

# Don't Fear Me: Spiders

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2026-01-29



# Content

- **Overview of Arachnids: Diversity, Classification, and Representative Species ----- Zijian Liang**
- **Superpowers in Action: Key Behaviors and Sensory Strategies in Arachnids ----- Dongliang Chen**
- **Why Arachnids Matter: Applications in Biomaterials, Medicine, and Ecology ----- Chang Li**

# Overview of Arachnids: Diversity, Classification, and Representative Species

Zijian Liang  
2026-01-27

**Do you like spiders ?**

# Why Spiders Scare Us: Pop-Culture Stereotypes

WARHAMMER COMMUNITY



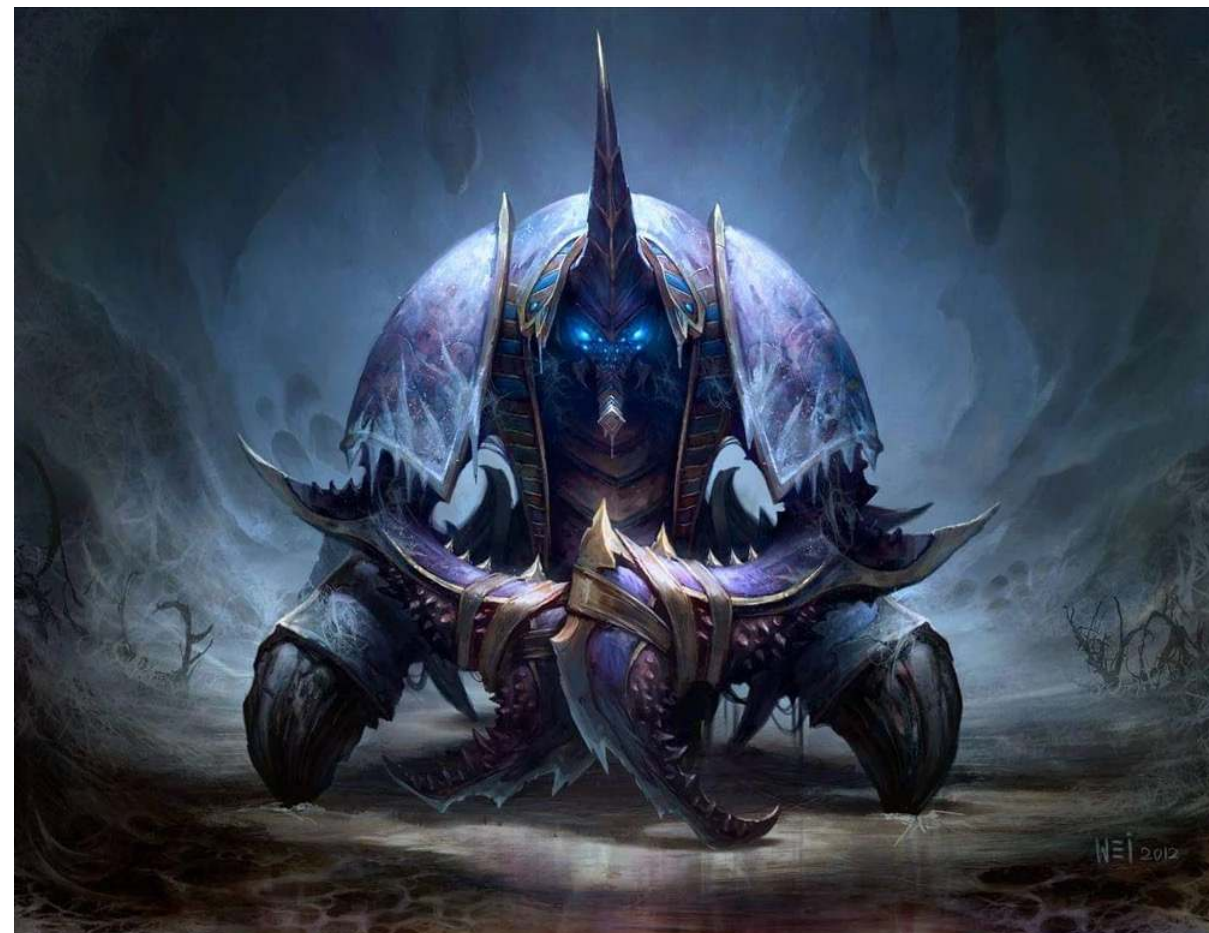
**Shelob** — *The Lord of the Rings: The Two Towers* (2002)



**Aragog** — *Harry Potter and the Chamber of Secrets* (2002)



**Spiders (swarm trope)** — *Eight Legged Freaks* (2002)



**Anub'arak** — *Warcraft III: The Frozen Throne* (2003)

# Spiders as Heroes: Friendly Faces in Pop Culture



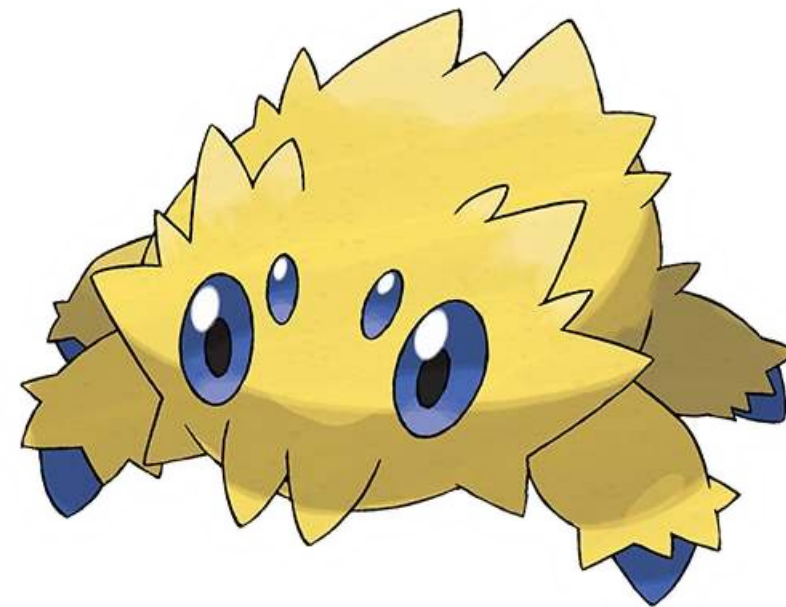
**Spider-Man** — Marvel Comics: *Amazing Fantasy* #15 (1962)



**Charlotte A. Cavatica** — *Charlotte's Web* (1952)



**Lucas**— *Lucas the Spider* (2017)



**Joltik** — *Pokémon Black and White* (2010)

## Tarantulas Up Close: Who's Who in Our Tanks



*Chromatopelma cyaneopubescens*



*Avicularia versicolor*



*Nhandu vulpinus*



*Brachypelma hamorii*

## Insects

vs.

## Spiders



- 3 main body parts
- 6 legs
- 2 pairs of wings
- 2 compound eyes
- 2 antennae



- 2 main body parts
- 8 legs
- No wing
- 2-8 simple eyes
- 2 Pedipalps and 2 fangs

**scorpion**  
(Scorpiones)



12–210 mm

**spider**  
(Araneida)



0.5–90 mm

**acarid**  
(Acari)



0.1–30 mm

# World Spider Catalog (WSC): Spider diversity in numbers

## World Spider Catalog

Version 26

**139**

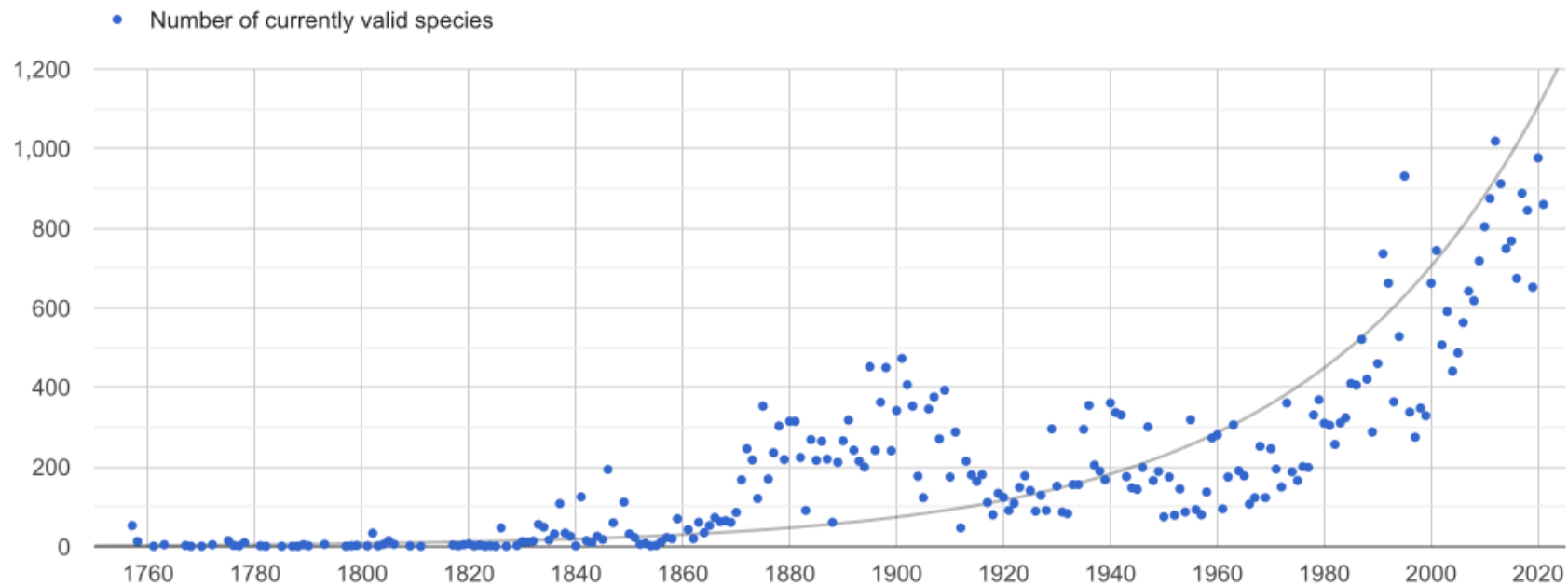
FAMILIES

**4,502**

GENERA

**53,680**

SPECIES



# Arachnid Zoo Tour: Major Orders at a Glance

## Class : Arachnida

Includes 2 superorders and 10 extant orders



Mites  
(Acariformes)



Scorpions  
(Scorpiones)



Small whipscorpions  
(Schizomida)



Harvestmen  
(Opiliones)



Camel spiders  
(Solifugae)



Spiders  
(Araneae)



False scorpions  
(Pseudoscorpiones)



Ricinuleids  
(Ricinulei)



Mites and Ticks  
(Parasitiformes)



Micro whipscorpions  
(Palpigradi)



Whipscorpions  
(Uropygi)

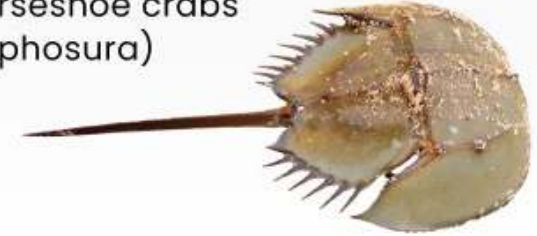


Whipspiders  
(Amblypygi)

## Class : Merostomata

Includes 1 extant order

Horseshoe crabs  
(Xiphosura)



## Class : Pycnogonida

Includes 1 extant order

Sea spiders  
(Pantopoda)

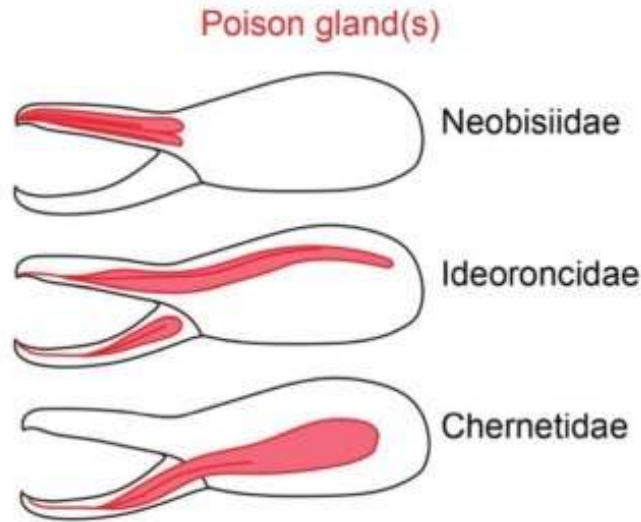
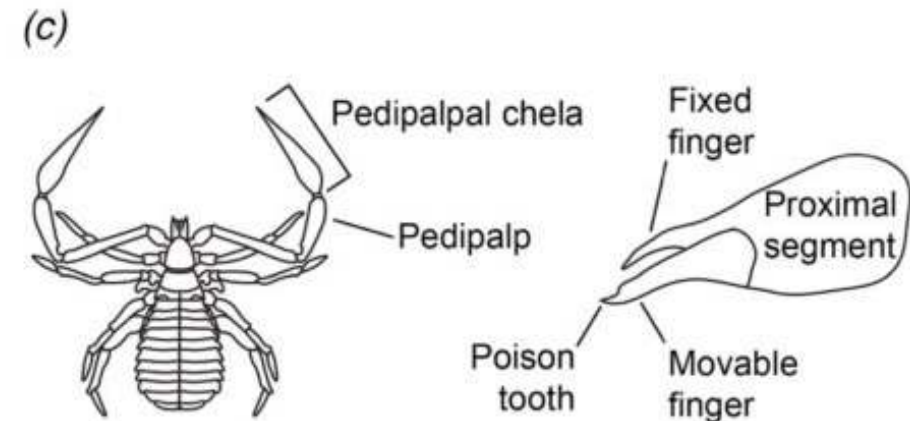




**Harvestmen (Order: Opiliones)** are arachnids often mistaken for spiders.

- They typically have a **more unified body outline** (no obvious “narrow waist”) and **do not produce silk**.

