MODULE 5 SESSION 4

The Endocrine Glands
and the
Functions of their Secretions

"Hormones carry the signals that orchestrate and animate every moment and milestone of our lives"

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Endocrinologist

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WHY THE ENDOCRINE SYSTEM MATTERS

Honey bee endocrine glands release hormones into the haemolymph, coordinating development, reproduction and changes in adult behaviour.

The principal endocrine centres

- Brain neurosecretory cells initiate hormonal signals
- Corpora cardiaca store and release neurohormones
- Corpora allata produce juvenile hormone
- Prothoracic glands produce ecdysone in larvae and pupae

Why they are important

Shape the developing bee

Ecdysone triggers moulting; juvenile hormone helps determine whether development remains larval or advances towards metamorphosis.

Adapt the adult and colony

Hormonal shifts influence caste, reproduction and the worker's transition from nursing to foraging, and from summer to winter bee.

Together, these glands link the nervous system, the bee's body and the changing needs of the colony.

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WHAT ARE ENDOCRINE GLANDS?

Ductless glands that release hormones straight into the haemolymph, where tiny amounts act on distant target tissues.

Key features

- No duct — secretion passes directly into the haemolymph
- Hormones act at very low concentration
- Slow to act, but effects are long lasting
- Only tissues with the matching receptor respond

Endocrine or exocrine?

Endocrine — no duct

Corpora allata (juvenile hormone), prothoracic glands (ecdysone), corpora cardiaca.

Exocrine — has a duct

Hypopharyngeal (brood food), mandibular (queen pheromone), wax glands.

Exocrine products act between bees; endocrine hormones act within the bee.

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LIST OF ENDOCRINE GLANDS

Four endocrine centres, from the brain to the prothorax

Brain neurosecretory cells

Pars intercerebralis and pars lateralis. Secrete PTTH and other neuropeptides.

Corpora cardiaca

Paired neurohaemal organs behind the brain. Store and release brain neurohormones; add their own secretions.

Corpora allata

Paired glands behind the corpora cardiaca. Source of juvenile hormone (JH).

Prothoracic (ecdysial) glands

Paired, in the prothorax. Secrete ecdysone in larva and pupa only.

The ovaries of a laying queen also release ecdysteroids — a secondary endocrine source.

PTTH = prothoracicotropic hormone — the brain peptide that switches on the prothoracic glands. It was historically called brain hormone or ecdysiotropin.

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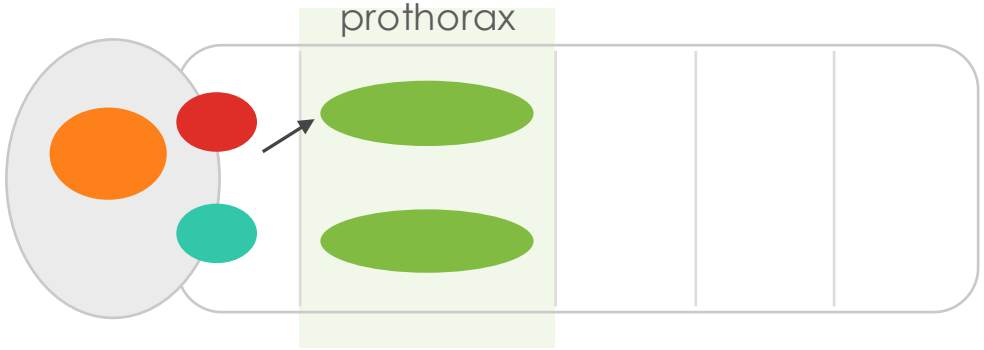
ENDOCRINE GLANDS — LOCATION, SECRETIONS AND FUNCTIONS

Structure	Location	Principal hormones / secretions	Main functions
Neurosecretory cells (NSCs)	Brain, particularly protocerebrum and other regions of the brain; also associated with the ventral nerve cord	PTTH-like factors, allatotropin/allatostatin, ecdysiotropins, insulin-like peptides and other neuropeptides	Coordinate endocrine activity; regulate development, metabolism, reproduction and behaviour
Corpora cardiaca (CC)	Paired neurohaemal organs immediately behind the brain, associated with the aorta	Adipokinetic hormone (AKH) and neurosecretory products released from brain NSCs	Release neurohormones into haemolymph; regulate energy mobilisation and metabolism
Corpora allata (CA)	Paired glands posterior/lateral to the brain, close to the corpora cardiaca	Juvenile hormone (JH III)	Controls larval development, metamorphosis, adult reproduction, division of labour and seasonal physiology
Prothoracic glands (PG)	Mainly associated with the thorax in immature insects; functional equivalent in honey-bee larvae is associated with the prothoracic glandular system	Ecdysteroids, principally ecdysone/20-hydroxyecdysone (20E)	Controls moulting and metamorphosis, particularly larva → pupa → adult

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LARVA — ENDOCRINE GLANDS AND THEIR SECRETIONS

Larval honey bee, Apis mellifera — all four endocrine centres present



- brain neurosecretory cells (pars intercerebralis / lateralis)
- corpora cardiaca — paired neurohaemal organs
- corpora allata — paired endocrine glands
- prothoracic (ecdysial) glands — paired, in the prothorax

Ecdysone secretion ends with metamorphosis — the glands break down soon after adult eclosion.

Secretions and their functions

PTTH (brain neurosecretory cells)

Released via the corpora cardiaca; stimulates the prothoracic glands.

Ecdysone (prothoracic glands)

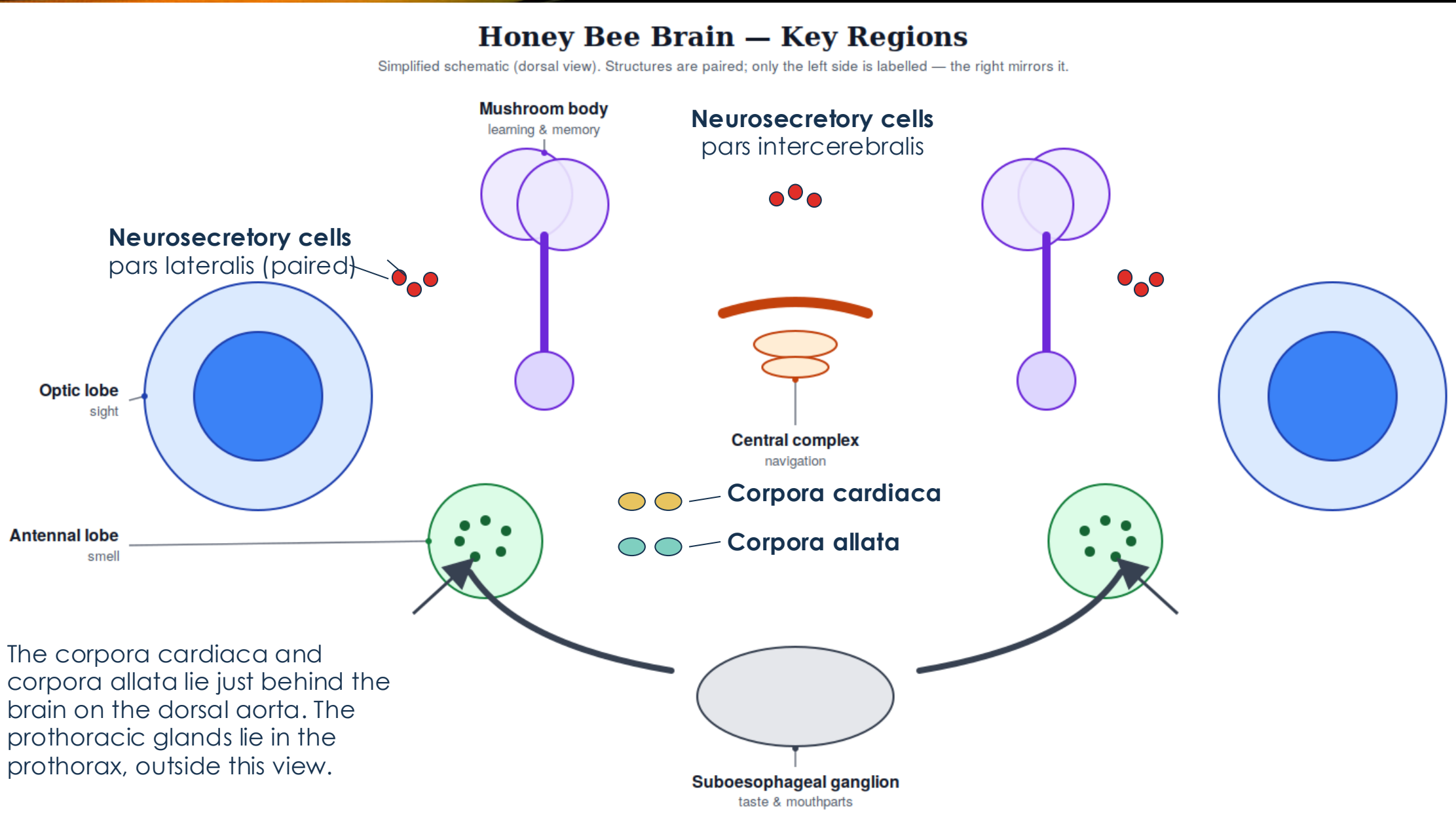
Converted to 20-hydroxyecdysone; triggers apolysis and each larval moult.

