

Integument, Development, and Reproduction



1

Introduction

Have you ever watched a butterfly emerge from its cocoon?



molting: formation of new cuticle of greater surface area and shedding of old cuticle

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Objectives

By the end of this unit you should be able to:

1. Describe the three layers of an insect's integument.
2. Describe the advantages and disadvantages of an exoskeleton.
3. Discuss the life histories and growth phases of insects.
4. Using the proper terms for the structures involved, explain the steps in the molting process.
5. Explain the role of JH and Ecdysone, where they come from, and how they are used together during the molting process.
6. Identify the internal and external reproductive structures of insects and describe what they do or how they are used.



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Integument Layers

Exoskeleton (cuticle)

Epicuticle – waterproof (lipids and polyphenols)

Exocuticle – hardened layer (chitin-protein microfibers)

Endocuticle – flexible inner layer (unlinked chitin and proteins)

Epidermis – cellular layer (provides proteins, chitin, lipids)

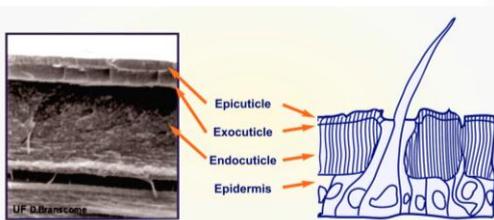


Chitin is like rebar in concrete.

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Integument

The cuticle and epidermis make up what we call the insect's **integument**.



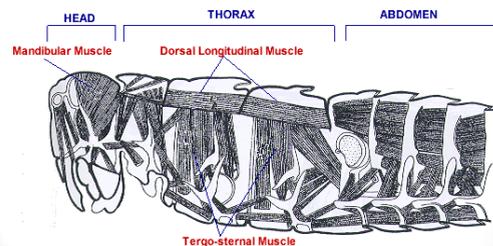
Cross-section of cockroach cuticle

Integument cross-section

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Exoskeleton Advantages

In the human muscular system, you can imagine how our muscles attach to our bones. Insect muscles attach to their exoskeleton just as our muscles attach to our internal skeleton.

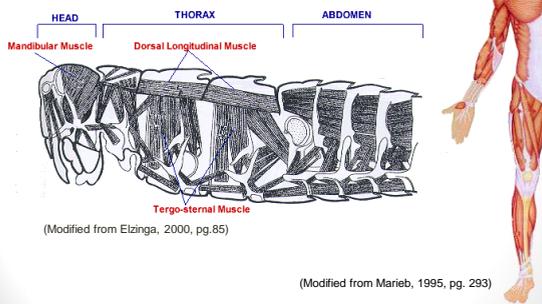


(Modified from Etzinga, 2000, pg.85)

*Notice how these grasshopper muscles are attached to the exoskeleton

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Skeleton comparison



Note: Grasshoppers have ~900 muscles while humans only have ~800.

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Exoskeleton Disadvantages

Our skeleton grows with our body, but an insect skeleton does not grow. Once it is formed, it stays its original size. Molting is a time-consuming and dangerous process that insects must undergo in order to grow.



Monarch caterpillar



Monarch adult

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Cuticle Hardening



Newly molted German Cockroach



Cockroach tanning process
(with permission, Kunkel, 2005)

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Molting Process

When an insect grows too large for its exoskeleton, it is time for it to discard it by molting. This process occurs in a series of steps.

- ❑ **Apolysis**--the outer cuticle separates from the epidermal cells.
 1. Epidermal cells secrete enzymes to break down the old cuticle.
 2. The old exoskeleton will be recycled to form part of the new cuticle.
 3. Epidermal cells secrete foundation for a new cuticle.
 4. The new cuticle is continually built upon, which shifts the old cuticle up and away. Eventually the old cuticle will break from the pressure.
- ❑ **Ecdysis**--the insect will wriggle and move its way out of the old cuticle. The old exoskeleton is left by the wayside. The insect, vulnerable to the environment, will need to remain still until the new cuticle hardens.



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Vocabulary Terms

The following terms all refer to immature insect stages. You have heard these terms mentioned in the introductory units, but make sure you know the difference between them.

Instar Stadium Larva(e) Nymph Pupa(e)

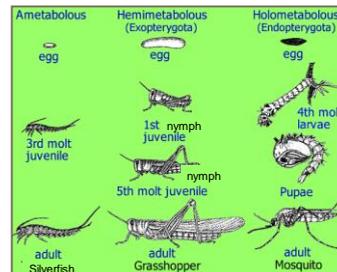
- ❖ **Instar** refers to a stage between two successive molts.
- ❖ A **stadium** is the time between molts.
- ❖ The term **larvae** (larva is singular) refers to the immature stages of holometabolous insects.
- ❖ **Nymph** refers to the immature stages of non-holometabolous insects.
- ❖ A holometabolous insect larva turns into a **pupa** (pupae is plural) before it molts into the adult.

Note: Some phorid flies use the heads of fire ants as a pupal case -- talk about losing your head.