- Many rely on **chemical defenses** and diverse life histories, making them a great example of arachnid diversity beyond spiders.



**Pseudoscorpions (Order: Pseudoscorpiones)**  
**Scorpions (Order: Scorpiones)**  
 They scorpion look-alikes with large pincers but no tail and stinger.  
 Recognizable by the **elongated tail (metasoma) and stinger, plus robust pedipalps.**  
 Many species deliver venom via a **poison tooth** on the pedipalp, and some have **venom glands** in the **chela**.  
**parental care:** newborns often ride on the mother's back.

• Often overlooked, yet they are effective **micro-predators** in leaf litter, under bark, and even indoors (“book scorpions”).



**Whip spiders (Order: Amblypygi)** are arachnids, but **not true spiders** (*Araneae*).

- Their first pair of legs is modified into **antenna-like feelers** for navigation and prey detection.
- Enlarged pedipalps act as **raptorial “claws”**, enabling fast, precise ambush strikes.
- Many species show notable **parental care**, with females carrying offspring on the abdomen.



**Whip scorpions / vinegaroons (Order: Uropygi) have a whip-like terminal flagellum (no stinger).**

- They defend themselves using **chemical secretions** (the “vinegar” nickname).

- Despite the name, they are **not true scorpions** (*Scorpiones*).



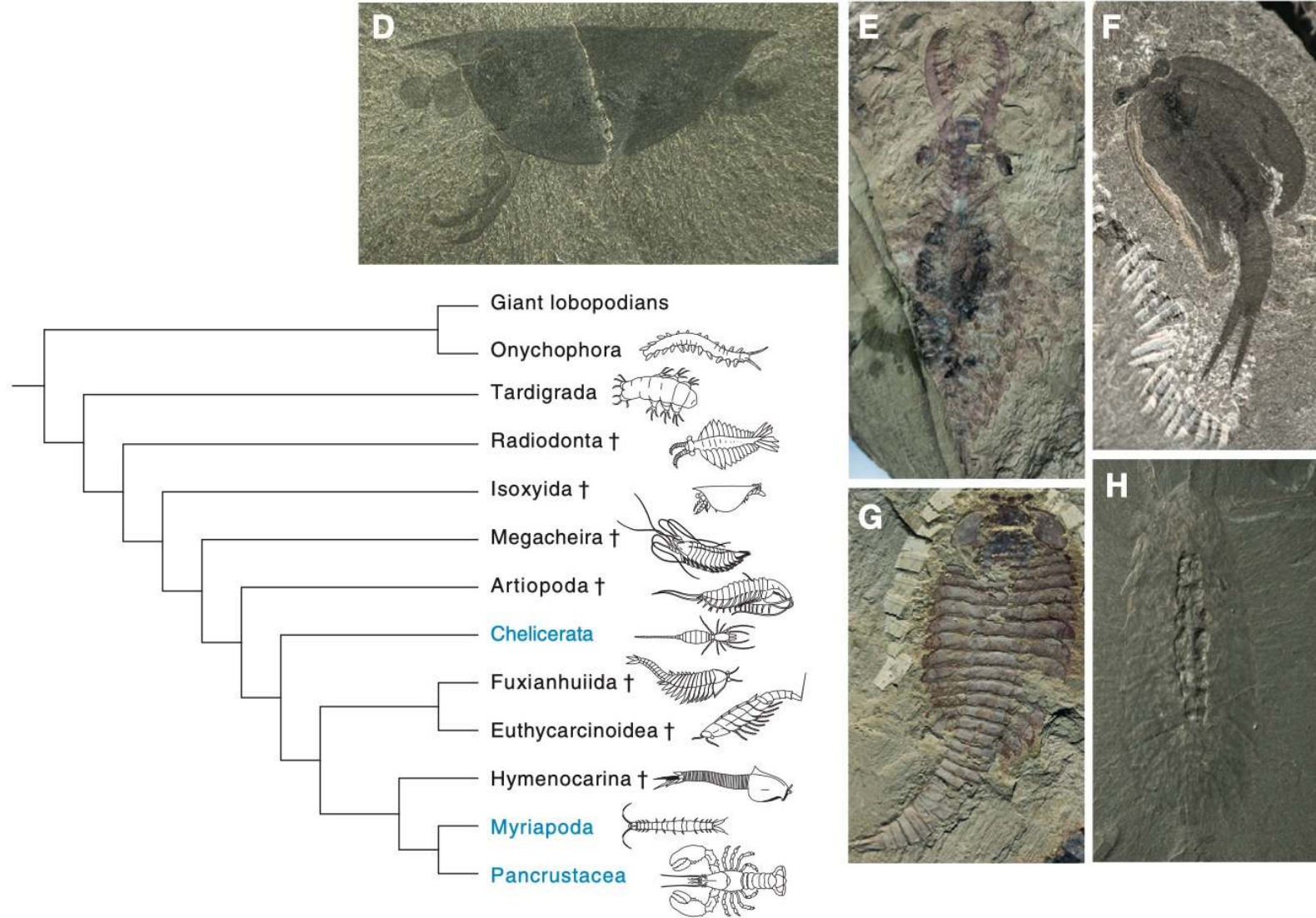
**Solifugae (“camel spiders”)** are fast-moving, cursorial arachnid predators

- Their most striking feature is the **massive chelicerae**, used for powerful prey capture and processing.

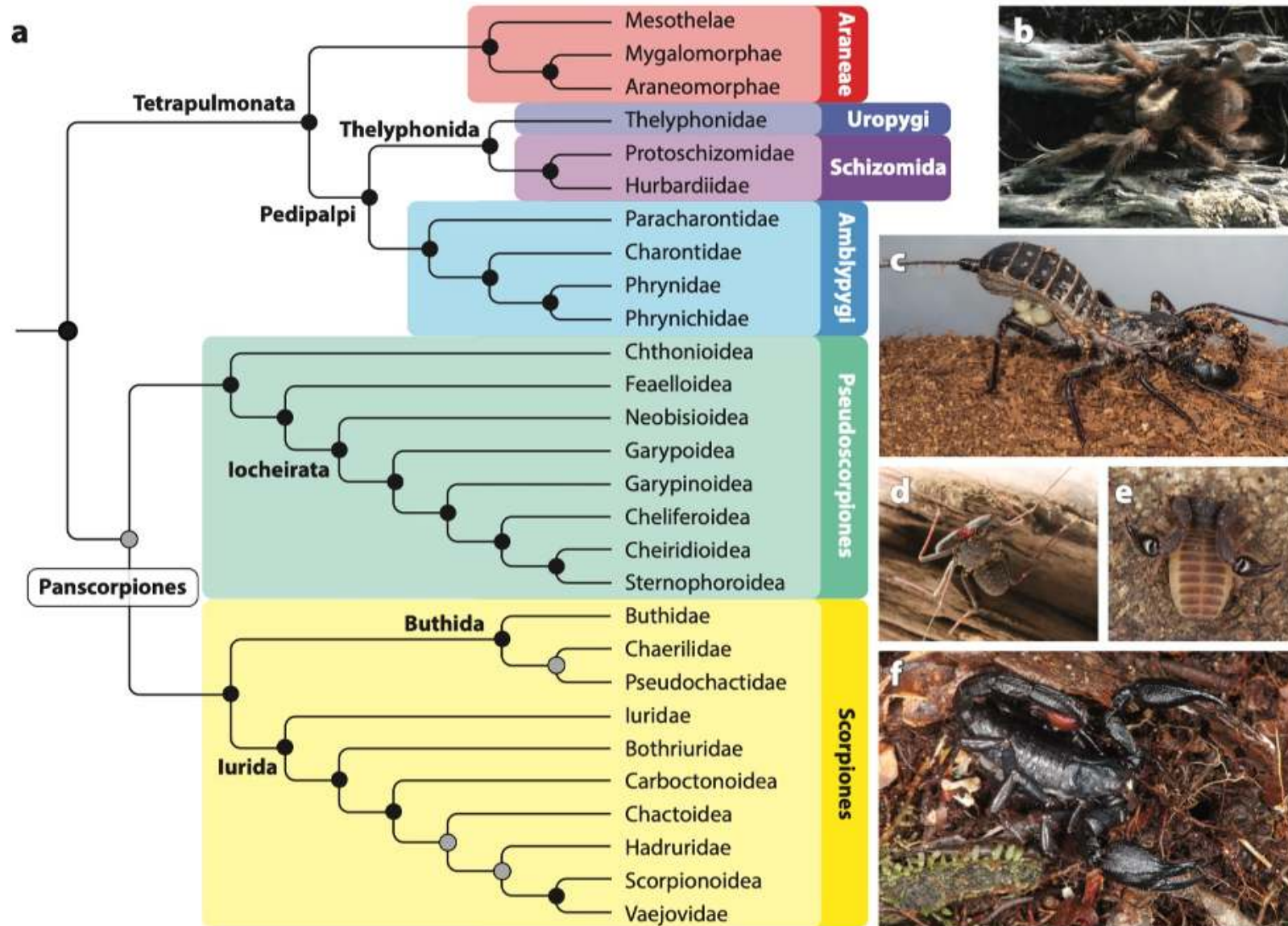
- Unlike web-building spiders, solifuges rely on **speed and direct pursuit**, not silk traps.

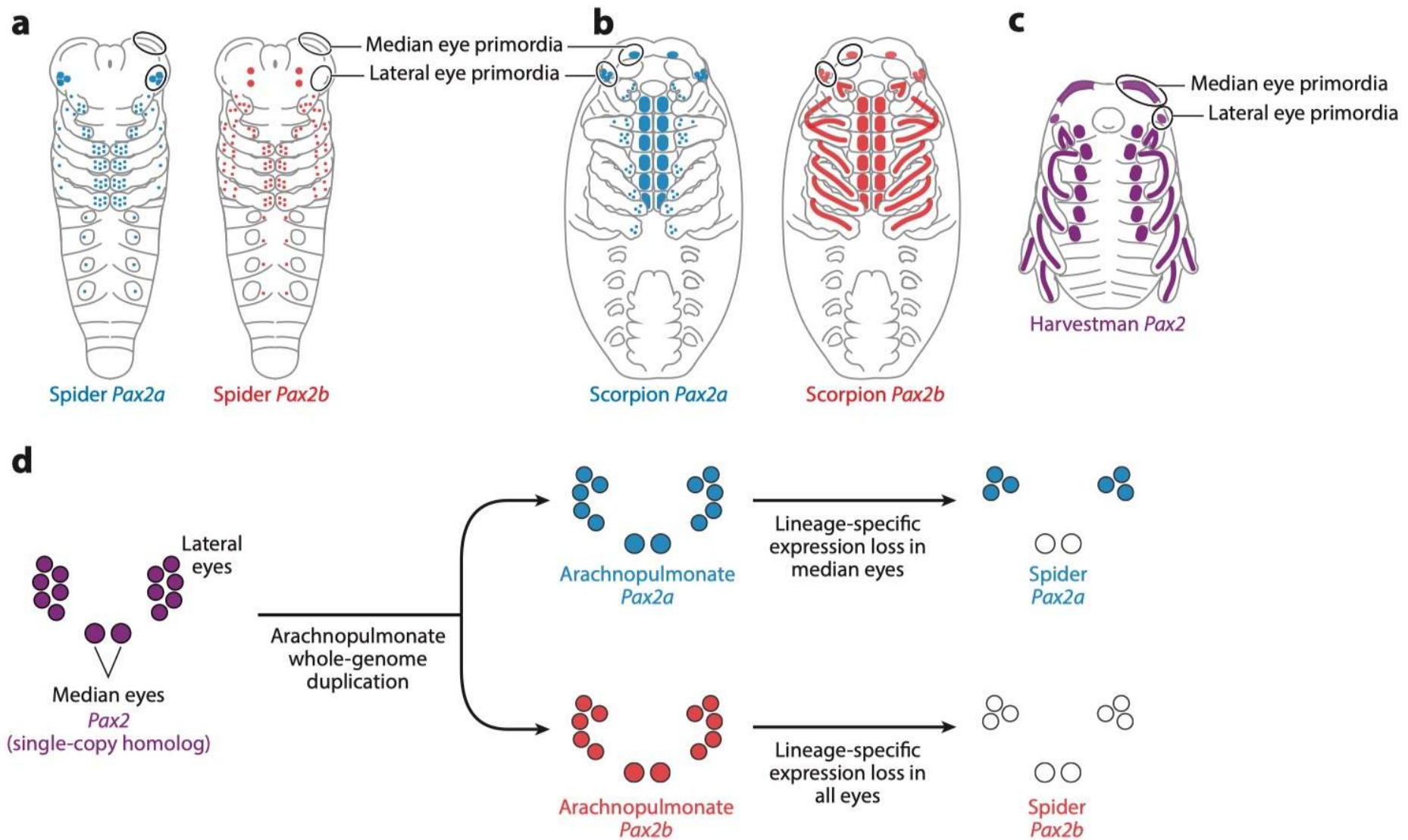
- **Parental care can occur in some species:** females may **guard the eggs and/or remain with hatchlings** in a burrow for a period.