Juvenile hormone (corpora allata)

Keeps each moult larval; falling JH titre permits pupation.

PTTH = prothoracicotropic hormone — the brain peptide that switches on the prothoracic glands. It was historically called simply "brain hormone" or ecdysiotropin.

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The corpora cardiaca and corpora allata lie just behind the brain on the dorsal aorta. The prothoracic glands lie in the prothorax, outside this view.

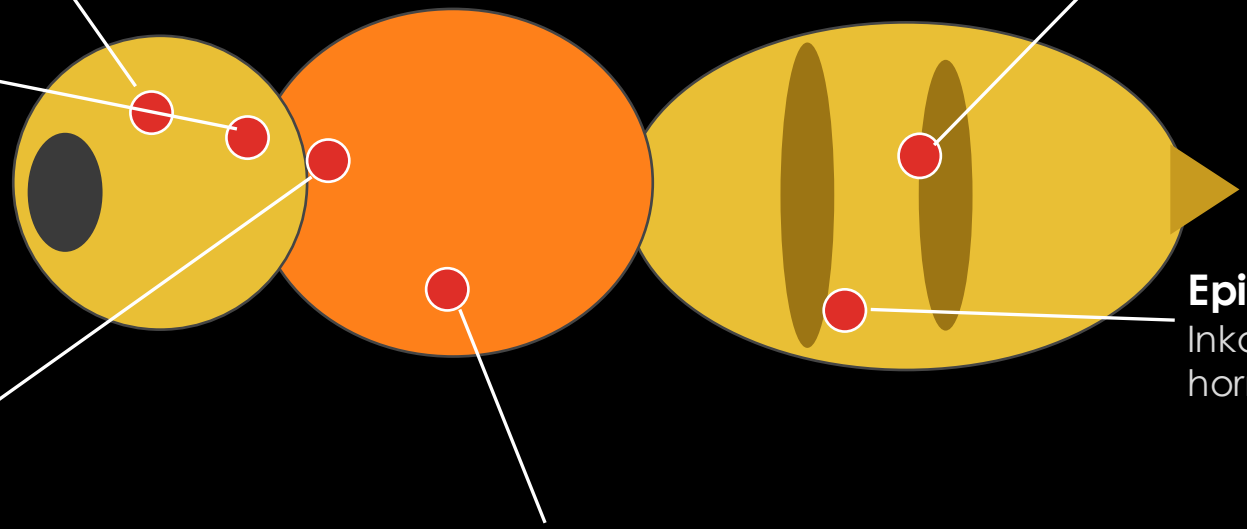
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WHERE THE ENDOCRINE GLANDS LIE IN THE BODY

Brain: neurosecretory cells
median (PI) + lateral (PL)

Corpora cardiaca
storage and release site

Corpora allata
secrete juvenile hormone



Ovaries
ecdysteroid source in adults

Epitracheal glands
Inka cells: ecdysis-triggering hormone

Prothoracic glands
ecdysone; lost after adult emergence

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ADULT WORKER

The prothoracic glands have degenerated

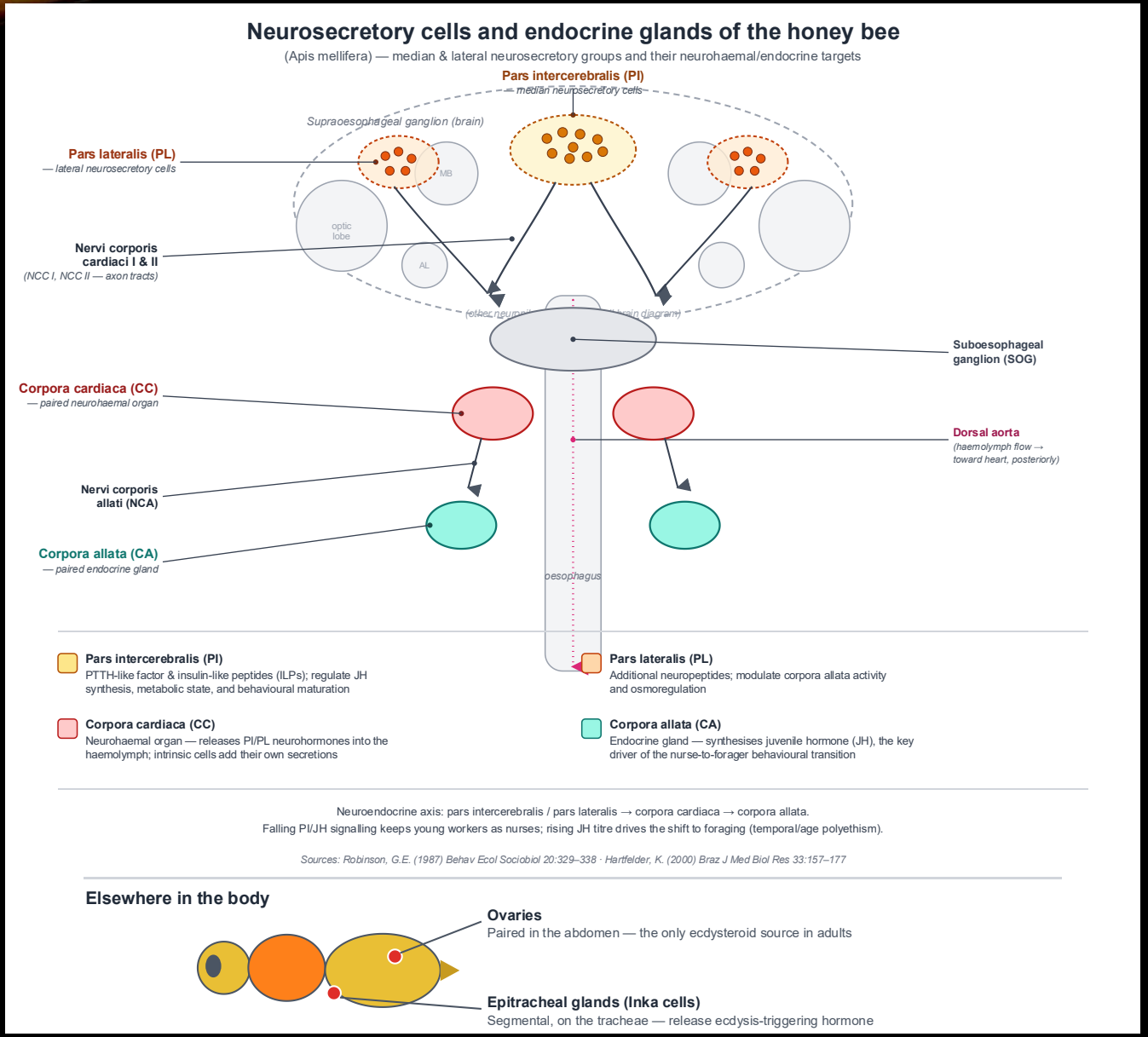
No ecdysone source remains.

Corpora allata continue to release juvenile hormone

Driving the nurse-to-forager shift.

