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.

3

Integument Layers

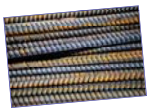
Exoskeleton (cuticle)

Epicuticle – waterproof (lipids and polyphenols)

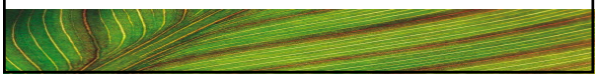
Exocuticle – hardened layer (chitin-protein microfibers)

Endocuticle – flexible inner layer (unlinked chitin and proteins)

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

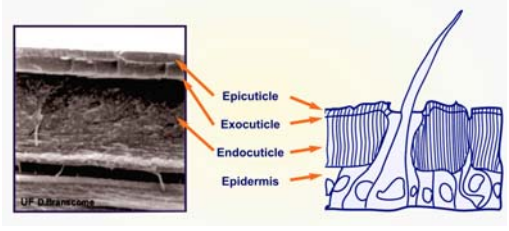


Chitin is like rebar in concrete.



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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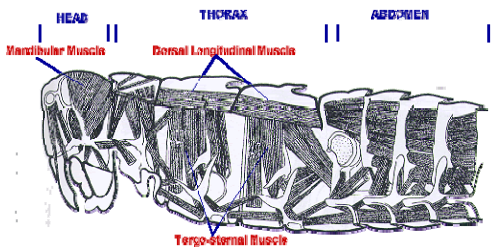
Exoskeleton Advantages

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 Elzinga, 2000, pg.85)

*Notice how these grasshopper muscles are attached to the exoskeleton

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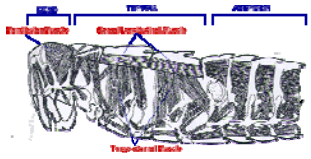
Skeleton comparison



(Modified from Elzinga, 2000, pg.85)

(Modified from Marieb, 1995, pg. 293)

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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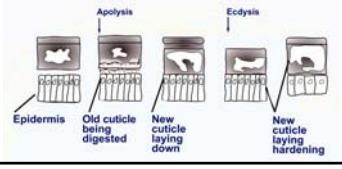
Molting Process

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.

1. **Apolysis**--the outer cuticle separates from the epidermal cells.
2. Epidermal cells secrete a molting fluid containing enzymes to break down the old cuticle. Material from the broken down exoskeleton will be recycled to form part of the new cuticle.
3. Epidermal cells secrete the foundation for a new cuticle and recycle parts of the digested old cuticle. The new cuticle is continually added to which shoves the old cuticle up and away. Eventually the old cuticle will break from the pressure.
4. **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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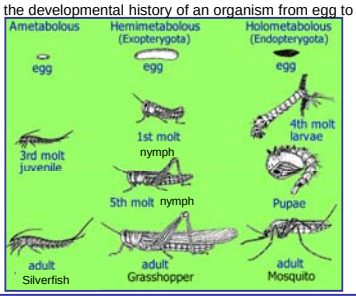
New Skin

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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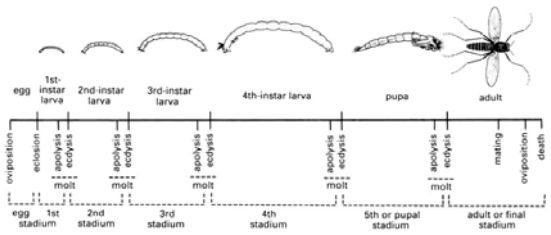
Life Cycle of Midge



Gullen and Cranston Fig. 6.1

Additional Terms

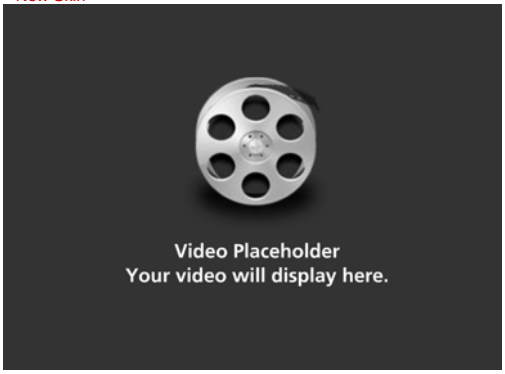
Pharate – Referring to the developmental stage enclosed in the integument of the preceding instar, especially adults that are pharate and in the pupal integument.

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

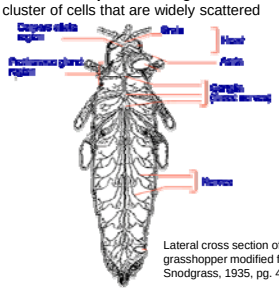
Video – New Skin



IMPORTANT NOTE:
Throughout the 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.**

Molting Hormones

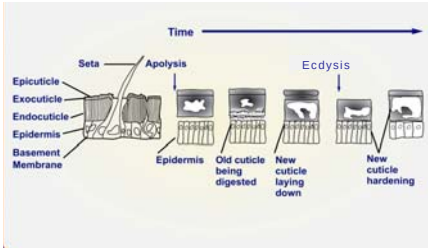
Two hormones interact during the molting process: **juvenile hormone** and **ecdysone**. Juvenile hormone, or JH for short, is secreted from the part of the insect brain called the **corpora allata**. It is located in the head region of the insect. Ecdysone is produced from a tiny pair of glands located 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.