# A Quick Arthropod Family Tree

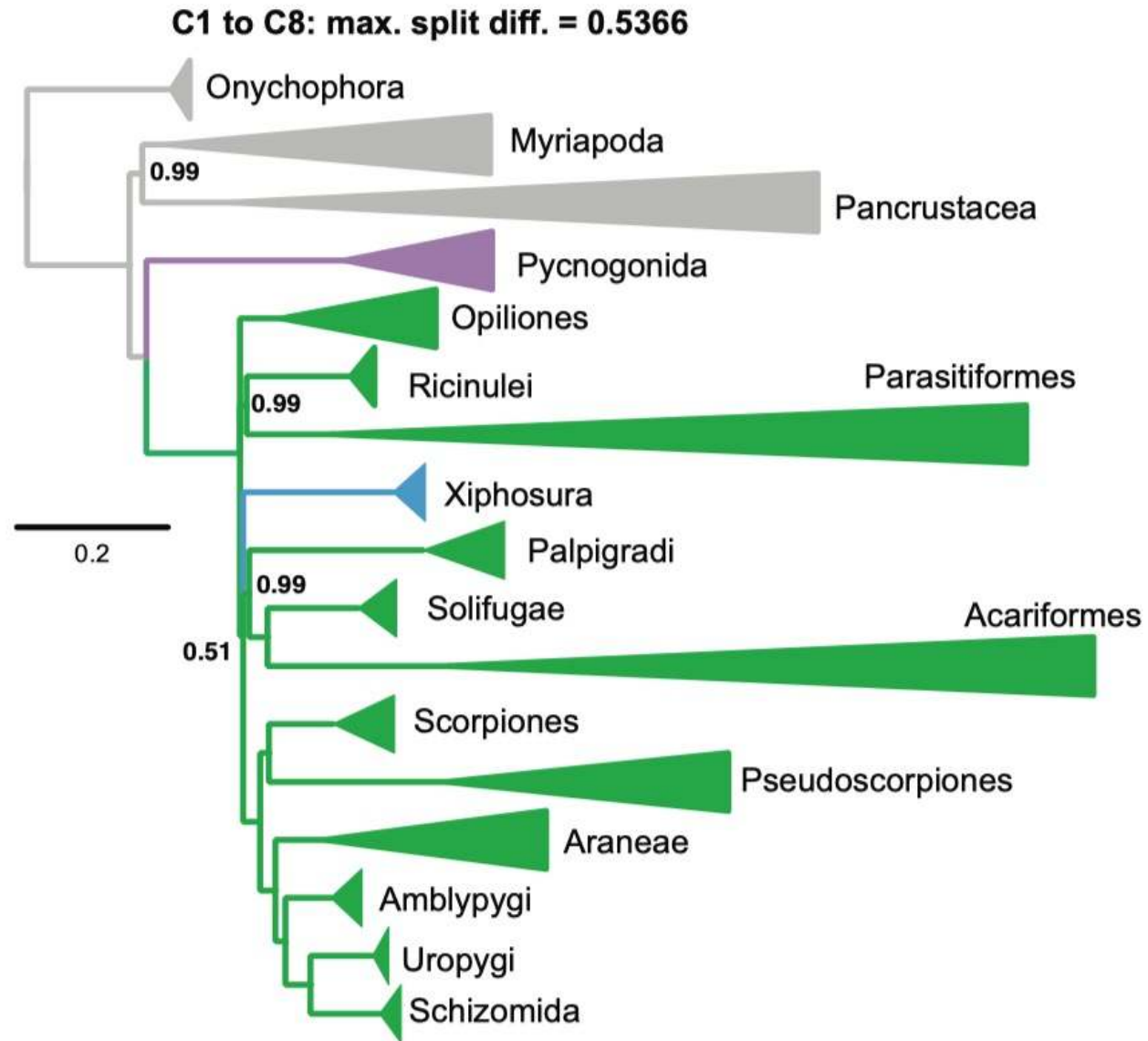


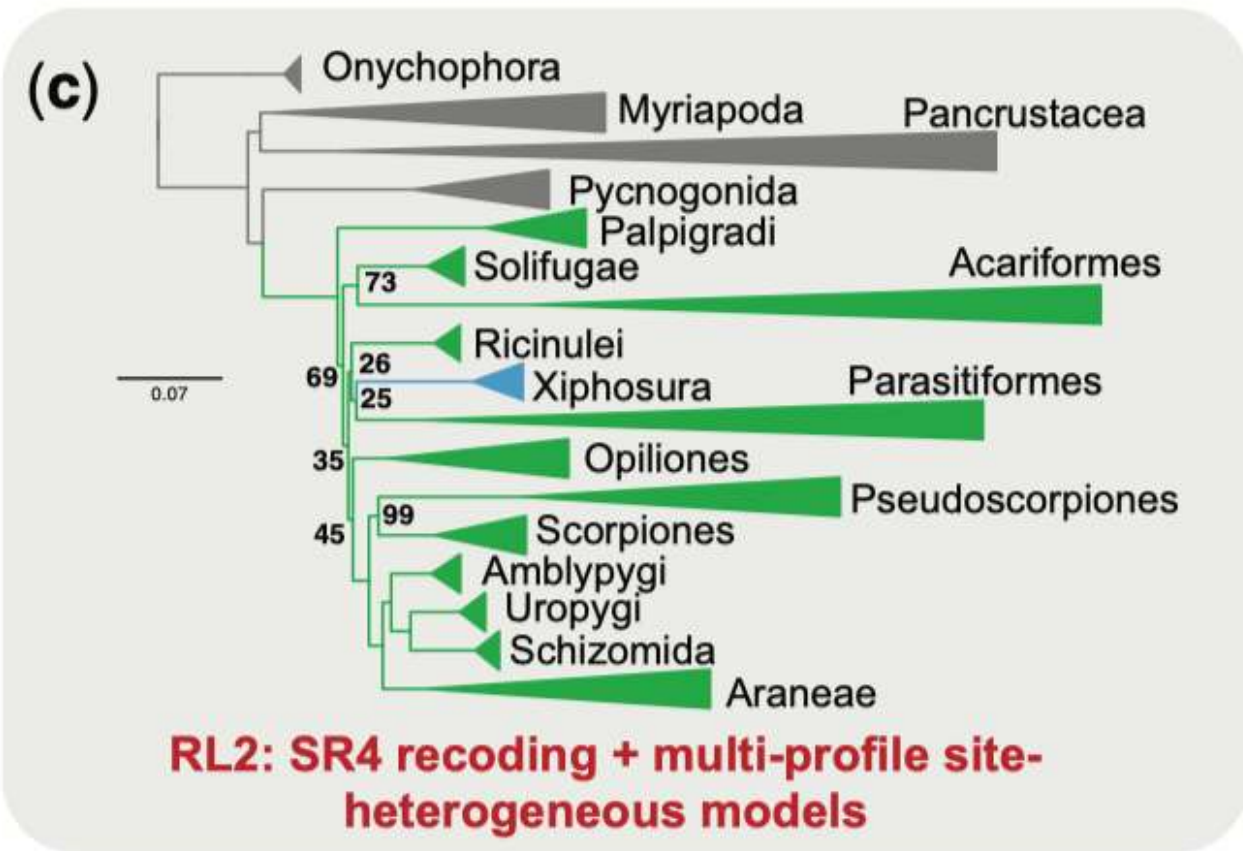
# Major Orders in an Evolutionary Context





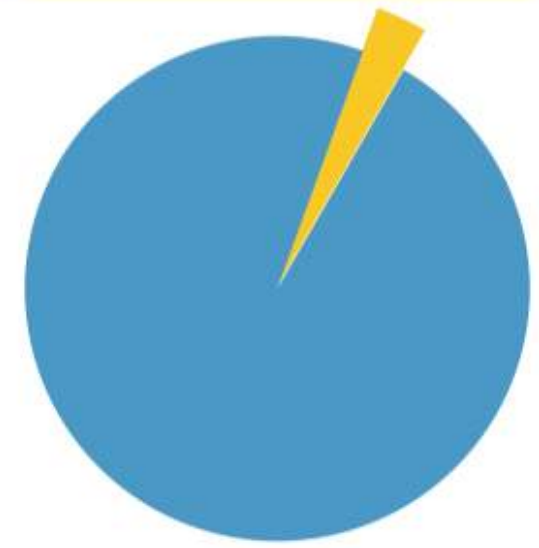
# An Ongoing Debate: Is “Arachnida” One Natural Group?





**All chains:**

Proportion of a *posteriori* tree space supporting Arachnida: **2.8%**



Proportion of a *posteriori* tree space supporting Xiphosura nested: **97.2%**

# Take home message

- **Arachnid diversity is deeper than “spiders”:** multiple orders (e.g., Scorpiones, Amblypygi, Uropygi, Solifugae, Acari) represent distinct evolutionary experiments in form and ecology.
- **Modern phylogenomics reframes chelicerate relationships:** major lineages can be placed in a clear evolutionary context, and genome-scale events (e.g., WGD) may provide raw material for diversification.
- **High-level classification is still evolving:** some analyses challenge the monophyly of “Arachnida,” reminding us that taxonomy is a hypothesis continuously updated by data and methods.

# Superpowers in Action: Sensory Strategies and Key Behaviors in Arachnids

从微型大脑到扩展认知：蜘蛛的感官极限与行为决策

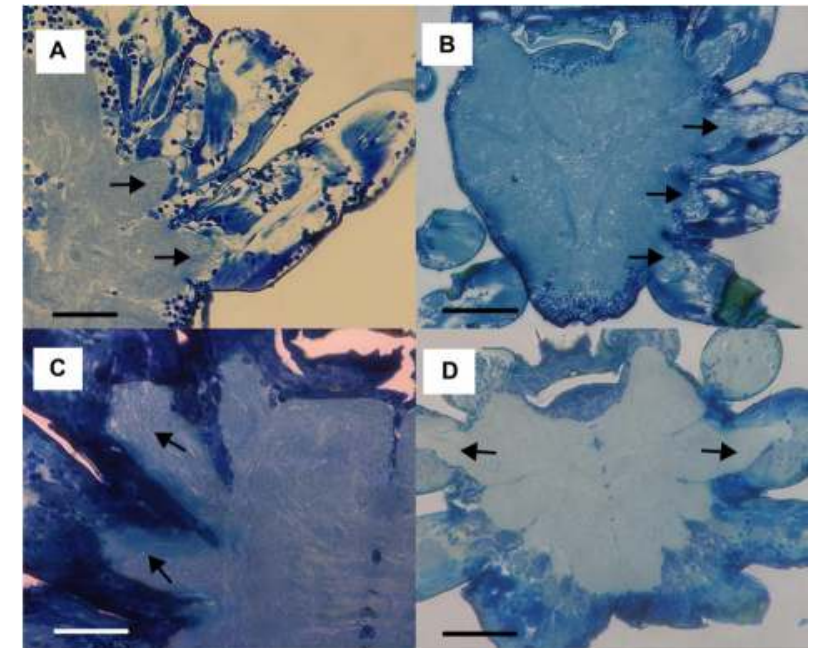
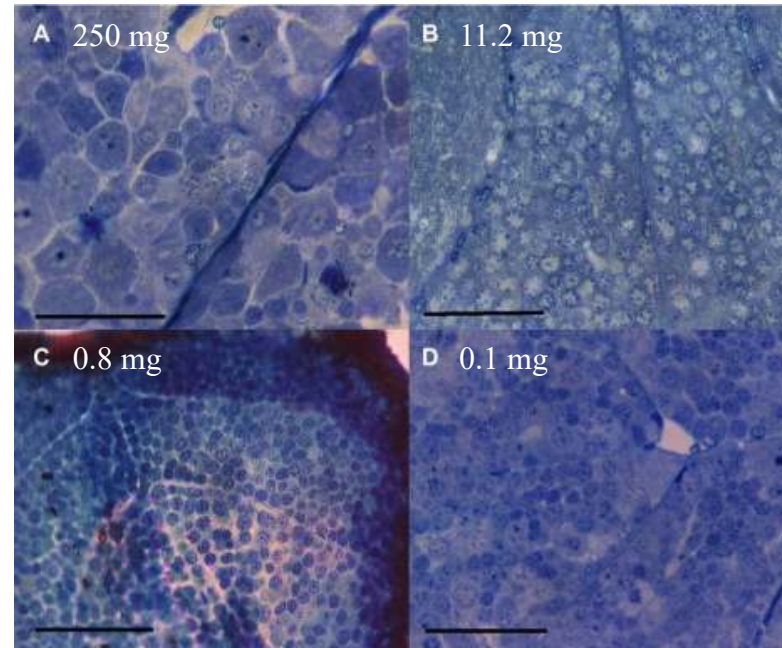
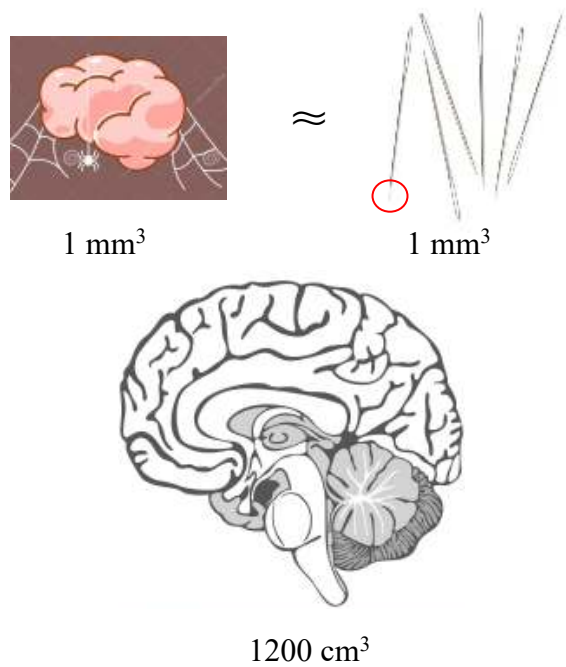
20260127  
陈东亮



