RECEPTION & INTEGRATION:
THE NERVOUS SYSTEM

1

OBJECTIVES

1. Describe the origin of the insect nervous system.
2. Identify and describe the major structures of the insect nervous
3. Compare and contrast compound eyes and simple eyes.
4. Differentiate between the types of simple eyes.
5. Describe the mechanical receptors insects possess.

2

INTRODUCTION

Have you ever thought about how insects receive information from their environment?

We use our five senses, but what about them?

Does an insect have a nose?

Insects do not have noses, but they smell!

They acquire scents through antennae and other body organs.

3

HUMAN OLFACTION

- ✓ Molecules bind to hairs in the nasal cavity.
- ✓ These hairs are extensions of olfactory (smelling) nerve cells.
- ✓ Nerve cells are also called **neurons**.

I. Chemical binding causes olfactory nerves to fire.
II. The brain interprets the message.
III. You begin to salivate.

(All this talk about food is making me hungry.)

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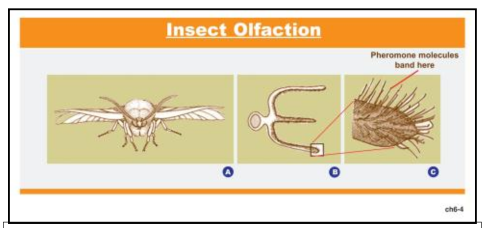
INSECT OLFACTION

I. Olfactory neurons are enclosed within their antennae, mouthparts, or legs.
II. These neurons fire a message to the brain.
III. The brain interprets the signals and stimulates neurons that cause action.



Antennae of a male moth of *Trictena atripalpis*: (a) anterior view of the head; (b) cross-section through the antenna showing the antenna is branched three times; (c) enlargement of the tip of one of the branches showing olfactory hairs.
(modified from Gullan & Cranston, 2005, pg. 100)

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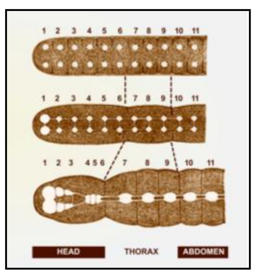
NERVOUS SYSTEM DEVELOPMENT

- ➢ Neuroblasts develop in embryonic ectoderm.
- ➢ Ganglia develop from these.
- ➢ Two ganglia form in each body segment.
- ➢ Neuron fibers connect the ganglia together.



Representation of nervous system development.
(a) neuroblast formation;
(b) neurblasts form ganglia and ganglia interconnect;
(c) ganglia fusion.

(modified from Elzinga, 2000, pg. 91)

Hemiptera: Pentatomidae

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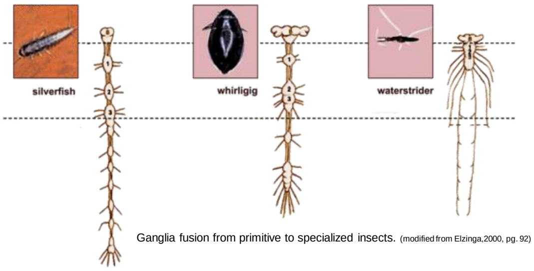
GANGLIA FUSION



Ganglia fusion from primitive to specialized insects. (modified from Elzinga,2000, pg. 92)

- Fusion of ganglia 1, 2, & 3 = **Supraesophageal ganglion**
- Fusion of ganglia 4, 5, & 6 = **Subesophageal ganglion**
- Remaining ganglia fuse into the ventral nerve cord.
- Specialized and highly evolved species have all ganglia fused into a large mass in the head and prothorax.

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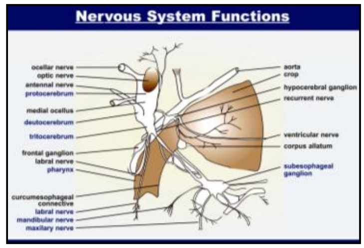
NERVOUS SYSTEM FUNCTIONS

The **supraesophageal** ganglion lies above the esophagus (*supra*-, above).
It is made up of three main lobes, the **protocerebrum**, the **deutocerebrum** and **tritocerebrum**. We will discuss each of their functions on the next slide.



Insect brain and associated structures

(modified from Elzinga, 2000, pg. 93).

The **subesophageal** ganglion is located below the esophagus.
It coordinates and controls the maxilla, mandibles and labium.
This makes sense since the ganglion is located so close to these structures.

Note: The human nervous system is dorsally located along our back. ***Insects are ventral.***

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SUPRAESOPHAGEAL GANGLIA FUNCTIONS

Protocerebrum:
Receives and processes signals from the eyes.

Deutocerebrum:
Receives impulses from and controls the antenna.
This lobe will trigger responses to the stimulus.