Epitracheal glands (Inka cells) are now silent

Ovaries: the only remaining ecdysteroid source



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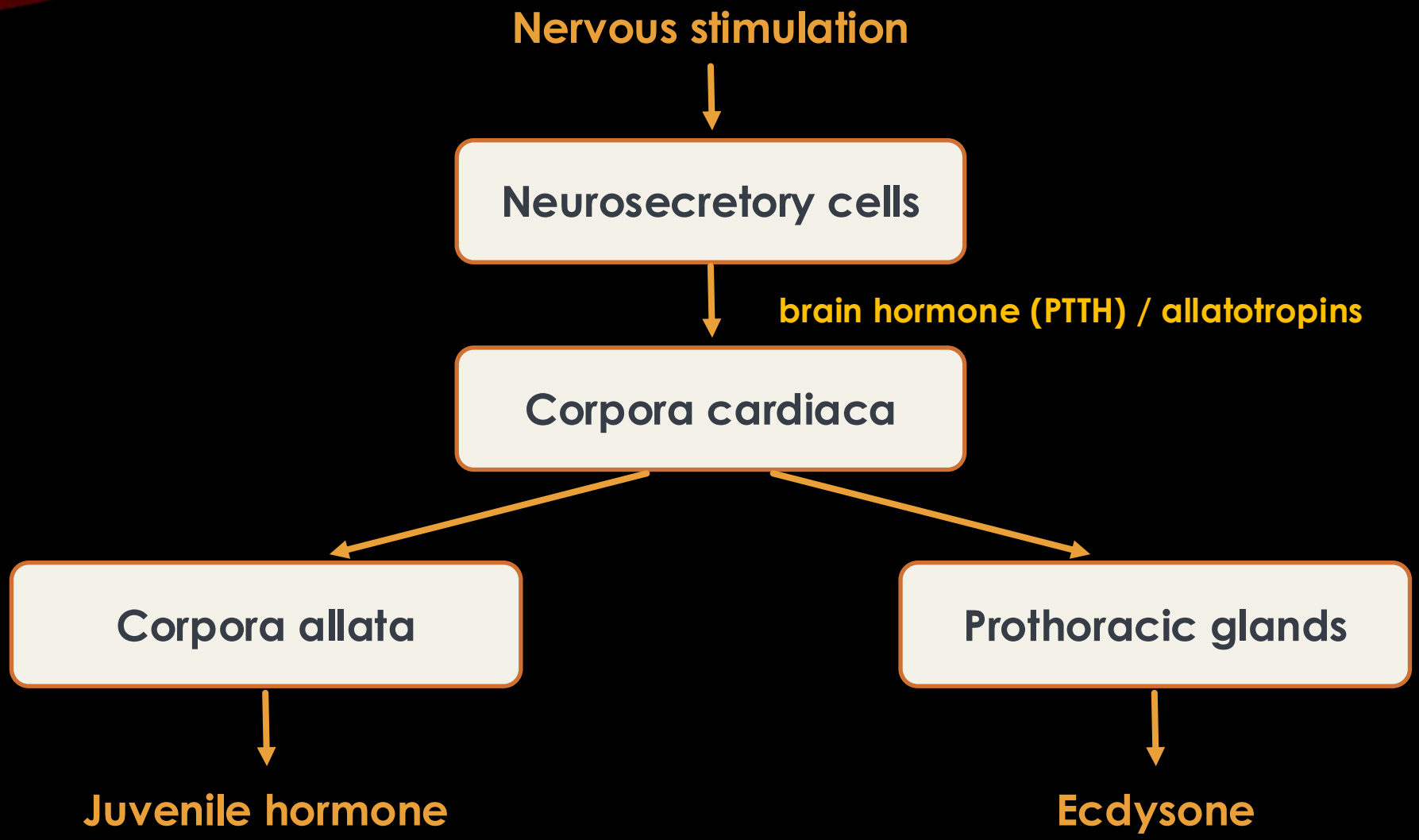
CASTE COMPARISON — SAME GLANDS, DIFFERENT SECRETION PROFILES

	QUEEN	WORKER	DRONE
Larval JH titre	High from the 3rd instar (royal jelly)	Low throughout	Moderate
Ecdysteroid peaks	Early and high	Later, lower	Later; longest larval stage
Prothoracic glands	Present in larva and pupa in all three castes — degenerate soon after adult eclosion		
Adult JH role	Low in the mated layer; uncoupled from behaviour	Rises with age — nurse to forager	Rises at sexual maturation and flight
Other endocrine source	Ovaries secrete ecdysteroids for egg production	Ovaries normally inactive	Testes; no ecdysteroid role
Development time	16 days	21 days	24 days

One set of endocrine glands in all three castes — what differs is hormone titre and timing, not anatomy.

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Interaction between the CNS and the the Endocrine System



PTTH = prothoracicotropic hormone

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NEUROSECRETORY CELLS

Where they are

- Pars intercerebralis — median group in the protocerebrum
- Pars lateralis — paired lateral groups
- Axons run in the nervi corporis cardiaci I and II
- Release sites lie in the corpora cardiaca

What they secrete

- PTTH — switches on the prothoracic glands
- Insulin-like peptides — growth and metabolism
- Allatotropins and allatostatins — tune the corpora allata

cell body in the brain → axon in NCC I / II → release in corpora cardiaca → carried in the haemolymph

Neurosecretory cells are nerve cells that work as endocrine cells — the link between brain and hormone.

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CORPORA CARDIACA

A pair of small neurohaemal organs just behind the brain, lying on the dorsal aorta — the outlet through which brain hormones reach the blood.

Storage and release

Axons from the brain neurosecretory cells end here; their neurohormones, including PTTH, are stored and released into the haemolymph.

Its own secretions

Intrinsic glandular cells add adipokinetic-type hormones that mobilise sugars and lipids for flight.

Connections

Nervi corporis cardiaci carry axons in from the brain; nervi corporis allati link on to the corpora allata behind.

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CORPORA ALLATA

A pair of true endocrine glands lying just behind the corpora cardiaca — the sole source of juvenile hormone (JH III in the honey bee).

In the larva

High JH keeps each moult larval and prevents metamorphosis. Royal jelly raises JH in queen-destined larvae — this is caste determination.

In the adult worker

Rising JH drives behavioural maturation — the nurse to forager shift.

At pupation

JH falls away; with ecdysone unopposed, the larva pupates.

Control and caste

Allatotropins and allatostatins from the brain set the rate. Mated queens run a low JH titre; drones peak at sexual maturity.

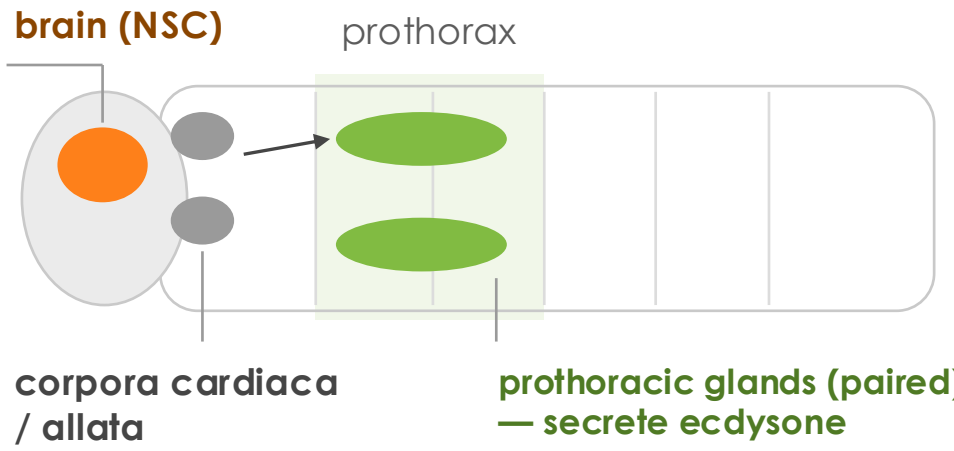
One hormone, three jobs: caste, metamorphosis and adult behaviour.

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PROTHORACIC GLANDS

Prothoracic (ecdysial) glands — larval honey bee, Apis mellifera

Location: paired glands in the prothorax



- Brain neurosecretory cells release PTTH
- Corpora cardiaca / allata — PTTH into haemolymph
- Prothoracic glands secrete ecdysone
- Ecdysone → 20-hydroxyecdysone → apolysis and moult

In the adult, ecdysone output ceases and the glands break down shortly after eclosion.

Juvenile hormone from the corpora allata sets the type of moult.