- **The Sensory system of Arachnids**
- **The Key Behaviors in Arachnids**
- **An excellent animal for Cognition study**

## **How Spiders Feel the World?**

# Limitations of Spider Brain Volume

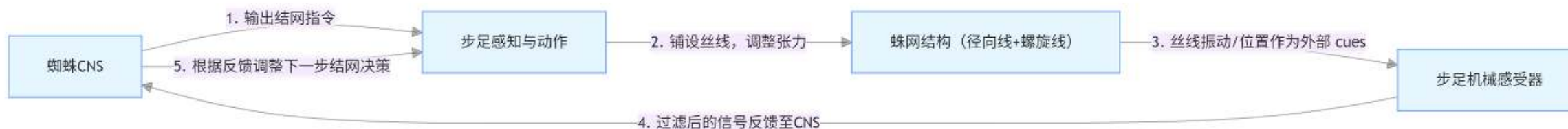


# The Spider Web: An Extension of Cognitive System

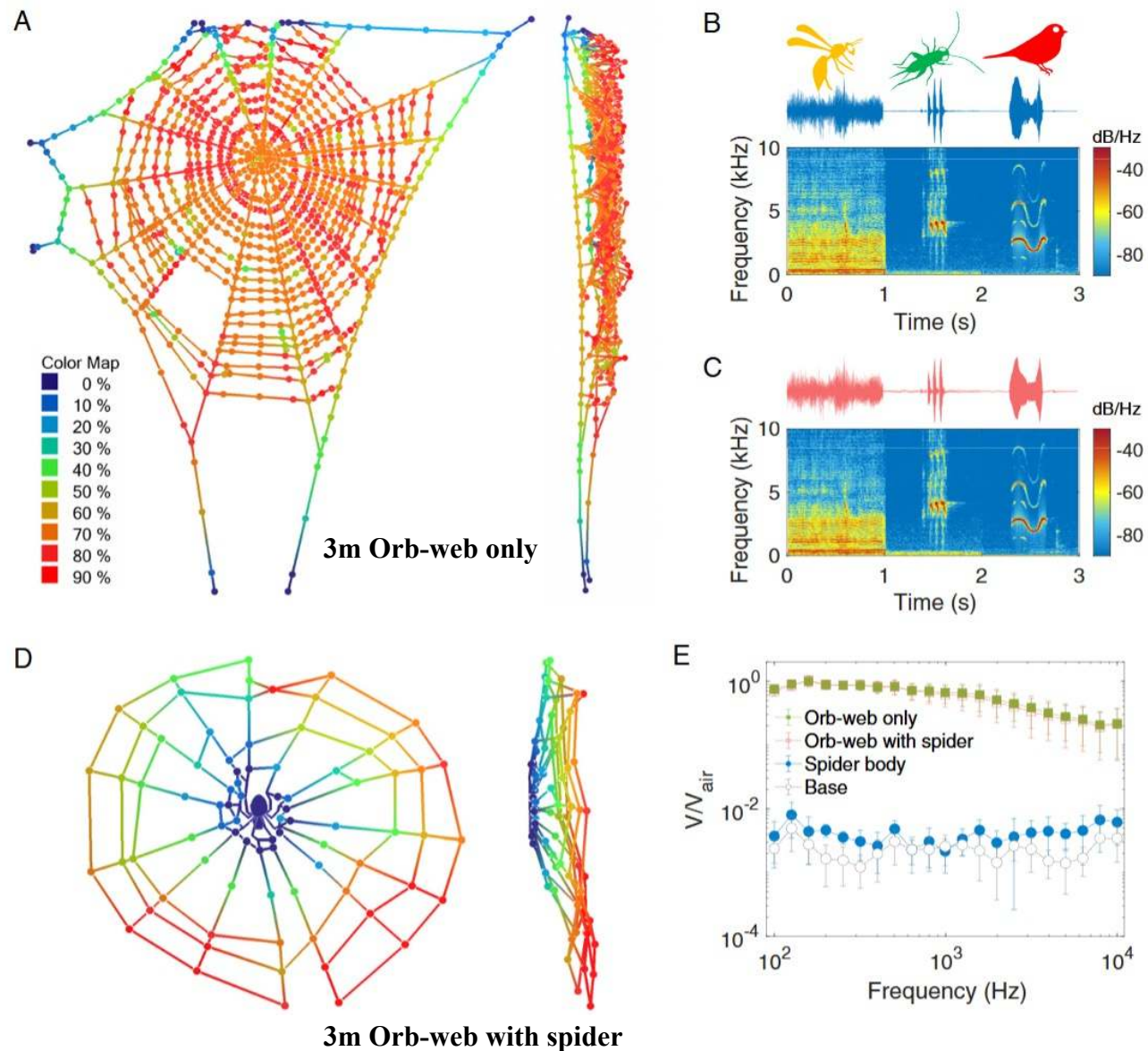
操纵蛛网→影响认知

操纵认知→影响蛛网

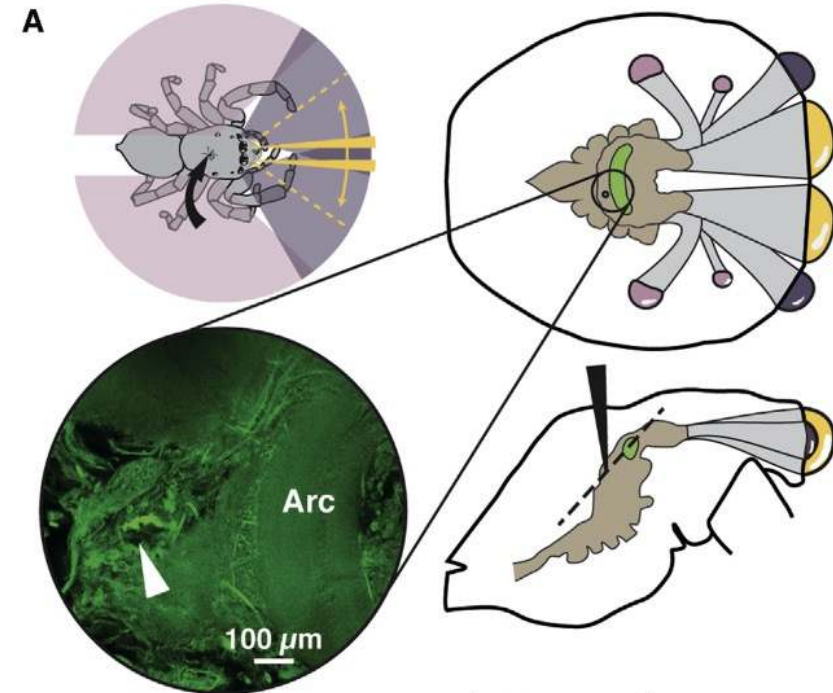
层级	组件	信号流向
核心层 (CNS)	神经中枢 (如 C3 区域、工作记忆模块)	接收外周层信号→输出调控指令至外周层
外周层 (身体)	步足感受器、纺丝腺	传递 CNS 指令至环境层→传递环境层信号至核心层
环境层 (蛛网)	径向线、螺旋线、丝线张力	接收外周层调控→反馈预处理信号至外周层



