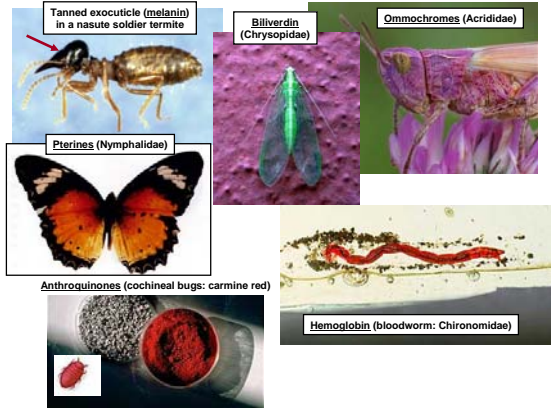
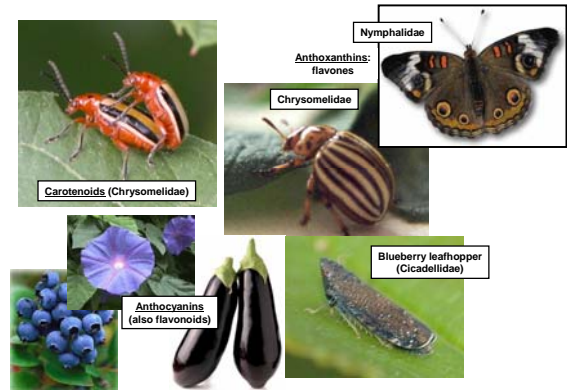


**Pigment colors I: Metabolic by-products**



**Pigment colors II: from food**



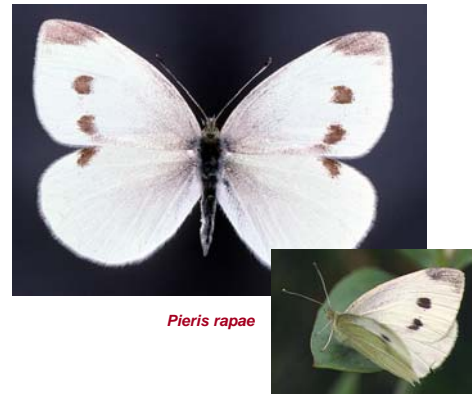
**Physical colors IA: Interference from a diffraction grating**

...dominated by Coleoptera

Family	Location of grating on body	Grating microstructure	Spectral reflectance
Tenebrionidae Psephenus	Abdominal striae		
Cerambycidae Cerambyx	Elytra		
Scaphisoma Scaphisoma	Elytra		
Cerambycidae Stenomacrus	Elytra		
Phalacridae Loricaria	Elytra		
Staphylinidae Loricaria	Abdominal tergite protrusion		
Hydrophilidae Sphenodesmus	Elytral apex		
Chrysomelidae Anthrenus	Elytral protrusion		
Loricidae Aphodius	Elytra		
Loricidae Aphodius	Elytral apex		

625 tracks/mm = 1.6 microns

**Physical colors IB: Diffraction from unordered striations**

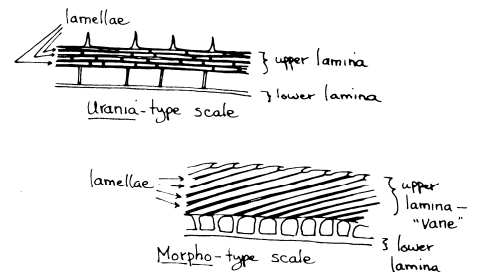


**Physical colors II: Interference from thin-layer reflections**

reinforcing (in-phase) reflections  
 incident light  
 interfering (out of phase) reflections  
 lamella  
 reflecting surfaces

**Morpho butterfly**  
**Chrysomelid beetle**

**Examples of interference colors from Lepidoptera**



**Physical colors III: Scattering**

Incoherent Tyndall scattering (?)



Zygoptera: Coenagrionidae

Multiwavelength scattering from air bubbles



Anisoptera: Aesnidae



**Significance of colors**

Mimicry & aposematism: monarch vs. viceroy



Camouflage

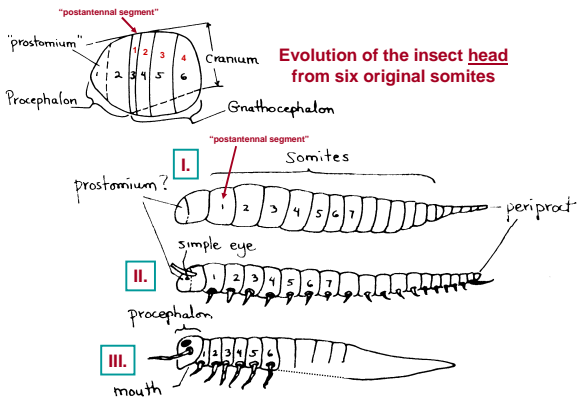


swallowtail larva

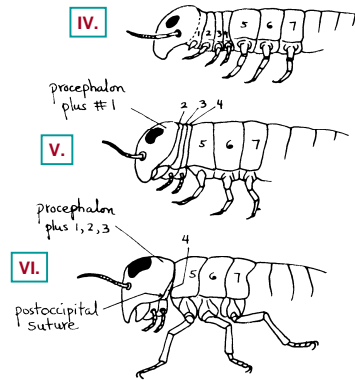
Startle & confusion: polyphemus moth



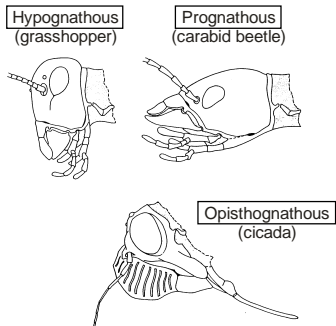
Indian leaf butterfly



**Head evolution, continued**



**Types of head orientation in insects**



**Head orientation -- more examples**