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New Skin

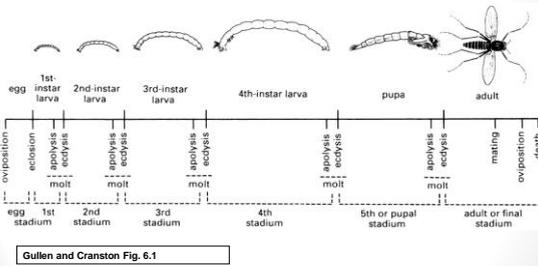
ontogeny - the developmental history of an organism from egg to adult



During the fourth molt, ecdysone forms the adult cuticle. (Ametabolous)
 During the 6th molt, ecdysone forms the adult cuticle. (Hemimetabolous)
 During 5th molt, ecdysone forms the pupal cuticle. (Holometabolous)
 (modified from Elzinga, 2000, pg. 117)

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Life Cycle of Midge



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Additional Terms

Pharate – Referring to the developmental stage enclosed in the integument of the preceding instar, especially adults that are pharate and in the pupal integument.

Teneral – The condition of the insect immediately after molting and before the cuticle has hardened.

Sclerotization – The polymerization and cross bonding of chitin and protein to produce the hardened insect exoskeleton



Eclosion and teneral stage of a sharpshooter – Hemiptera

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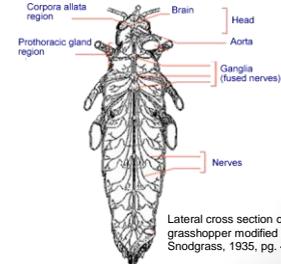
Video – New Skin

IMPORTANT NOTE: Throughout this course units, you will be asked to view short video clips. Please understand that many of these video clips are copyrighted and are NOT to be used outside of this class and only may be used for this semester. Please do not copy or distribute these clips.

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Molting Hormones

Two hormones interact during the molting process: **juvenile hormone** and **ecdysone**. Juvenile hormone, or JH for short, is secreted from the part of the insect brain called the **corpora allata**. It is located in the head region of the insect. Ecdysone is produced from a tiny pair of glands located near the first thoracic spiracles. These glands are called **prothoracic glands**. Prothoracic glands are often just a loose cluster of cells that are widely scattered throughout the prothorax.



Lateral cross section of a grasshopper modified from Snodgrass, 1935, pg. 476.

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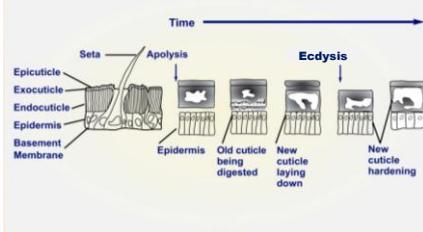
Molting Hormone Functions

Ecdysone

Ecdysone is released from the prothoracic glands. It travels to the epidermal cells where it stimulates the epidermal cells to secrete molting fluid.

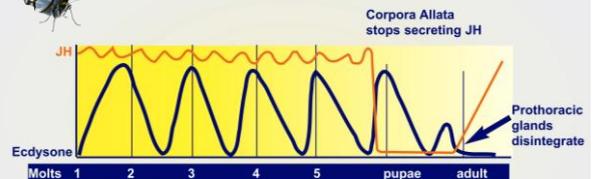
Juvenile Hormone

The corpora allata secretes JH continuously throughout each molt except during the last molt. Ecdysone by itself, stimulates the epidermis to form an adult cuticle.



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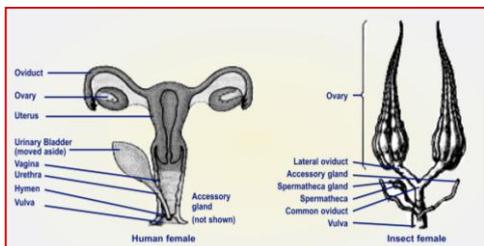
Molting Hormone Functions



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Reproductive System - Female

When two unrelated organism evolve the same type of structure for a given purpose it is called **convergent evolution**.

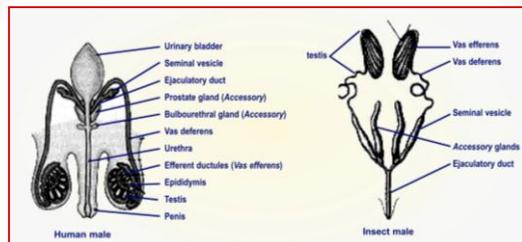


(Human reproductive modified from Marieb, 1995, pg. 989; insect system modified from Snodgrass, 1935, pg. 553)

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Note: Can you think of any other examples of convergent evolution in animals?

Reproductive System - Male



(Human reproductive modified from Marieb, 1995, pg. 989; insect system modified from Snodgrass, 1935, pg. 553)

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Reproductive Organ Functions

Read about the insect reproductive system and fill in the functions of the organs listed on your study guide.



Lovebugs in copula

A termite queen's body is greatly enlarged to house her enlarged ovaries. She may produce as many as 30,000 eggs in a day.

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Conclusion



Swallowtail caterpillar and pupae. Notice the color pattern of the integument.

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Learning Game Placeholder

Learning Game: Choices

Title: Review Quiz

References

- Daly, H.V., Doyen, J.T. and Purcell III, A.H., 1998. *Introduction to Insect Biology and Diversity*. Oxford University Press, New York, 2nd ed.
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