# The Web as a Hyperacute Acoustic Antenna

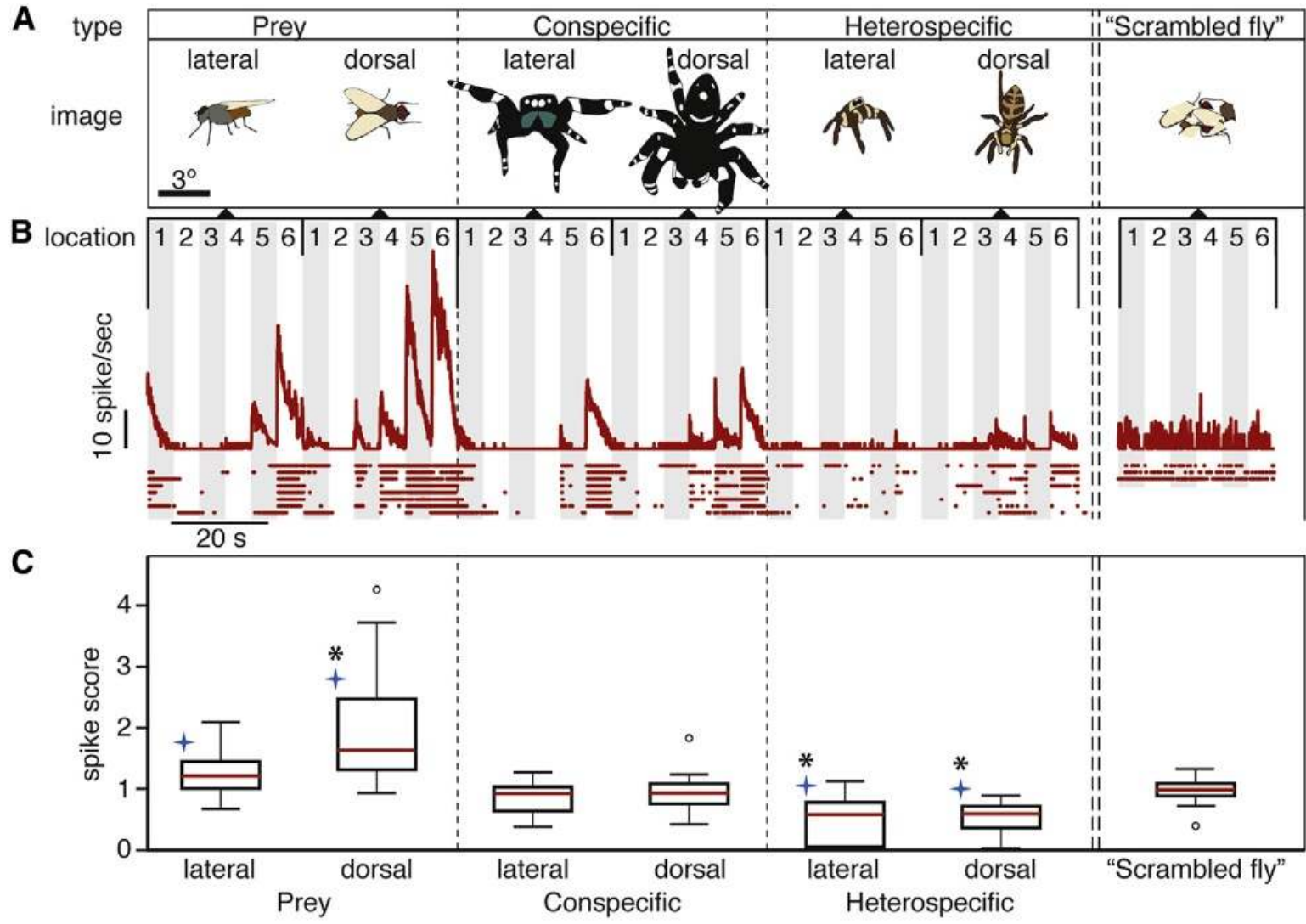


# How does jumping spider **see** the world

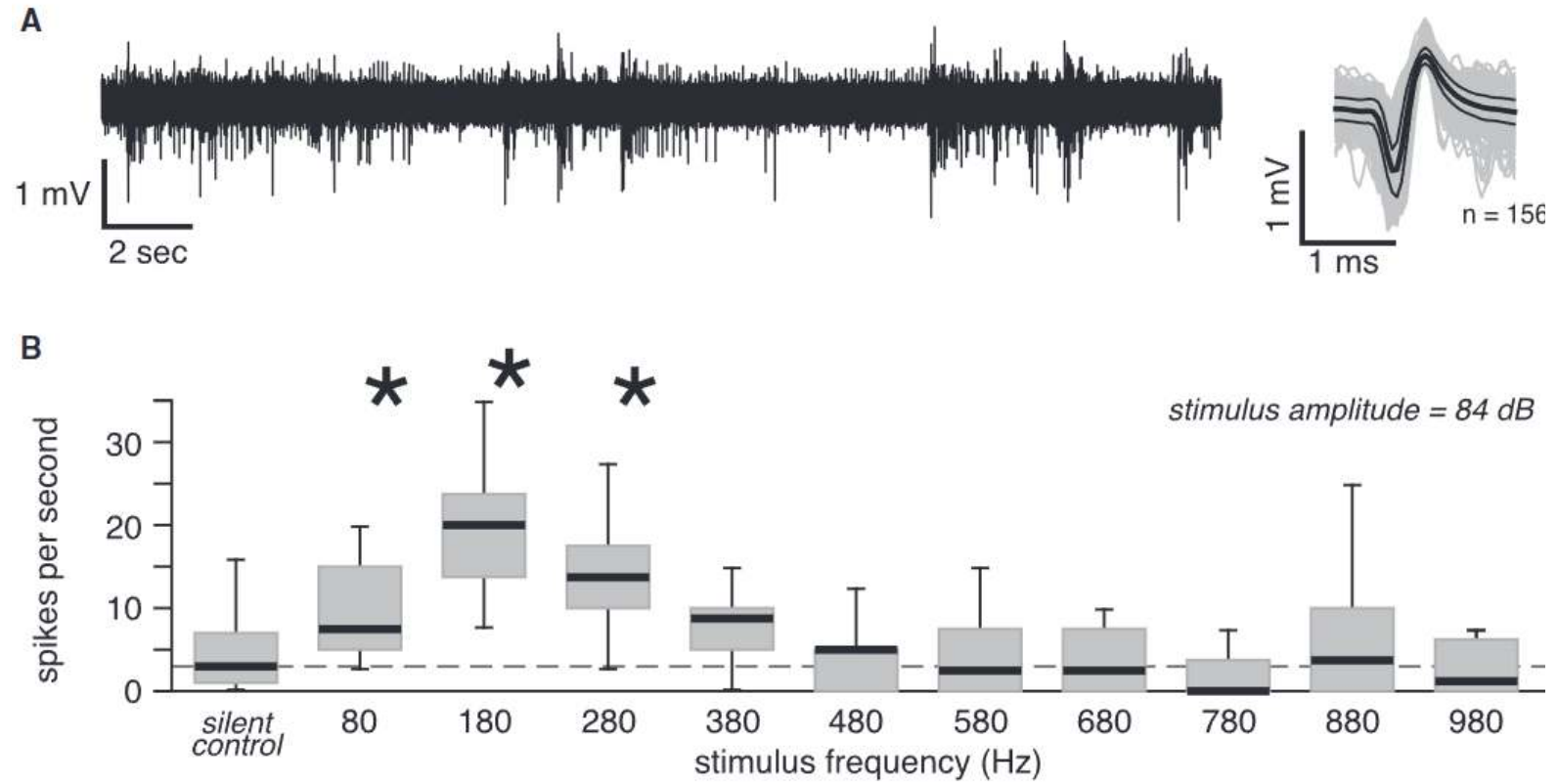
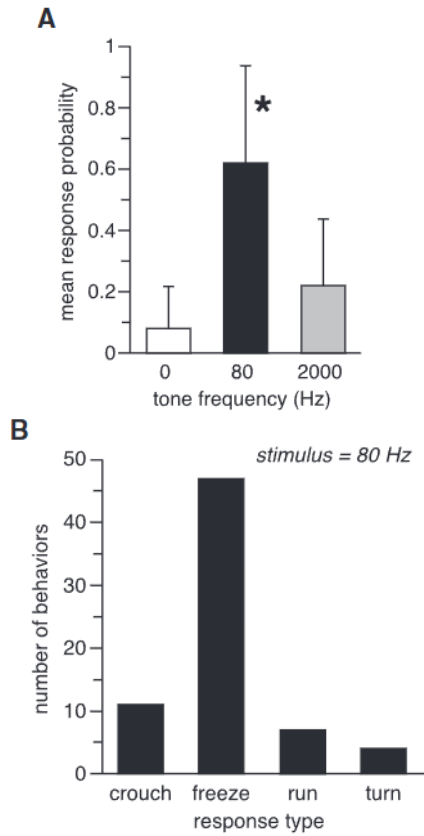
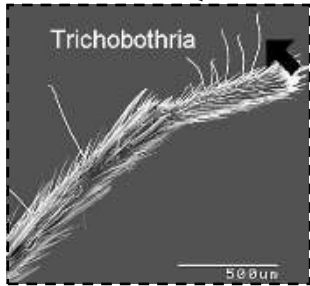
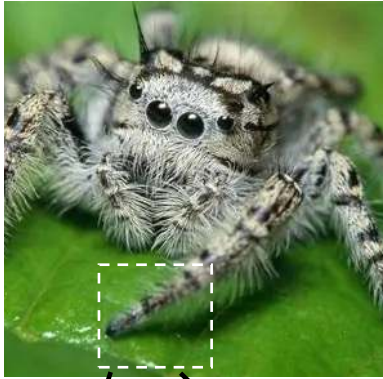


侧眼 360° 无盲区，主眼聚焦细节

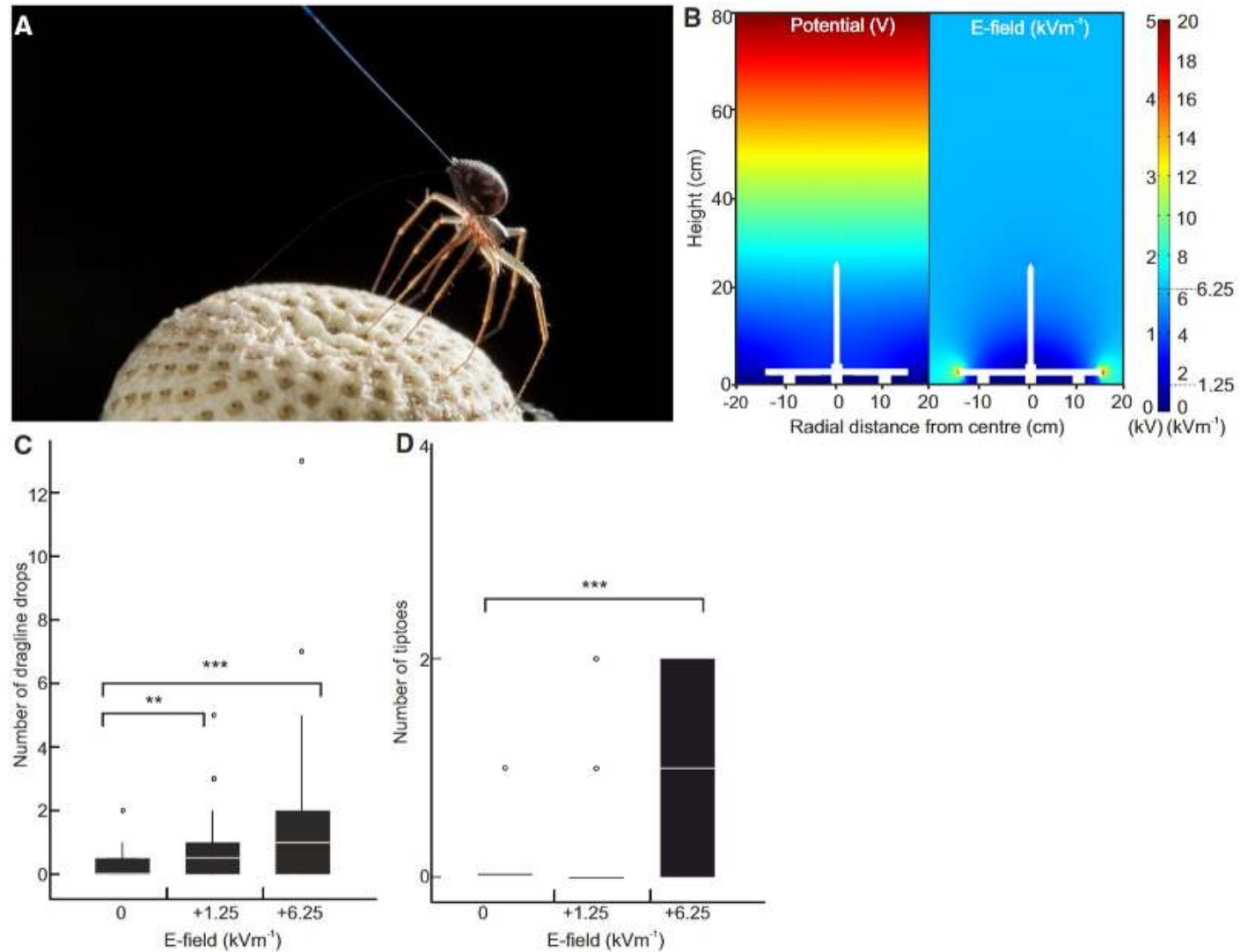
# Response to Ecologically Relevant Images of Jump Spider (*Salticidae*)



# Jumping Spiders Detect Distant Weak Airflow via Leg **Trichobothria**



# Spider Ballooning Behavior

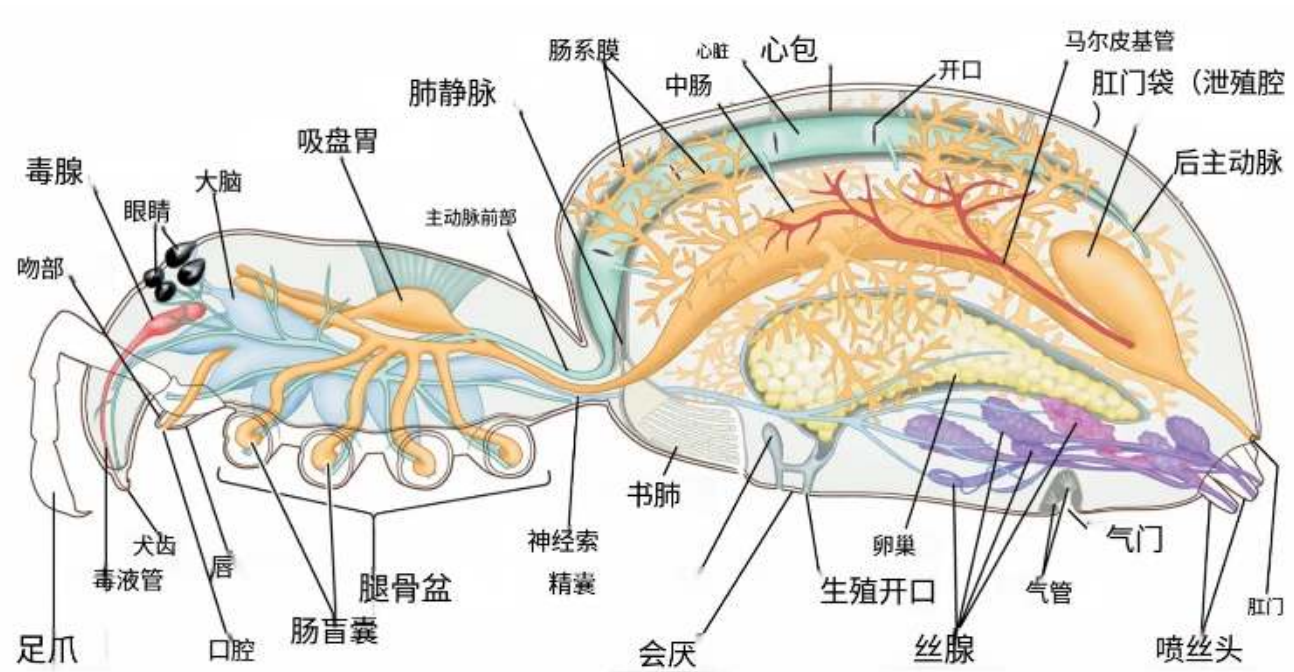


## **The special behavior of spider**

# Spider morphology



Sexual dimorphism of *Trichonephila clavata*



Spider anatomy. Internal organization of a spider.

## Spider mating positions

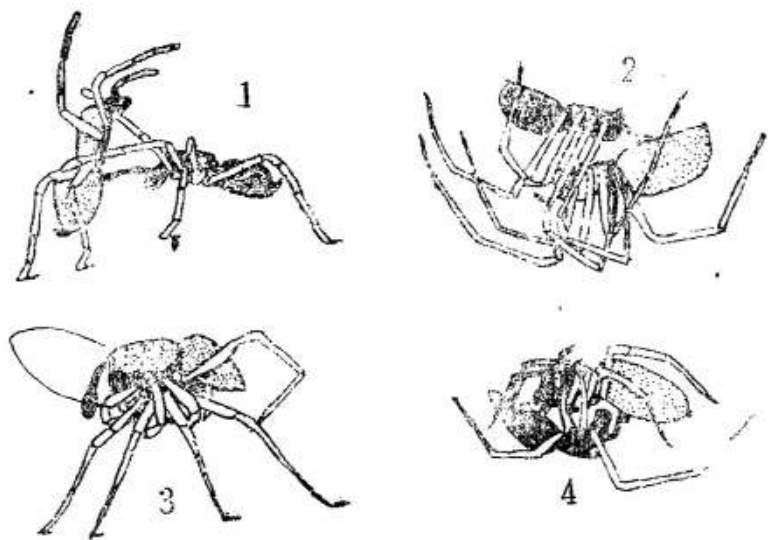


图 12. 各种蜘蛛的交配姿势  
1. 舞蛛 2. 皿网蛛 3. 狼蛛 4. 红螯蛛



知乎 (

# Courtship behavior



**Mating dance of *Maratus volans***

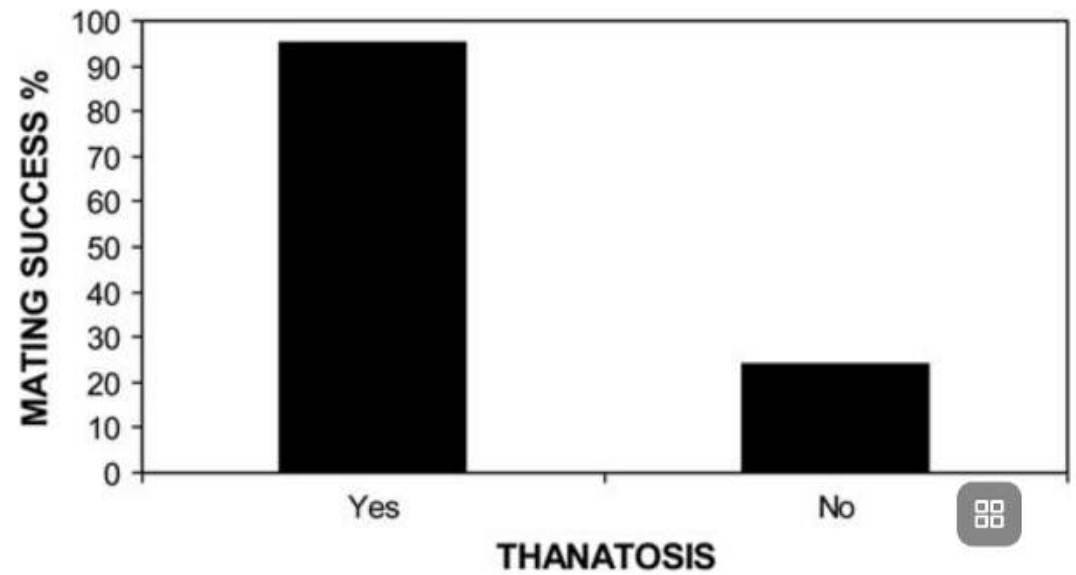


**crab spider**

## The thanatosis behavior of *Pisaura mirabilis*



*Pisaura mirabilis*



Thanatosis: 假死

Line Spinner Hansen, et al. Behavioral Ecology, Volume 19, Issue 3, May-June 2008.