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THE MOULTING CASCADE — FROM STIMULUS TO MOULT

Follow the signal: each click moves it one step along the chain

Stimulus
Size, feeding and day length

Brain cells
PTTH is made

Corpora cardiaca
PTTH into the haemolymph

Prothoracic glands
Ecdysone released

Epidermis
Apolysis — the moult

Corpora allata
JH sets the moult type

High JH → another larva.
Low JH → pupa, then adult.

Nothing happens out of turn
Each gland only acts when the stage before it has released its hormone — remove any link and the moult fails.

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NURSE TO FORAGER — HOW THE SWITCH IS MADE

Follow the signal: each click moves it one step along the chain

Colony cue
Fewer foragers, less brood to feed

Brain
Octopamine rises; allatotropin to the glands

Corpora allata
Juvenile hormone titre climbs

Fat body
Vitellogenin falls away

Forager
Leaves the nest to fly and forage

A feedback loop, not a clock

Juvenile hormone and vitellogenin suppress each other, so the colony's needs — not age alone — set the day a nurse becomes a forager.

Ethyl oleate
Forager pheromone puts the brake on

Plenty of foragers holds nurses back; a shortage sends them out early.

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CASTE DETERMINATION — HOW A LARVA BECOMES A QUEEN

Follow the signal: each click moves it one step along the chain

Royal jelly
Fed in excess for the whole larval life

Nutrient sensing
Insulin-like peptides and TOR signalling rise

Corpora allata
JH titre climbs from the 3rd instar

Gene response
Ecdysteroids peak early; queen genes switch on

Queen
Full ovaries, no pollen baskets, out in 16 days

Diet writes the difference
Queen and worker share one genome; the food a larva receives sets its juvenile hormone titre, and JH sets the caste.

Worker jelly
Less, and diluted — JH stays low

The same egg becomes a worker — 21 days, small ovaries.

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LAYING WORKERS — WHAT HAPPENS WHEN THE BRAKE COMES OFF

Follow the signal: each click moves it one step along the chain

Queen lost
Queen mandibular pheromone disappears

→

Brood gone
No brood pheromone from young larvae

→

Inhibition lifted
Ovary-suppressing signals stop; JH and vitellogenin shift

→

Ovaries activate
Ovarioles mature and take up vitellogenin

→

Drone eggs
Unfertilised eggs — drones only, several per cell

Workers can lay, but only drones
Workers never mate, so their eggs are haploid. Pheromones from the queen and her brood normally keep their ovaries shut down.

Egg policing
While a queen is present, workers eat worker-laid eggs

A drone-laying colony cannot recover on its own — requeen it.

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SUMMER BEE TO WINTER BEE — THE AUTUMN SWITCH

Follow the signal: each click moves it one step along the chain

Autumn cues
Forage, day length and temperature all fall

Brood rearing ends
Few larvae to feed, so protein is not spent

Corpora allata quieten
Juvenile hormone titre stays low

Fat body loads
Vitellogenin stored; immunity strengthened

Winter bee
Lives months, heats the cluster, rears spring brood

The mirror image of the forager
A forager runs high JH and low vitellogenin; the winter bee is the reverse — and that is why she lives for months, not weeks.

What spoils it
Late brood, varroa and viruses drain vitellogenin

Winter losses often trace back to poorly fed autumn bees.

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IN SUMMARY — THE ENDOCRINE SYSTEM OF THE HONEY BEE

Four endocrine centres
Brain neurosecretory cells, corpora cardiaca, corpora allata — and the prothoracic glands, in larva and pupa only.

Two hormones do the work
Ecdysone decides when a moult happens; juvenile hormone decides what that moult produces.

One set of glands in every caste
Queen, worker and drone differ in hormone titre and timing, never in anatomy.

The same axis runs adult life
Juvenile hormone and vitellogenin oppose each other: nurse to forager, summer bee to winter bee, laying workers.

Why it matters at the hive
Larval feeding sets caste; well-fed autumn bees carry the colony through winter; a drone-laying colony needs requeening.

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MODULE 5 SESSION 4

THE HONEY BEE STING MECHANISM

INTRODUCTION

The honey bee has evolved over many millions of years to be a self-contained superorganism.

For the protection of its home, its brood and its stores, it has modified from the female genitalia

which form the ovipositor the sting, a powerful weapon of

defence against much larger predators such as bears and humans.

Present in queens & workers but not drones

Normally retracted in a chamber enclosed by the tergal and sternal plates of the 7th abdominal segment

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The parts of the sting are:

3 chitinous plates on each side:
- oblong
- quadrate
- triangular

2 Pairs of muscles:
- protractor
- retractor

Shaft
- 2 chitinous rami which continue into a pair of lancets
- stylet

The whole enclosed in the sting sheath

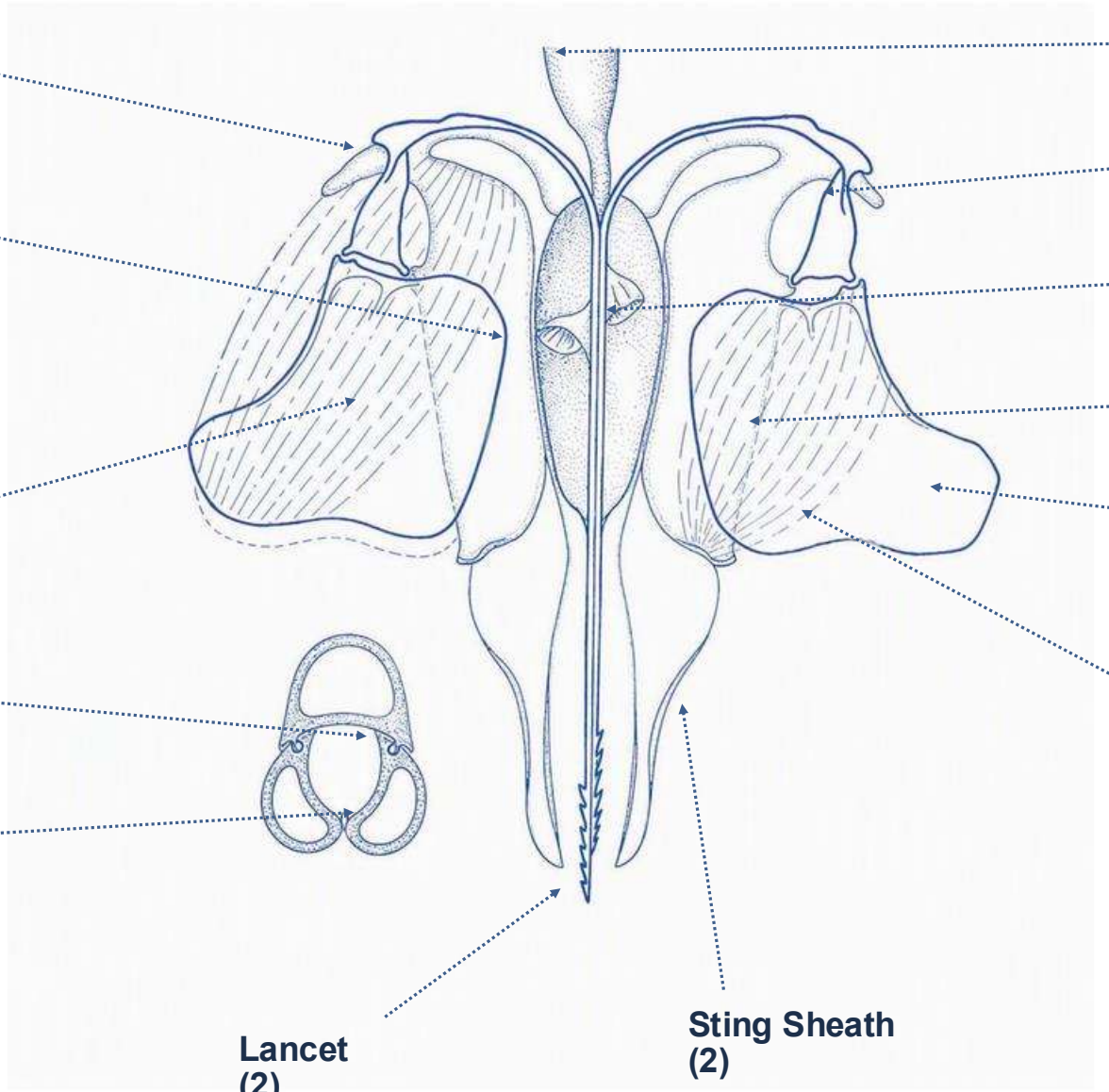
Venom sac which opens into the venom bulb