Tritocerebrum:
Receives input from the labrum nerves and subesophageal ganglion
Assists in controlling the digestive, circulatory and endocrine systems
Aids the corpora allata (an endocrine gland which secretes Juvenile Hormone).

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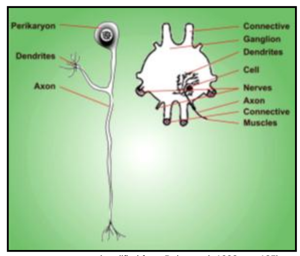
NEURONS

Soma (perikarya) - the cell body of the neuron that contains the nucleus and typical cellular organelles.

Axon the long, thin cytoplasmic extension that conducts the nerve impulse.

Dendrite the region of information input.



(modified from Daly, et. al, 1998, pg. 125)

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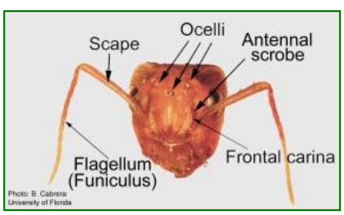
EYES

As with most other animals, insect eyes are located at the anterior end of the body. There are three kinds of insect eyes you will learn about including the compound eye and two simple eyes, the **ocelli** and **stemmata.** Let's begin with the simple eyes.



carpenter ant head showing position of ocelli

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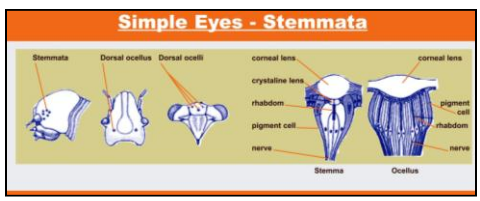
SIMPLE EYES - OCELLI



Simple eyes: (a) caterpillar; (b) stinkbug; (c) cicada (modified from Romoser & Stoffolano, 1998, pg. 32).

Longitudinal sections through the rhabdoms in simple eyes. Stemma of a caterpillar. Ocellus of an adult bug.

(modified from Gullan & Cranston, 2005, pg. 107)

Ocelli (Singular = Ocellus)
- Located on frons (top of head)
- Visible in nymphs and adults
- Made up of **corneal lens**, several **rhabdoms**, and neurons.
- Used to detect light changes (such as a shadow) rather than an image.

I. Light triggeres color pigments to start a chemical reaction around the rhabdoms
II. Impulses go to the protocerebrum and are processed into "vision."
III. Pigment cells surrounding the rhabdom cluster protects it from light rays.

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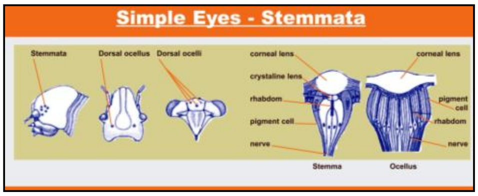
SIMPLE EYES - STEMMATA



Simple eyes: (a) caterpillar; (b) stinkbug; (c) cicada (modified from Romoser & Stoffolano, 1998, pg. 32).

Longitudinal sections through the rhabdoms in simple eyes. Stemma of a caterpillar. Ocellus of an adult bug.

(modified from Gullan & Cranston, 2005, pg. 107)

Stemmata (singular = Stemma)

- Between ocelli and compound eyes.
- Visible only in larvae of holometabolous insects.
- Made up of a corneal lens and a single rhabdom.
- Provide the insect with very limited images of the world.

The stemmata are lost during metamorphosis and are replaced by the adult compound eye.

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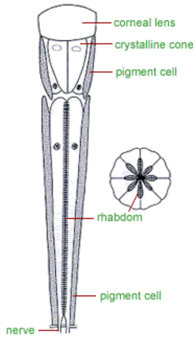
COMPOUND EYES

Compound eyes

- Multi-faceted (facet = **ommatidium**)
- Each facet has its own corneal lens, crystalline cone, rhabdom, and pigment cells.

- Light is focused by the lens *and the cone* onto color pigments in the rhabdom.
- Pigment cells create divisions among ommatidium and shield from adjacent light.
- Each facet forms a portion of the image (multi-faceted picture in the brain).
- More ommatidia = Higher resolution.



Longitudinal section through one ommatidium, with enlargement showing transverse section (Gullan & Cranston, 2005, pg. 108).

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PREDATOR EYES

Predators and fast-flying insects have the greatest number of ommatidia.

This allows them to catch quick moving prey or navigate swiftly past objects.

Nearly all adult insects and some hemimetabolous nymphs have compound eyes.

Holometabolous larvae only posses stemmata.

large compound eyes – tiger beetle

large compound eyes - damselfly

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VIDEO – BEE CAM

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.