## Female spider and her eggs



*Nursery-web spider*  
A female nursery-web spider  
carrying her egg sac.

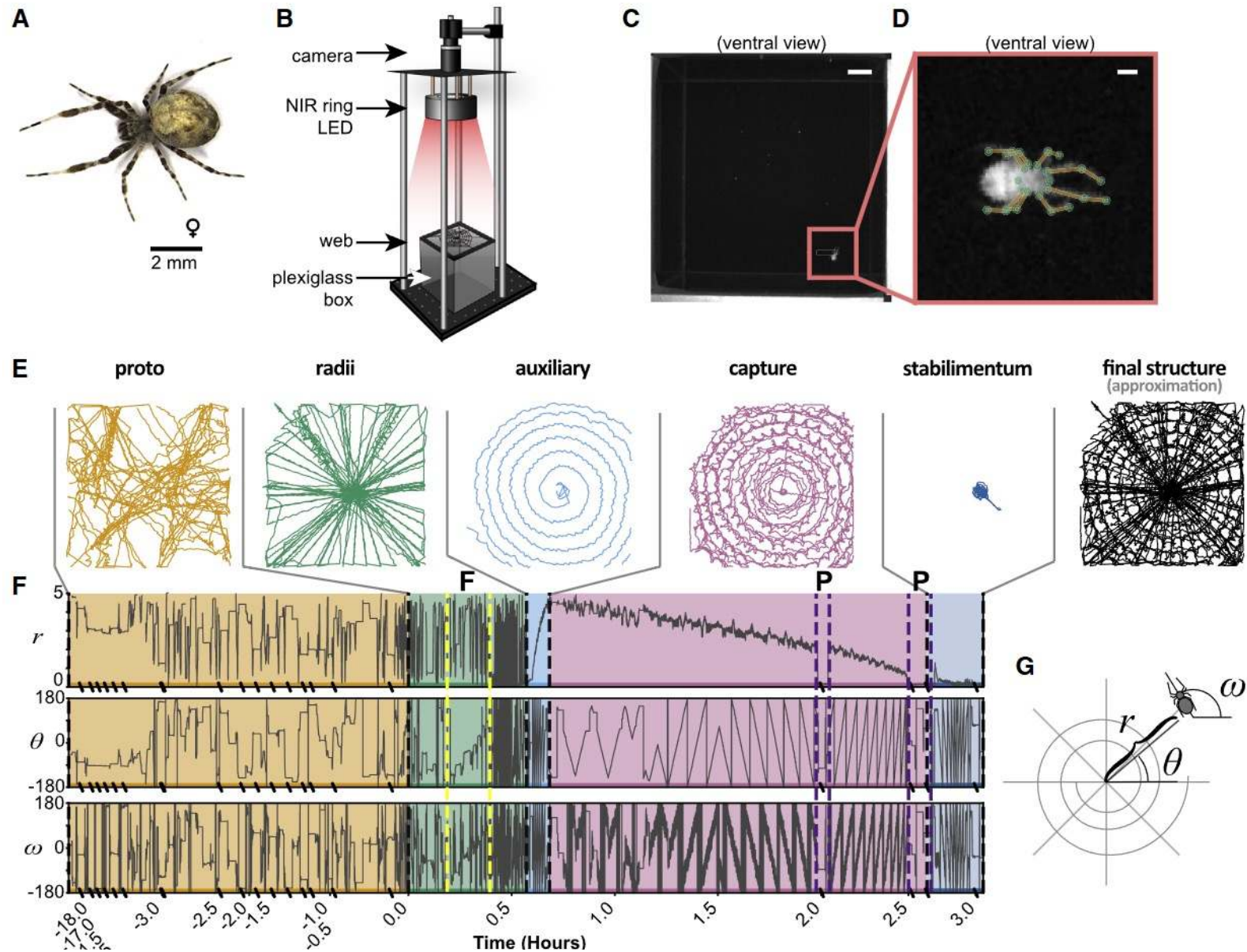


spider egg sac

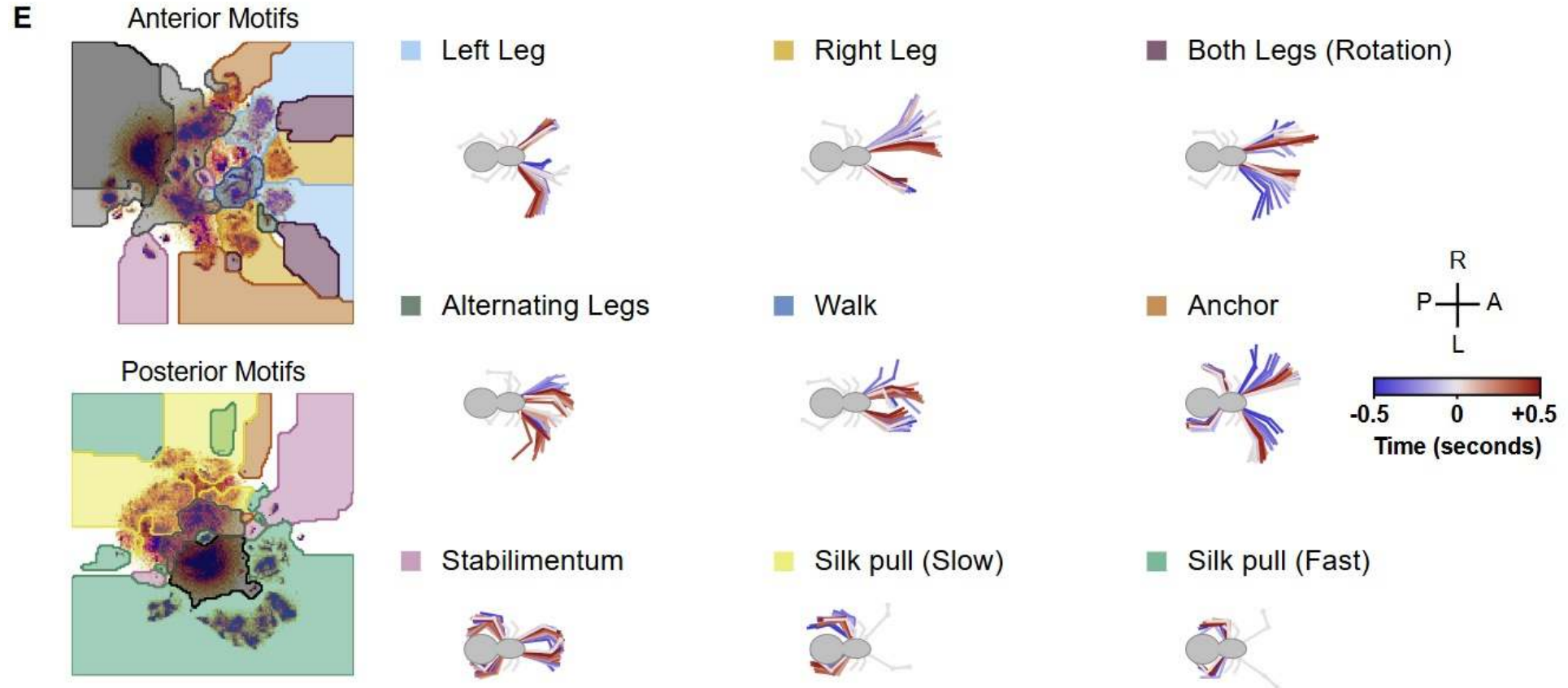
## Spider web-spinning process



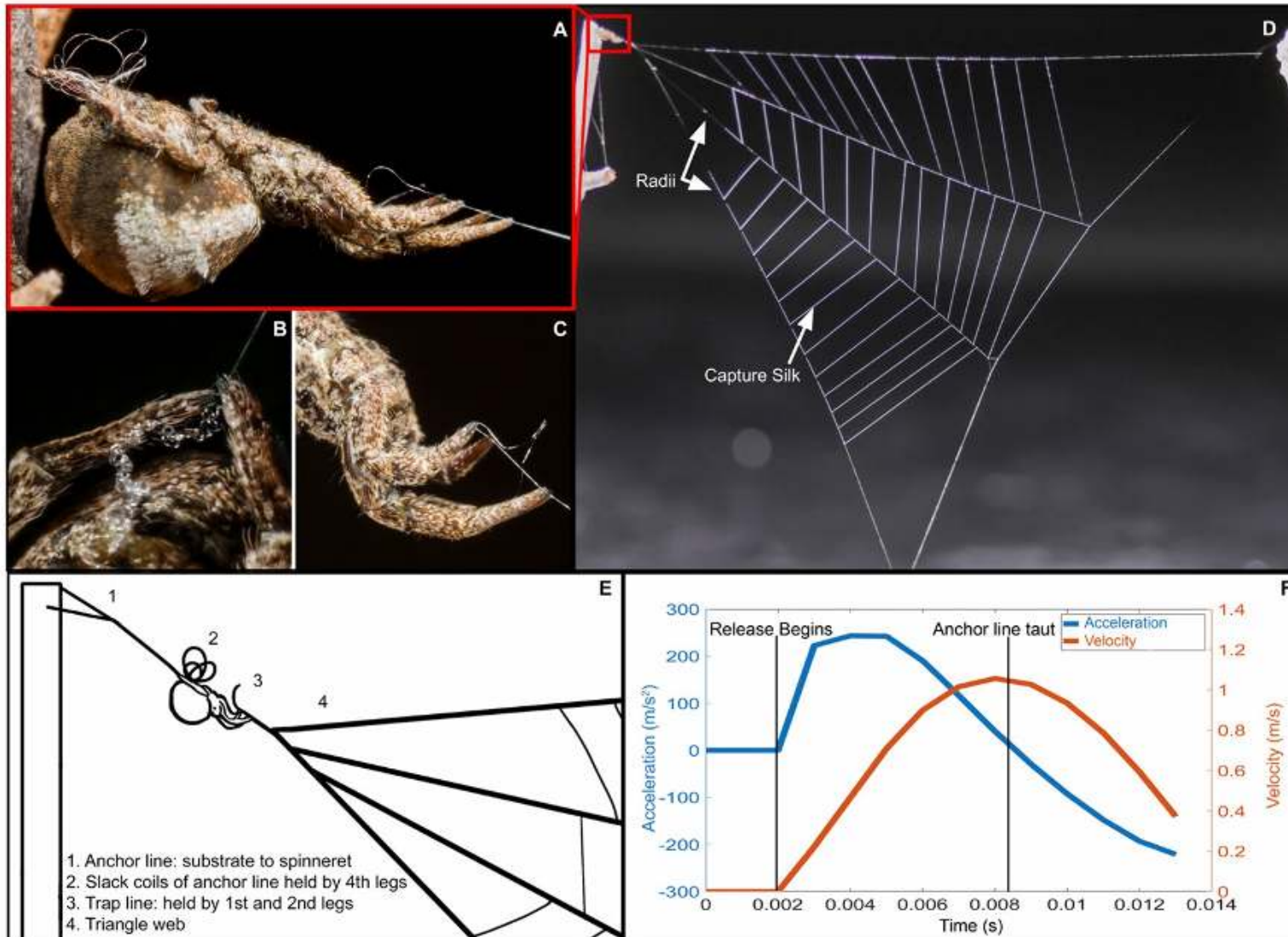
# The programmed behavior of spider web - weaving



# A shared set of movement motifs that characterize web making



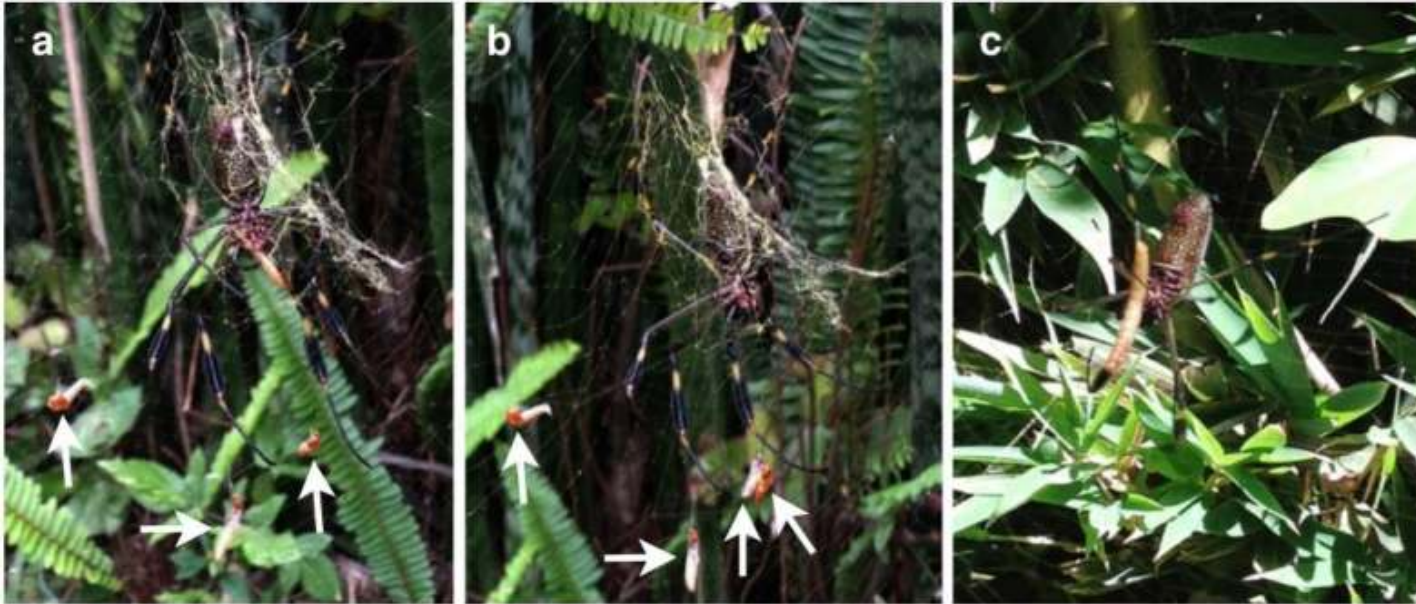
# External power amplification drives prey capture in a spider web