Pair of umbrella valves

Poison glands

Dufours gland

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The venom gland consists of 2 long secretory tubules (stu)

Unite to form a common duct (du)

Opening into the venom sac (vs)

Venom sac opens into the cavity of the bulb (bu)

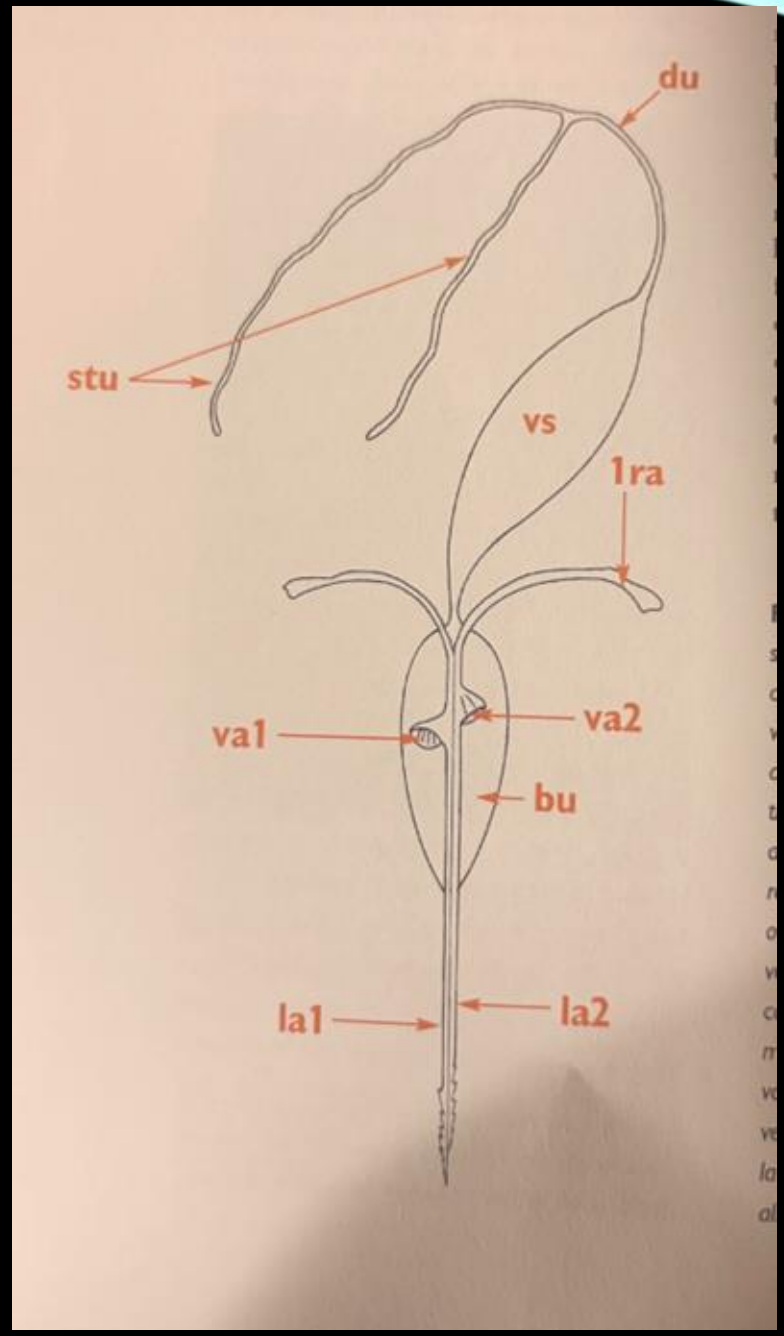
Venom drawn through the bulb into the venom canal by the action of the lancet valves (va1 & va2) and the first ramus (1ra)

As each lancet moves downwards it extends its valve, sweeping the venom ahead into the venom canal.

As the lancet moves upwards its valve collapses allowing the fluid to move past it

One sting: about 50–140 µg of venom delivered

The longer the sting is in place the more venom is delivered



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How it works – the mechanics

The bee curves its abdomen downwards with the sting at an angle of 90 deg to the skin of the victim

The legs and abdominal muscles push the sting downwards

The oblong plates either side of the bulb remain fixed

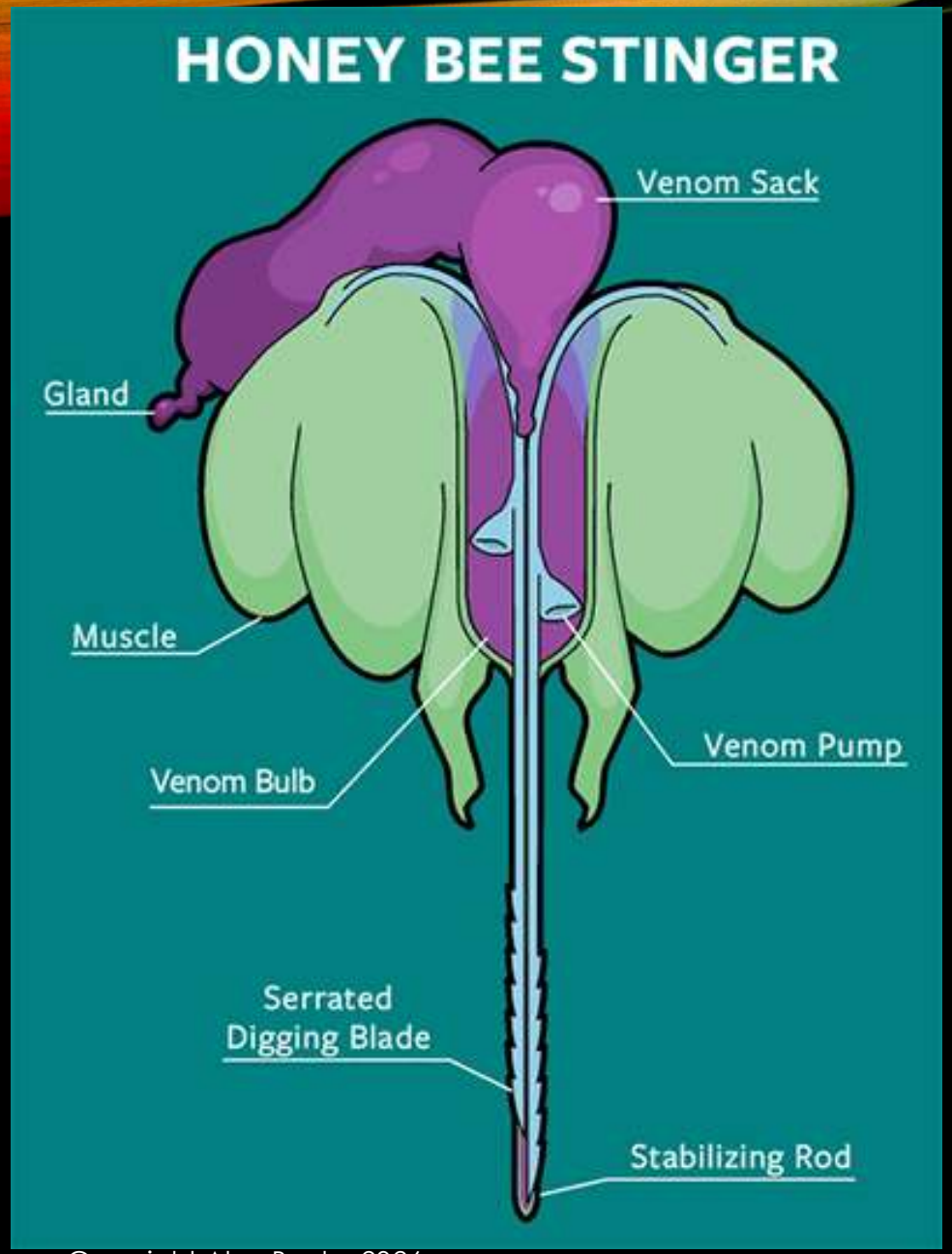
The protractor muscle contracts pulling the quadrate plate forward onto the triangular plate