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EYE SUMMARY

Table 1 – Summary of eye types

Eye:	**Ocellus**	**Stemma**	**Ommatidium**
Type:	Simple	Simple	Compound
Insects:	Nymphs and adults of many kinds of insects	holometabolous larva	Nearly all adult insects and some hemimetabolous nymphs
Structures:	Many rhabdoms in one ocellus.	One rhabdom per stemma.	One rhabdom per ommatidium. Many ommatidia in one eye.
	Lens, no crystalline structures.	Lens and crystalline lens similar to lens and crystalline cone in compound eye.	One lens and crystalline cone.
	Pigment cells surround and shield adjacent structures from light rays.	Pigment cells surround and shield adjacent structures from light rays.	Pigment cells surround and shield adjacent ommatidia from light rays.
Image:	Poor. Blurry.	Poor. Blurry. But as the number of stemmata increase on the insect, the better the vision.	Good vision. As the number of ommatidia increase per eye, so does the image resolution. Forms a mult-faceted image.

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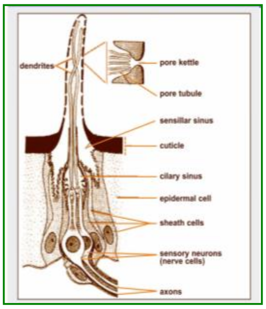
RECEPTORS

Chemoreceptors - Detect chemical molecules in the surrounding air

Mechanoreceptors - Detect movement



Longitudinal section through a multiporous sensillum.
(modified from Gullan & Cranston, 2005, pg. 99)

Molecules enter a sensillum (plural = sensilla)

- Uniporous = one entry pore
- Multiporus = multiple entry pores

I. The molecule attaches to receptors in the dendrite membrane.

II. Each receptor is designed to receive or sense specific stimuli.

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CHEMORECEPTORS

Chemoreception:
Ability to taste and smell (**olfaction**).
- tasting involves sampling molecules suspended in liquid (saliva, etc.)
- olfaction involves sensing molecules floating in the air.

Chemoreceptors
located in what we would consider strange places.
Ex: Flies have taste receptors on their feet.

(Just think about that the next time one lands on you or your hamburger.)

house fly on soda can

Some parasitic insects select a suitable host by first tasting them to determine if they are fit enough to be a good incubator for their young or even if they should lay male or female eggs in the host.

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OLFACTION

Olfaction is incredibly important for insects!
- Location of food.
- Plant/insect signaling.
- Mate finding (using **pheromones**).

Regal moth, *Citheronia regalis* (Fabricius)

Some male moths have such sensitive olfactory receptors that they can detect a single molecule of female pheromone. We will discuss this in more detail in the next unit.

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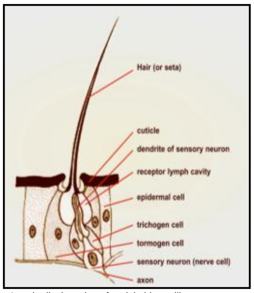
MECHANORECEPTORS

Mechanoreceptors are sensilla that detect physical movement.

We will only cover a single example here.



Longitudinal section of a trichoid sensillum (modified from Gullan & Cranston 2005, pg. 87).

Trichoid sensilla:
- Hair-like setae that have a single dendrite.
- When brushed, movement is immediately sensed.
- Transmits an impulse to the rest of the system.

- Used to sense what's passing by
- Used to sense the relative position of appendages.

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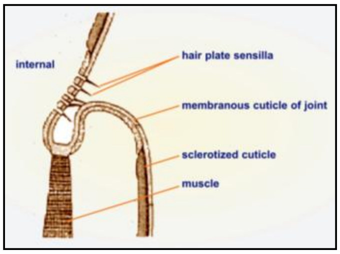
TRICHOID SENSILLA

Trichoid sensilla are in gaps between insect joints.

Joint moves, depresses hairs, and position is relayed to the nervous system.



Sensilla located at a joint, called **hair-plate sensilla**, showing how the hairs are stimulated by contacting adjacent cuticle. (modified from Gullan & Cranston 2005, pg. 88)

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Learning Game Placeholder
Learning Game: Choices
Title: Review Quiz

CONCLUSION

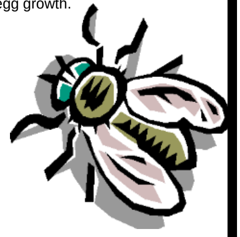
Insects smell(!) with receptors on the body.

Taste receptors are found on places like tarsal pads.
Eyes are anterior, but have single lensed light detectors and multi-lensed compound eyes.

Neurons develop into intricate structure following egg growth.

Now when you see a housefly land on a piece of food, you will be able to think about:

- Which taste receptors he may be using.
- What types of eyes he has.
- How they form their images.
- Which part of his brain he may be using.



That's not something just anyone can do!

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2.
3. Elzinga, R.J., 2000. *Fundamentals of Entomology.* Prentice Hall, Upper Saddle River, New Jersey, 5th ed.

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