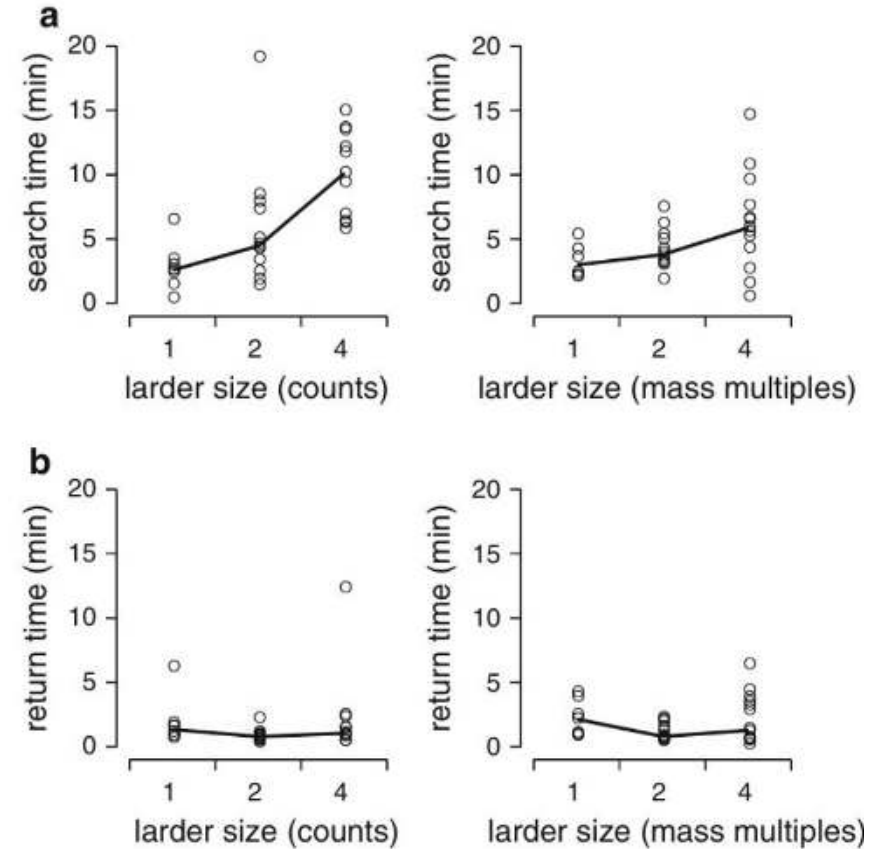
**An excellent animal for Cognition study**



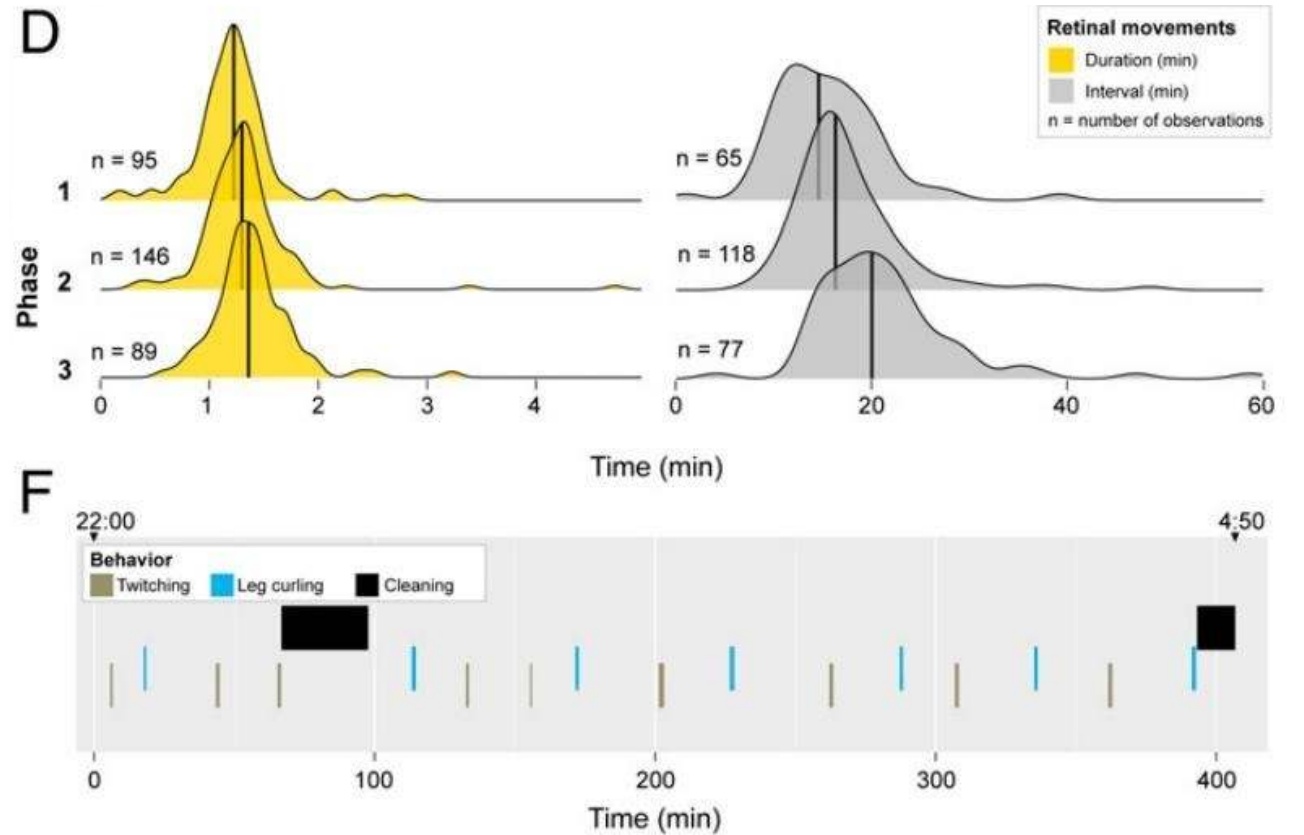
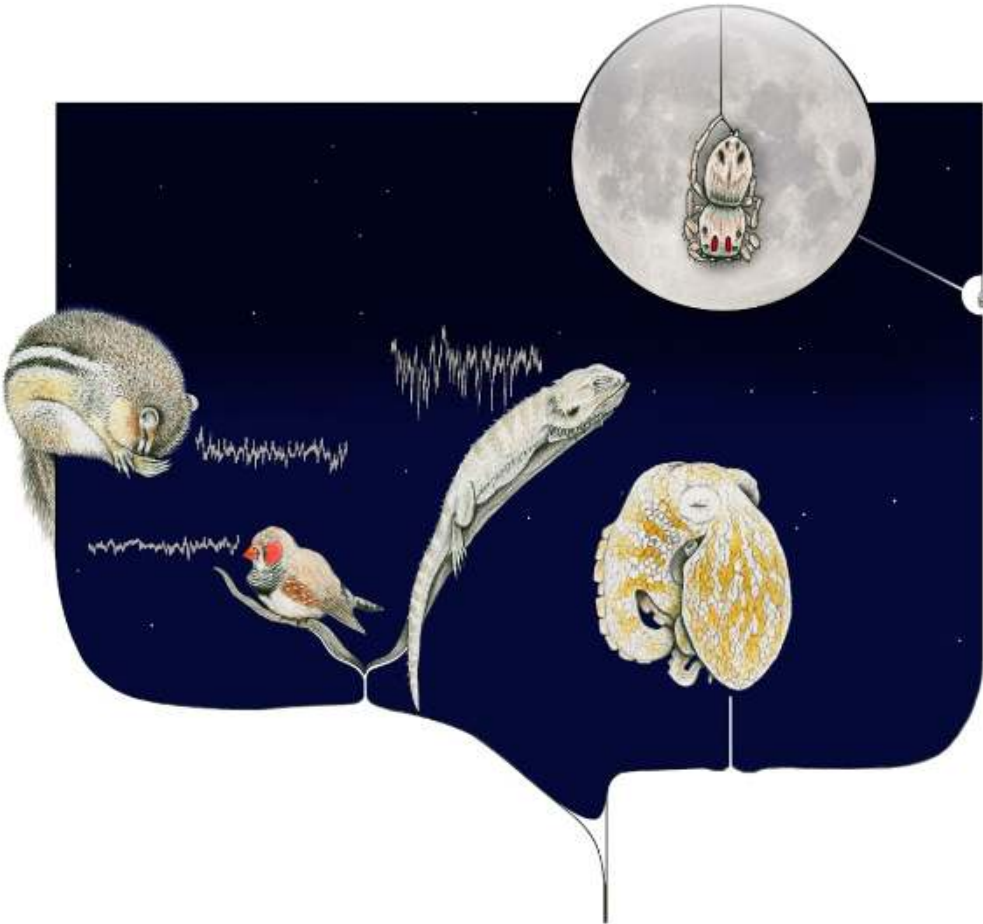
# Numerical Cognition of *Nephila clavipes*



*Nephila clavipes* accumulate prey larders at the hub of their web.



# An REM sleep-like state in jumping spiders



Klein BA. *Proc Natl Acad Sci U S A*. 2022;119(34):e2211216119.

Röbber DC, Kim K, De Agrò M, Jordan A, Galizia CG, Shamble PS. *Proc Natl Acad Sci U S A*. 2022;119(33):e2204754119.

# 总结

- 1. 感知的延伸：**蜘蛛通过“扩展表型”（蛛网）和高度敏感的机械感受器（听毛），将物理世界的信息处理“外包”给环境，从而弥补了中枢神经系统规模的局限。
- 2. 高效的行为策略：**利用外部物理结构进行功率放大，以及织网行为中体现的固定动作模式，展示了生物力学与神经回路极其高效的耦合。
- 3. 认知的深度：**从空间预判到类 REM 睡眠的发现，证明了高阶认知并非大型脊椎动物的专属，蜘蛛为研究“微型神经系统的计算极限”提供了绝佳模型。

# **Why Arachnids Matter: Applications in Biomaterials, Medicine, and Ecology**

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**1.**

**Arachnids × Biomaterials:**

The Ultimate Masterclass from Nature's Materials Maestro

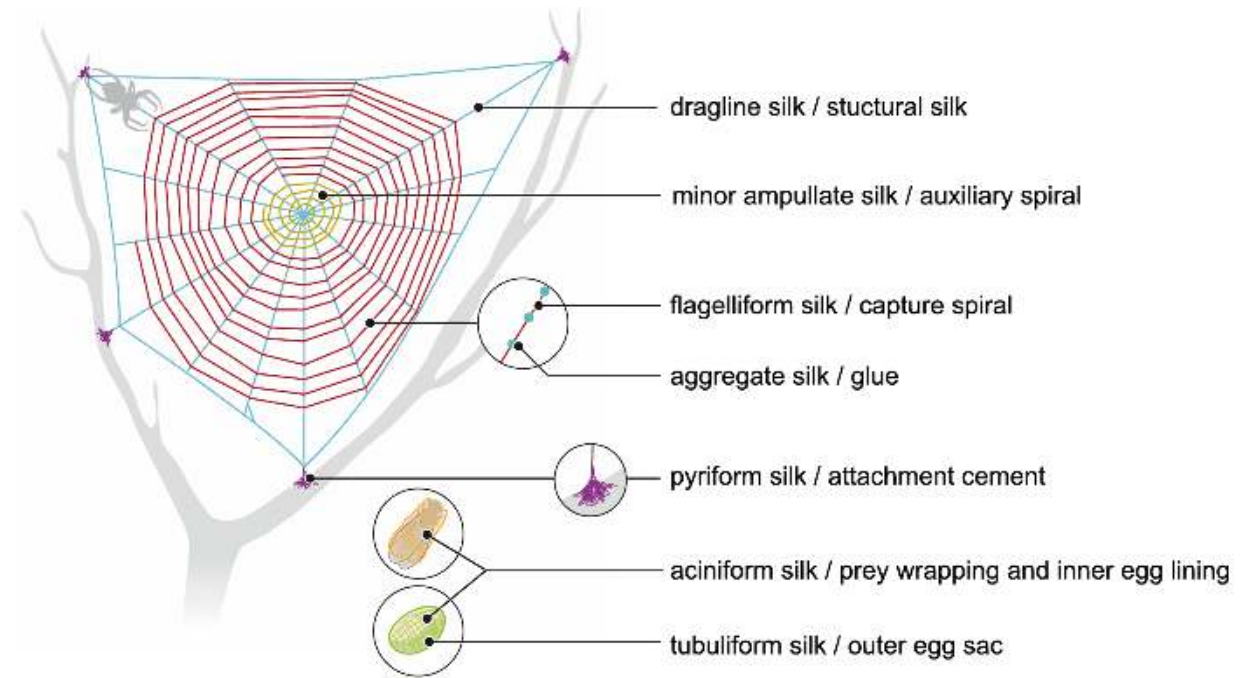
# Spider-Man!