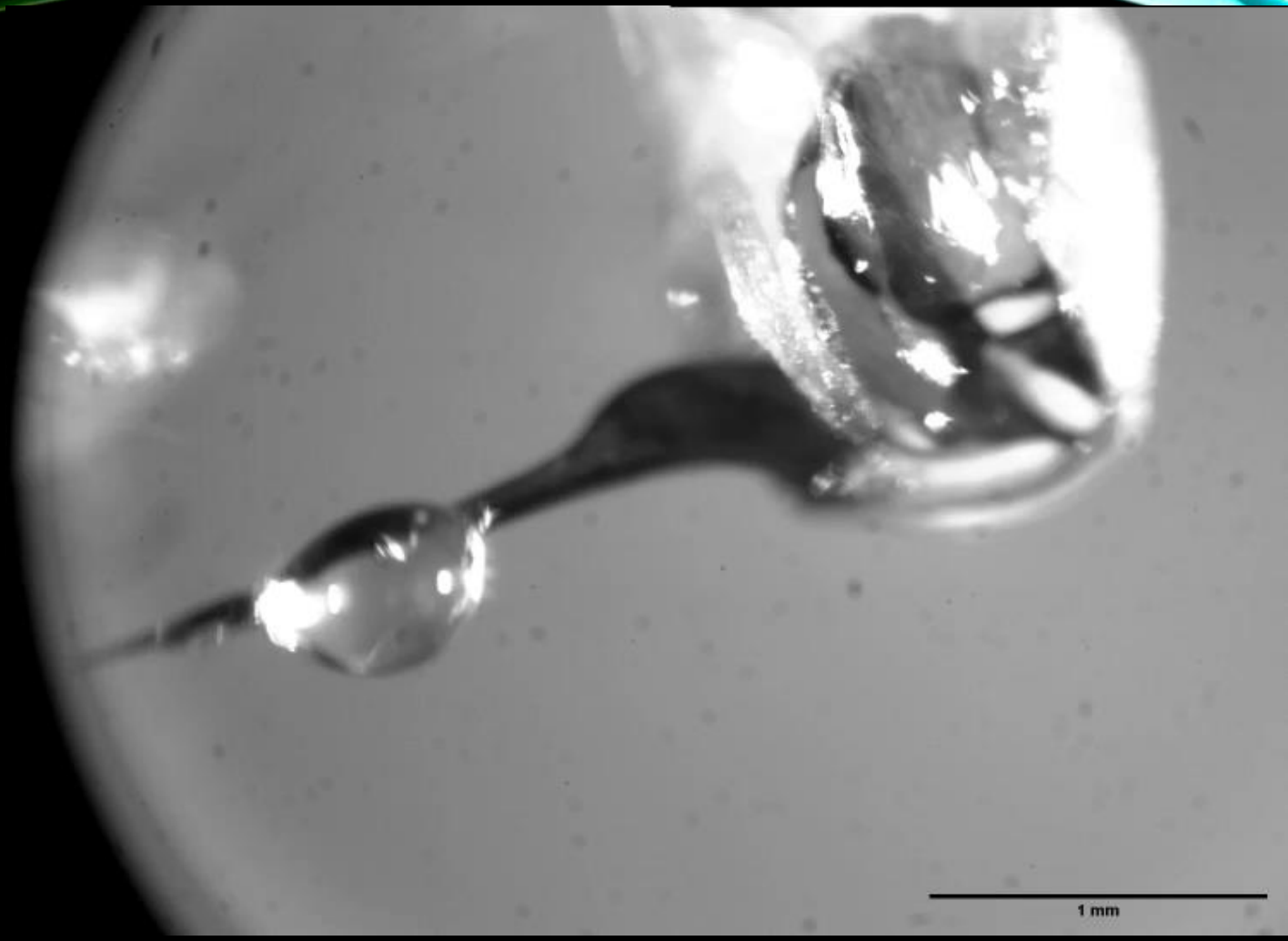
The triangular plate swings on its articulation with the oblong plate

The third corner of the triangular plate is fixed to the ramus of the lancet

The lancet is forced downwards into the skin of the victim

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Unfortunately for the bee the barbs of the sting prevent it from retracting the sting.

When it withdraws the sting mechanism

the terminal ganglion of the central nervous system is detached with it

and continues to activate the muscles pushing the the sting deeper into the wound