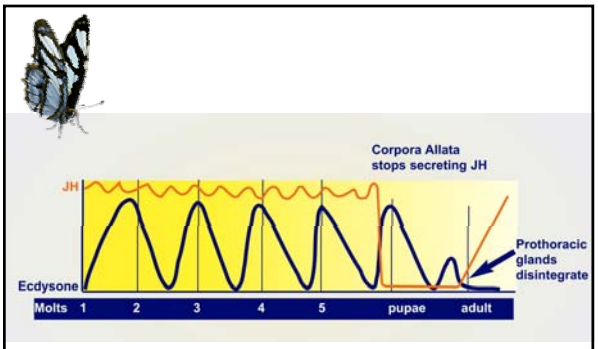


Lateral cross section of a grasshopper modified from Snodgrass, 1935, pg. 476.

Molting Hormone Functions

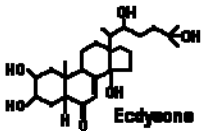
Ecdysone
Ecdysone is released from the prothoracic glands. It travels to the epidermal cells where it stimulates the epidermal cells to secrete molting fluid.
Juvenile Hormone
The corpora allata secretes JH continuously throughout each molt except during the last molt. Ecdysone by itself, stimulates the epidermis to form an adult cuticle.





Adult Molt

German cockroach female carrying an ootheca (egg case). JH stimulates egg production in adult insects.



Lady beetle adult (left) and pupa (right).

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Monarch Emergence Video

- Last instar caterpillar molts into pupal stage
- Pupa undergoes changes for about 10 days before the pupal case darkens
- One day after the case darkens, the adult butterfly emerges
- The adult butterfly expands its wings and rests until its cuticle hardens

Dr. Jim Nation, professor emeritus at the University of Florida, examines a monarch adult

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Caterpillar Pupation Video

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JH Mimics

Because JH keeps a larva from becoming an adult, scientists found that we could use JH as an insecticide.

Since the caterpillars never become adults, they will never mate with each other and lay eggs. Eventually the caterpillars start to die off but won't be replaced because there aren't any eggs hatching. That is another way that JH is successful as an insecticide

These man-made juvenile hormones are called **JH mimics**, **JH analogs** or **Insect Growth Regulators (IGR's)**. These are the chemicals that are sold commercially to pest control companies, or are formulated in combination with other pesticides as flea treatments for your pet.

caterpillar

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JH Mimic Assignment

Find an insecticide label that advertises the use of JH mimics or JH analogs as an insecticide. Write a brief journal entry (1/2-1 page) of what you found. Be sure to include the answers to these questions.

- •What is the product?
- •What does it control?
- •How does it work?
- •Where did you find your information?
- •Do you consider it to be safe? Why or why not?
- •Is it toxic, and to what?

Example: IGR methoprene http://www.altosid.com/

Altosid label

ASSIGNMENT

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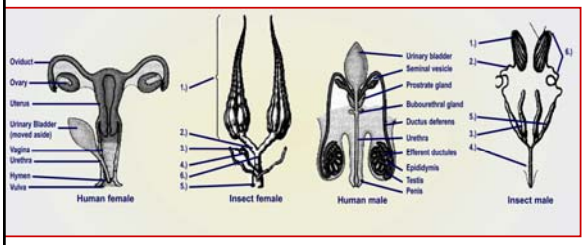
Reproductive System Activity



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

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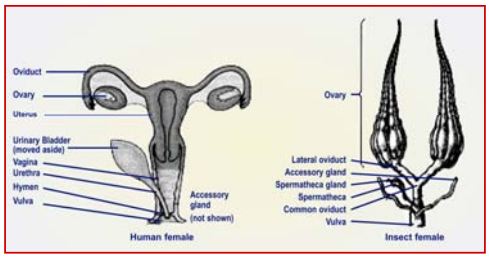
Reproductive System - Female

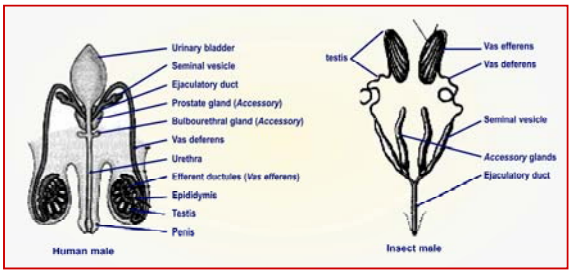
When two unrelated organism evolve the same type of structure for a given purpose it is called **convergent evolution**.



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

Note: Can you think of any other examples of convergent evolution in animals? 25

Reproductive System - Male



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

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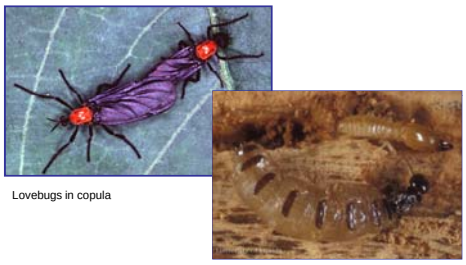
Reproductive Organ Functions

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. 27

Conclusion

Swallowtail caterpillar and pupae. Notice the color pattern of the integument. 28

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.

Elzinga, R.J., 1997. *Fundamentals of Entomology.* Prentice Hall, Upper Saddle River, New Jersey, 4th ed.

Kunkel, J. 2005. Biology Department, University of Massachusetts at Amherst. Accessed online: March 2005. http://www.bio.umass.edu/biology/kunkel/bomolt.html

Marieb, E.N. 1995. *Human Anatomy and Physiology*. Benjamin/Cummings Publishing Company, Inc. Redwood City, 3rd. ed.

Meyer, J. 2009. NCSU General Entomology Tutorial. Accessed online: September 2011. http://www.cals.ncsu.edu/course/ent425/tutorial/females.html

Snodgrass, R.E., 1935. *Principles of Insect Morphology*. McGraw-Hill Book Company, Inc. New York, 1st ed.

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