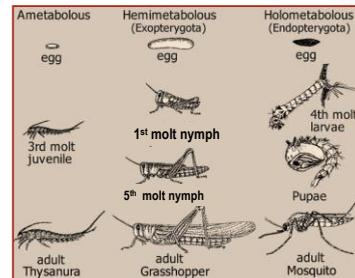
# Fossil Record

ERA	PERIOD	APPROXIMATE TIME BOUNDARIES	LIFE FORMS ORIGINATING
CENOZOIC	QUATERNARY	10,000	Human Beings
		2,500,000	
	TERTIARY	12,000,000	
		26,000,000	Grazing and Carnivorous Mammals
MESOZOIC		136,000,000	Primates - Flowering Plants
		195,000,000	Birds
		225,000,000	Dinosaurs-Mammals
PALEOZOIC	CARBONIFEROUS	280,000,000	Reptiles
		320,000,000	Fern Forests
		345,000,000	Vascular Land Plants
		395,000,000	Amphibians - Insects
		430,000,000	Fish - Cordates
		500,000,000	Shellfish - Trilobites
		570,000,000	
PRECAMBRIAN		700,000,000	
		1,500,000,000	
		3,500,000,000	
		4,850,000,000	
			Formation of Earth

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# Metamorphosis Terms

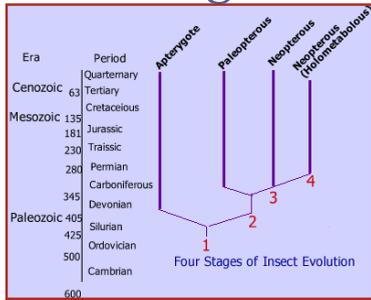
- Metamorphosis**
1. ametabolous
  2. hemimetabolous
  3. holometabolous



(modified from Etzinga, 2000, pg. 117)

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# Evolution Stages



(Modified from Elzinga, 1997, pgs. 334-335)

The thick lines of the tree represent actual fossils that have been found while the thin lines represent gradual changes in insects that have yet to be found in the fossil record.

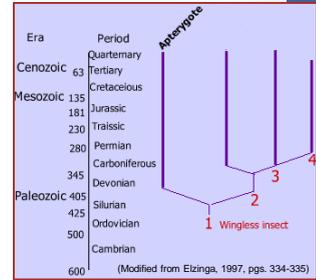
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# Apterygote

The first stage of insect evolution is referred to as the **apterygote stage**. This term when broken down means "without wings" (a- means without, - ptery means wings).



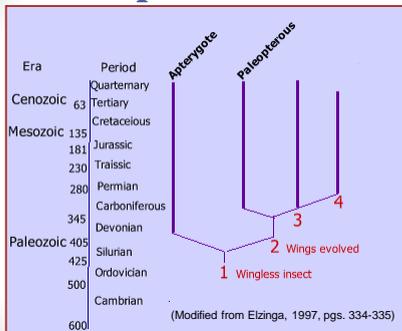
Silverfish



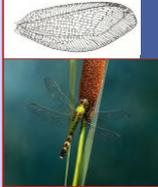
(Modified from Elzinga, 1997, pgs. 334-335)

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# Paleopterus



(Modified from Elzinga, 1997, pgs. 334-335)



*Paleo* means "ancient or old" and the root word *ptery-* means "winged."

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# Paleopterus

Wing advantages:

- disperse greater distances
- locate isolated food sources
- find mates more easily
- avoid predators more effectively



Damselfly



Mayfly

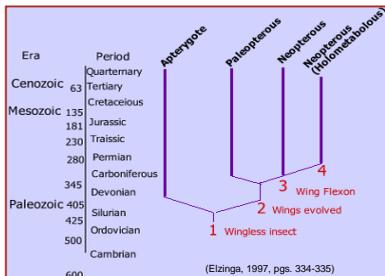


Dragonfly

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*Paleoptera* refers to "old wing" from *paleo-* (old) and *-ptera* (wing).

# Neopterus



(Elzinga, 1997, pgs. 334-335)



The new wing had a **flexion**, or the ability to bend at the base.

**Neopterus stage** meaning "new wing" from *neo-* (new) and *-pterus* (wing).

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# Examples of Neopterus Wings



Crickets

Cockroaches

Earwigs



Grasshoppers



Thrips

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# Flexon Advantages

Think about this question for a minute.

Why do you think a wing flexon is advantageous over a paleopterous wing that can only be held straight out or straight back? Do you think it is because:

- a) Insects with a wing flexon could now spray a pheromone that kept predators away.
- b) Insects with a wing flexon could now crawl into crevices or under rocks to hide from predators.
- c) The flexon now let them flap their wings quicker to attract more mates.

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# Flexon Advantages (Answer)

The answer is "b) Insects with a wing flexon could now crawl into crevices or under rocks to hide from predators."



Dragonfly with paleopterous wings.