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THE QUEEN

Has a sting but it is

Curved

Smooth

Thicker than worker

Attached to the body

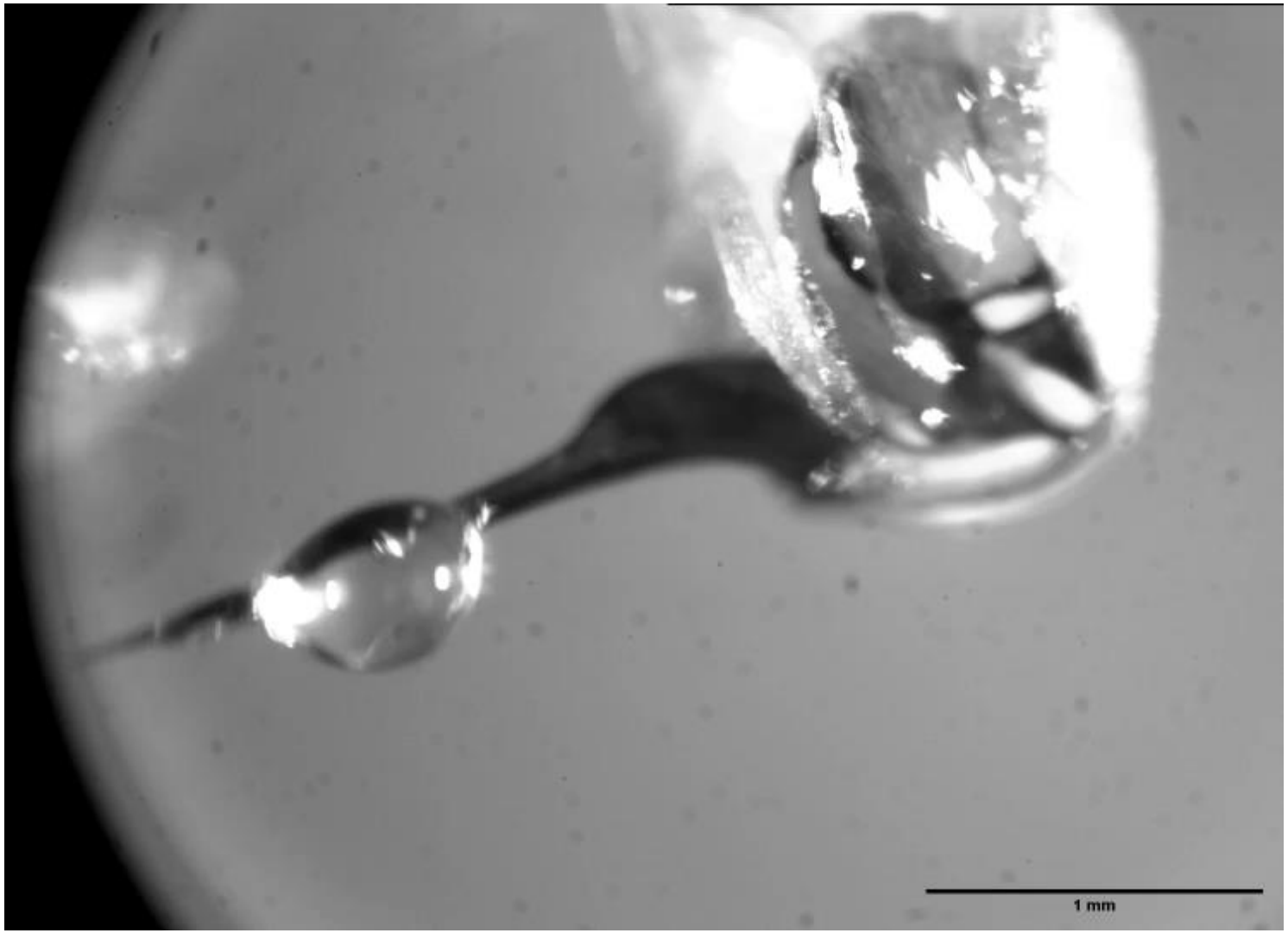
Venom gland longer

Venom sac larger

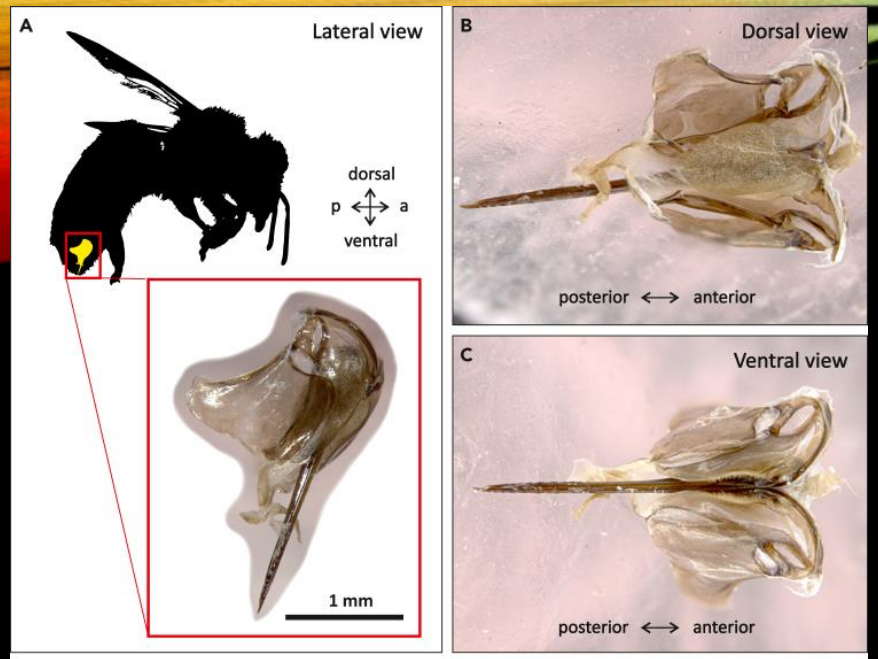
Enables queen to sting multiple times when killing larvae in queen cells or fighting with rivals

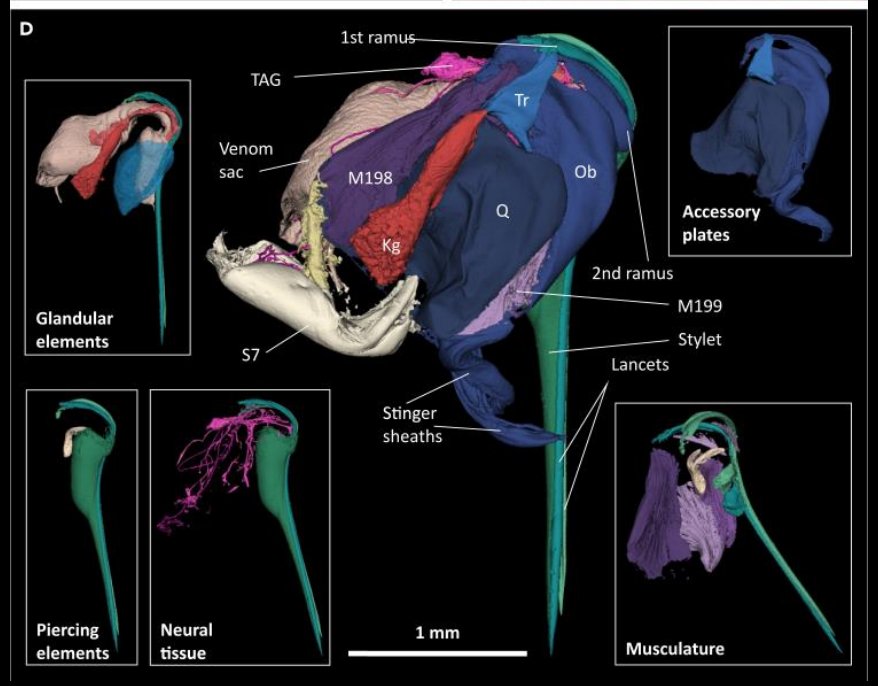


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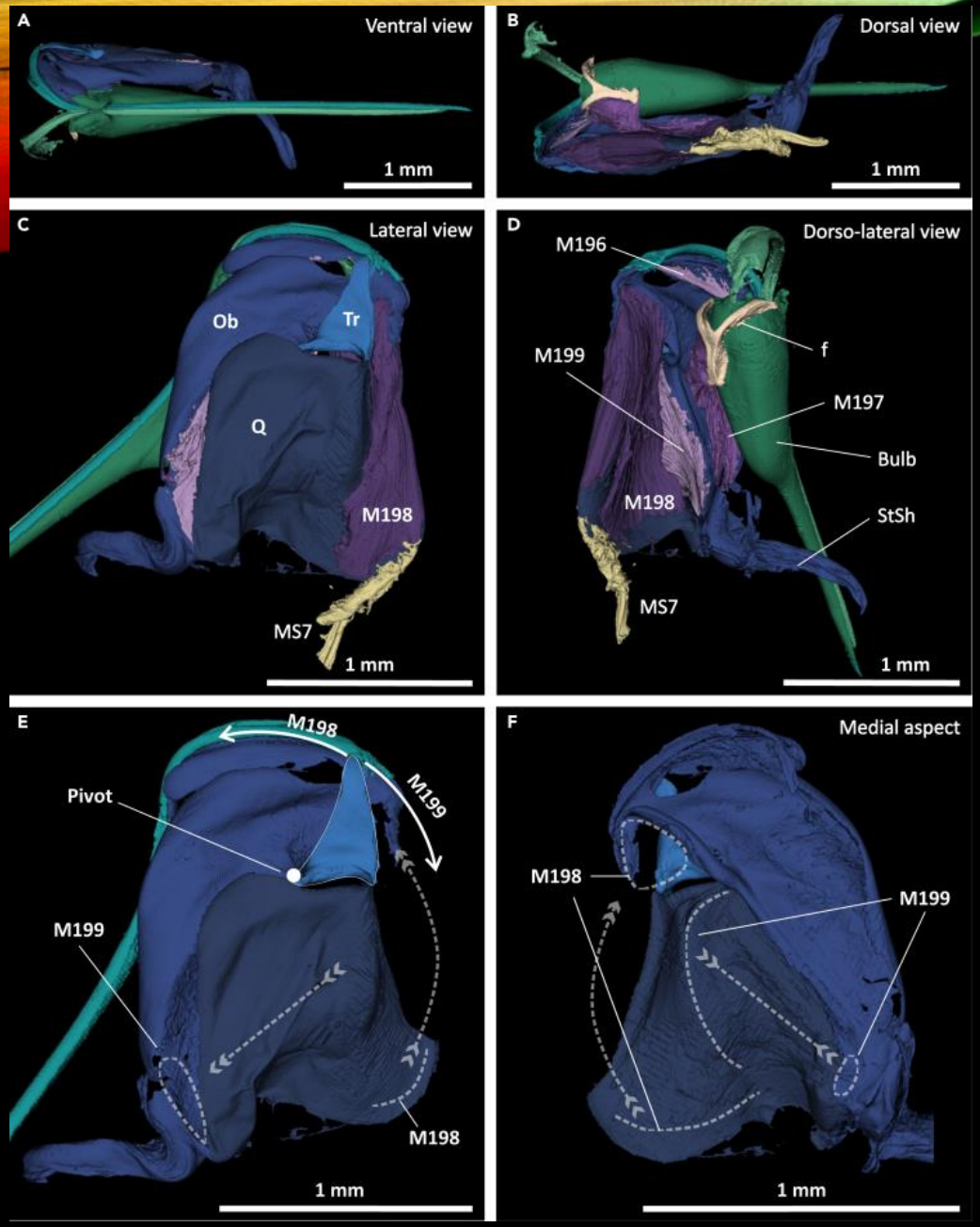


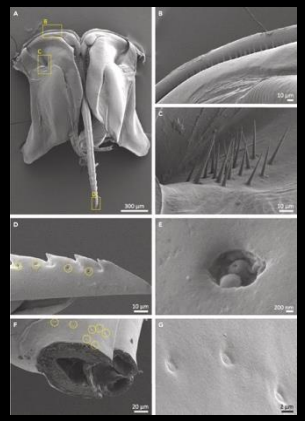
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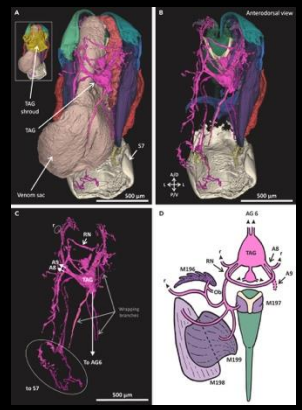




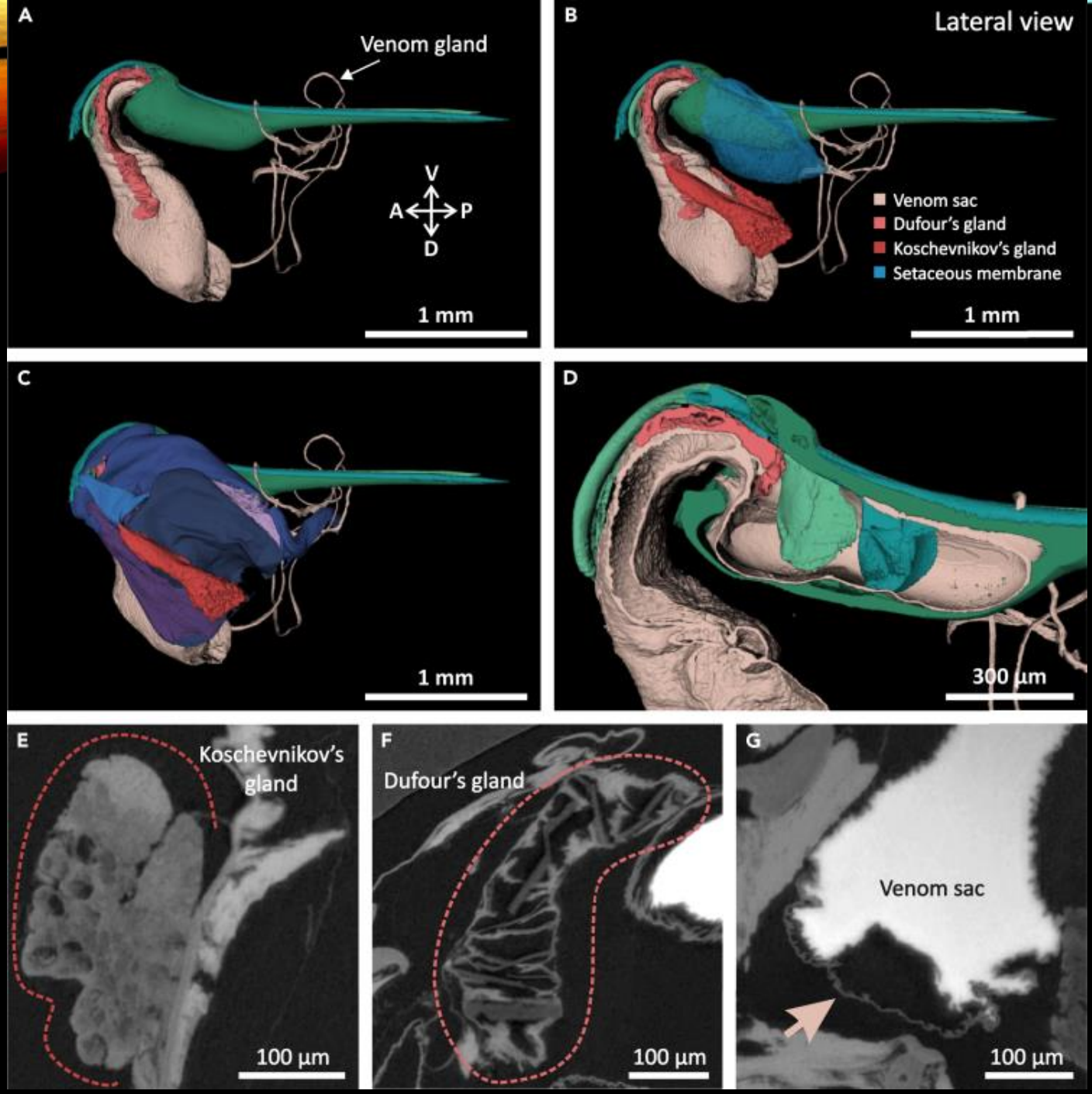
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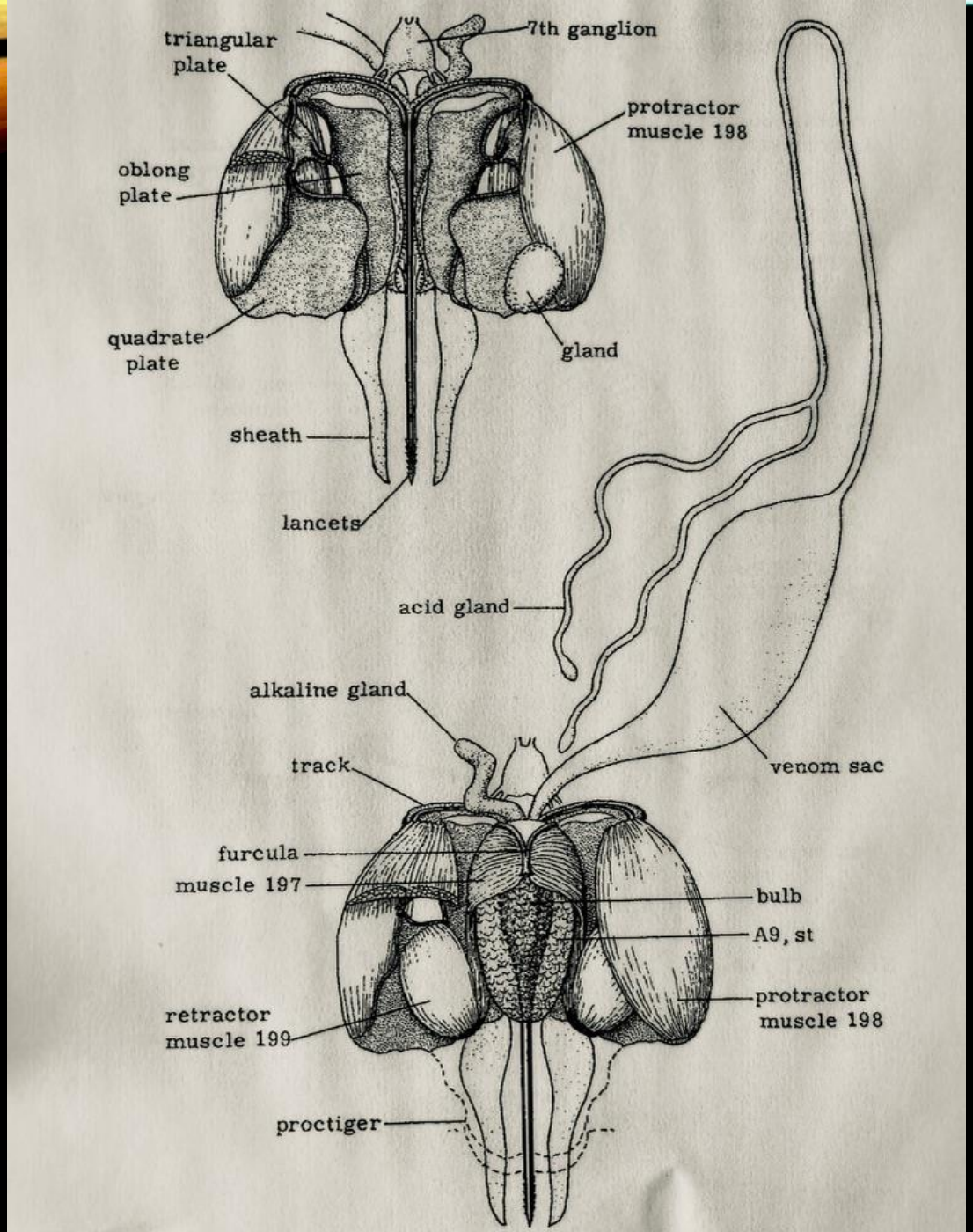


PLATE 11. The sting apparatus.

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