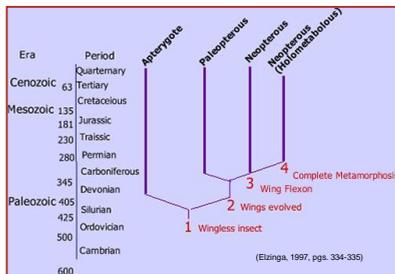
Grasshopper with flexon folded wings.



Squash bug with flexon folded wings.

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# Complete Metamorphosis

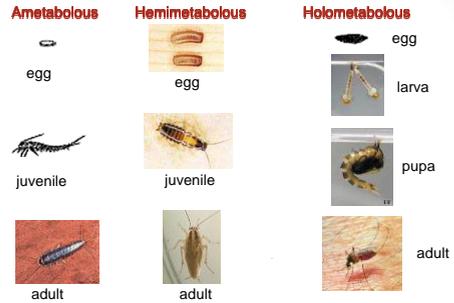


Neopterous + Holometabolous insects: wasps, bees, flies, beetles, fleas, moths, and butterflies.



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# Thought Question:



Why do you think it was advantageous for an insect to have holometabolous development over hemimetabolous or ametabolous development?

*Stop for a moment and jot down some of your thoughts.*

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# Development Advantages

Do you think it is because:

- a) those with holometabolous development won't have to go through as many molts to get to the adult?
- b) holometabolous insects can attract more mates, thus increasing the genetic diversity within their population?
- c) holometabolous insects can be more successful because the larval form can be more specialized?
- d) holometabolous insects will develop quicker?



Kohls

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# Development Advantages (Answer)



adult



caterpillar = larva

The answer is: c) Holometabolous - insects can be more successful because the larval form can be more specialized.



egg



larva



pupa



adult

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## Development Review

**Holometabolous Larvae:**  
specialized for eating and growing

**Holometabolous Adult:**  
specialized for reproduction.

**Hemimetabolous insect body:**  
not specialized



Holometabolous: beetle adult and grub (larva)



Holometabolous: fly eggs (left), maggot (larva), pupa (right), and adult male and female



Hemimetabolous: cockroach egg case, nymphs, and winged adult

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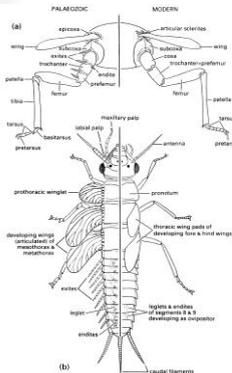
## Insect Flight

- Apomorphy - n. a derived state (apomorphic - adj.)
- Plesiomorphy - n. an ancestral state (plesiomorphic - adj.)
- Synapomorphy - n. shared derived state
- Sympleisiomorphy - n. shared ancestral state
- Homeoplasy - n. a character that is shared by multiple species due to a cause other than common ancestry.



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## Wing Evolution/Adaptation



Set aside some time to read through the articles associated with this lecture. You will be presented with different theories and hypotheses on how insect wings first developed.

While reading, write down or highlight points that will help you in the assignment for this unit.

Gullen and Cranston, 2005 p 210, Fig. 8.4. Appendages of hypothetical primitive Paleozoic and modern pterygotes. (a) thoracic segment of adult showing generalized condition of appendages (b) dorsal view of nymphal morphology

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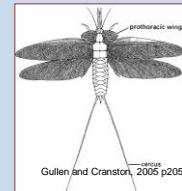
## Wing Development

Some questions to address as you read are:

Where did wings originate?

What adaptive functions could small, proto-wings serve?

- Main hypotheses for wing origins
- Paranotal-lobe hypothesis
  - Exite-entite hypothesis
  - Tracheal gill hypothesis



Gullen and Cranston, 2005 p205

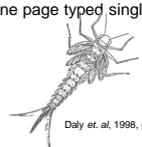
Wings evidently evolved only once; there weren't various groups of insects that developed wings at separate times. We know this because the place where the wings attach to the body, called **articulatory sclerites**, are similar among all the winged insects.

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## Assignment - Wing Evolution Project

Now that you have studied the various theories and hypotheses regarding the origin of insect wings, you are to discuss which theory seems the most valid to you.

In your discussion please compare the different theories with one another and justify why the theory you chose seems to be the most valid. Be sure to give support for your chosen hypothesis and list the problems with that theory. This assignment should be between 1/2 and one page typed single space.



Daly et. al, 1998, pg. 311



Daly et. al, 1998, pg. 311

Post your assignment as "wing evolution/adaptation".

*NOTE: See your syllabus for details about your journal entries.*

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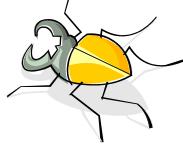
Learning Game Placeholder

Learning Game: Choices

Title: U2 Review Quiz

## Conclusion

We have discussed insect metamorphosis, the stages of insect evolution, and wing adaptations. Be sure to review all of the unit objectives and complete your journal entry. This concludes unit 2.



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