What's the secret behind Spider-Man's swing?

# Spider silks have mechanical properties that outperform most natural and synthetic fibers

- Stronger than steel
- Tougher than Kevlar
- Lighter than all synthetic fibers
- .....



COMPARISON OF THE MECHANICAL PROPERTIES OF *A. DIADEMATUS* DRAGLINE SILK AND OTHER NATURAL AND SYNTHETIC FIBERS IN THE ORDER OF TOUGHNESS

Material	Density (g cm <sup>-3</sup> )	Strength (GPa) (breaking point)	Stiffness (GPa) (Young's modulus)	Extensibility (%) (elongation to break)	Toughness (MJ m <sup>-3</sup> ) (work to fracture)
<i>A. diadematus</i> silk (dragline)	1.3	1.1	10	27	180
<i>A. diadematus</i> silk (flagelliform)	1.3	0.5	0.003	270	150
Nylon fiber	1.1	0.95	5	18	80
<i>Bombyx mori</i> silk (cocoon)	1.3	0.6	7	18	70
Wool (at 100% RH)	1.3	0.2	0.5	5	60
Kevlar 49 <sup>TM</sup> fiber	1.4	3.6	130	2.7	50
Carbon fiber	1.8	4	300	1.3	25
High-tensile steel	7.8	1.5	200	0.8	6
Elastin	1.3	0.002	0.001	15	2

RH, relative humidity. Data taken from Refs. 37,38.



VS



## If there were a Silkworm Heroine...

### (A) Metamorphosis



### (B) Shelter



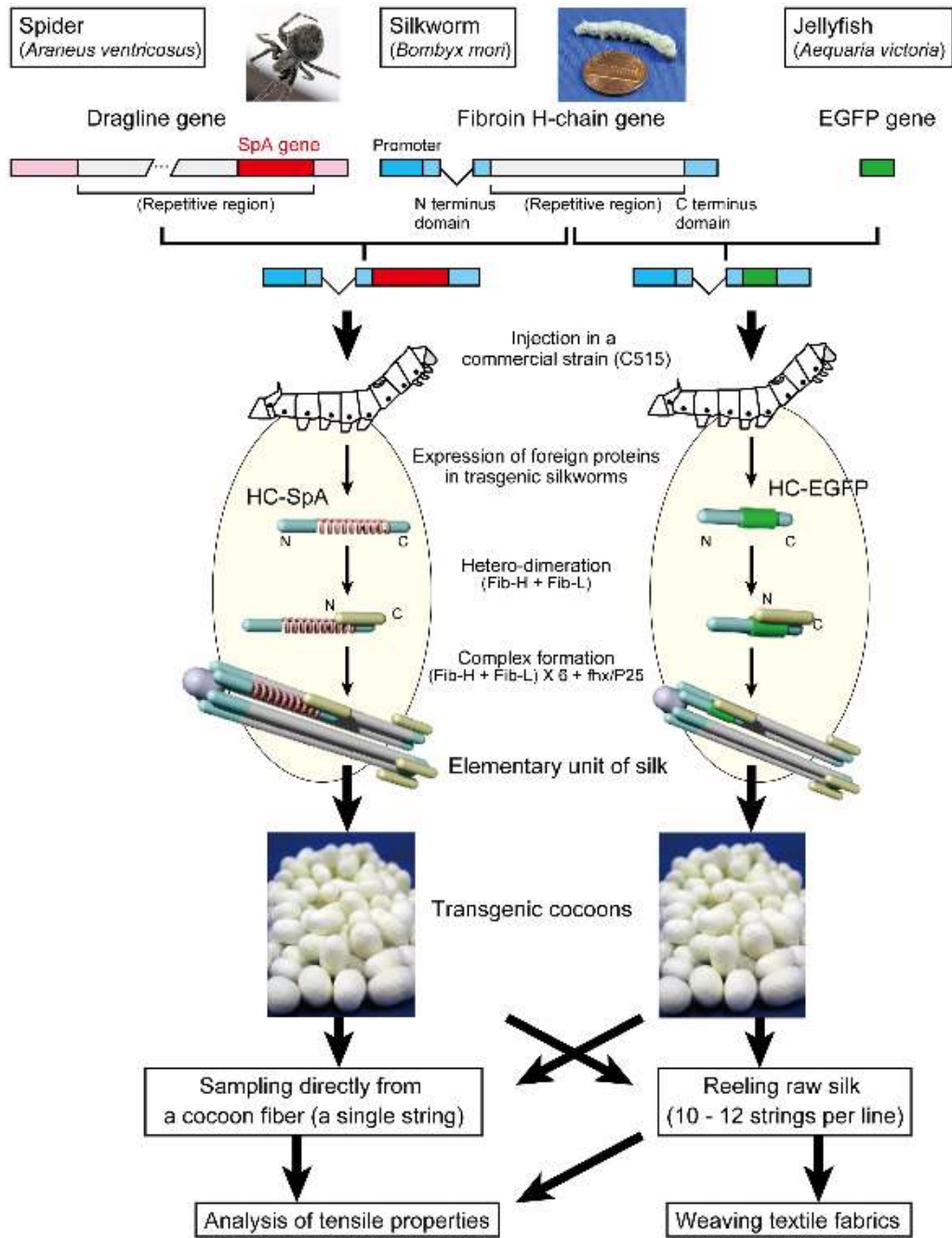
Table 1

Terrestrial silk proteins.

Organism	Amino acid abundance	Motif sequence	Secondary structures	Property	Function
Mulberry silkworm (Fibroin)	Glycine, Alanine	Poly(GA)	$\beta$ -sheet	Strong mechanical structure	Cocoon
Spider (Dragline)		ASAAAAAA, GGYGPG, GPGQQ	$\beta$ -sheet, amorphous	Mechanical strength and extensibility	Main structure of web
Spider (Tubuliform)		(S) <sub>n</sub> , (SA) <sub>n</sub> , (SQ) <sub>n</sub> , GX motifs	$\beta$ -sheet	High tensile strength and relatively low elasticity	Fibers wrapping eggs for breeding
Spider (Aciniform)	Serine, Alanine	(~200-mer) <sub>14</sub>	$\alpha$ -helix, $\beta$ -sheet	Efficient balance between strength and extensibility yielding the best toughness	Egg case lining and sperm web

Jung, Dooyup et al. Acta biomaterialia vol. 136 (2021)

X: acidic amino acids, pS: phosphorylated serine



# High-Toughness Silk Produced by a Transgenic Silkworm Expressing Spider (*Araneus ventricosus*) Dragline Silk Protein



# Overview of the expression systems used in the production of recombinant spider silk protein

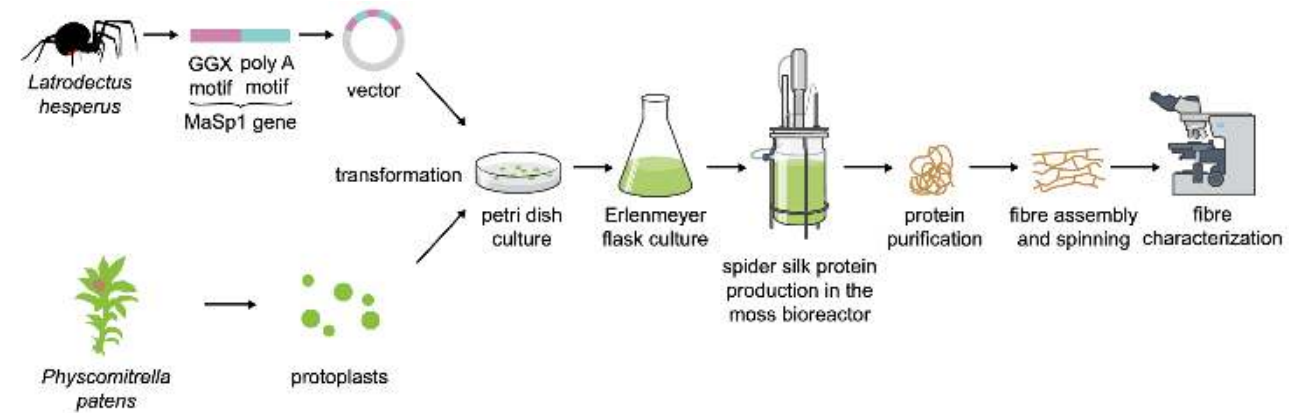
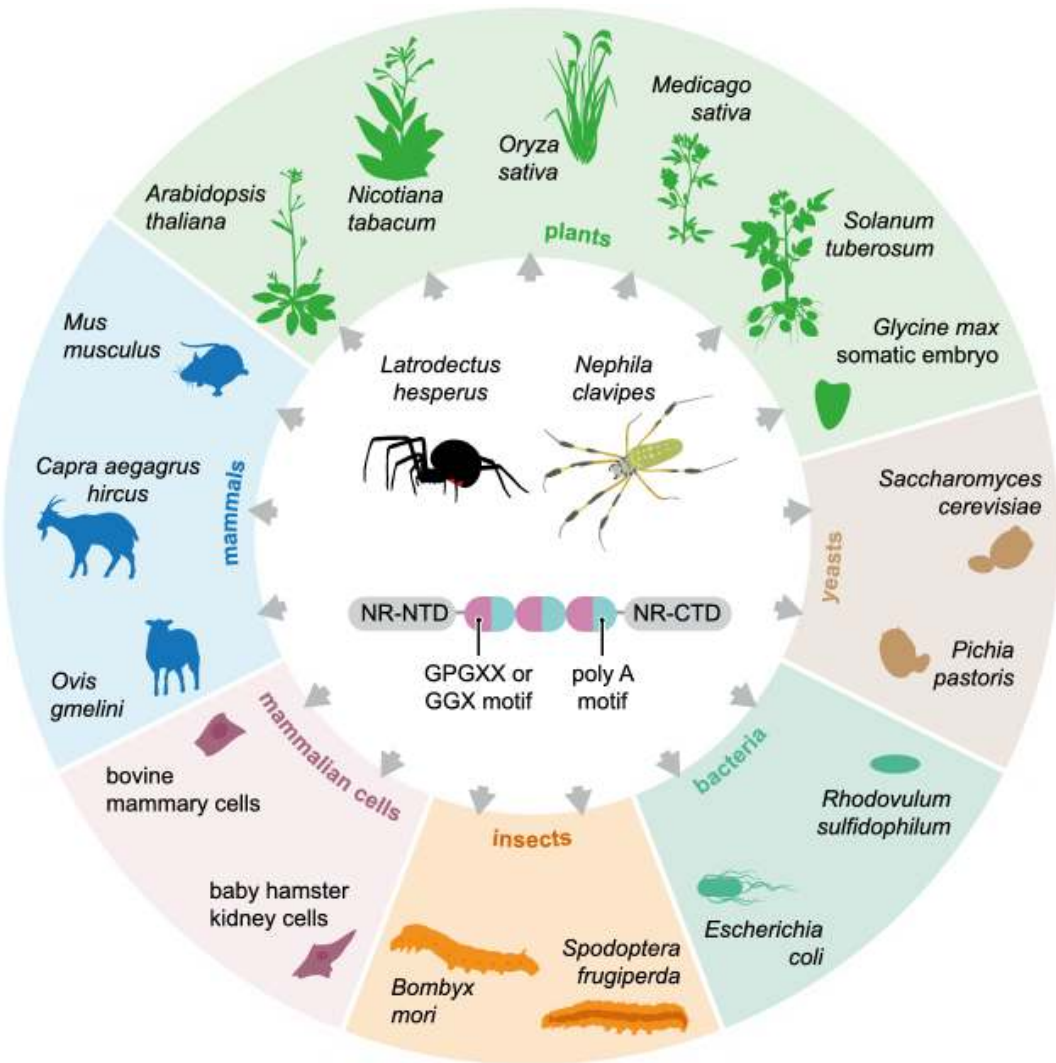
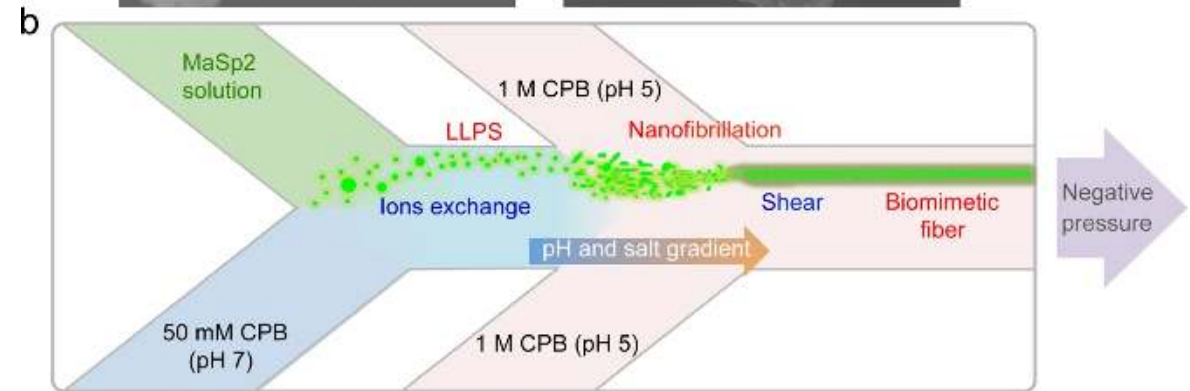
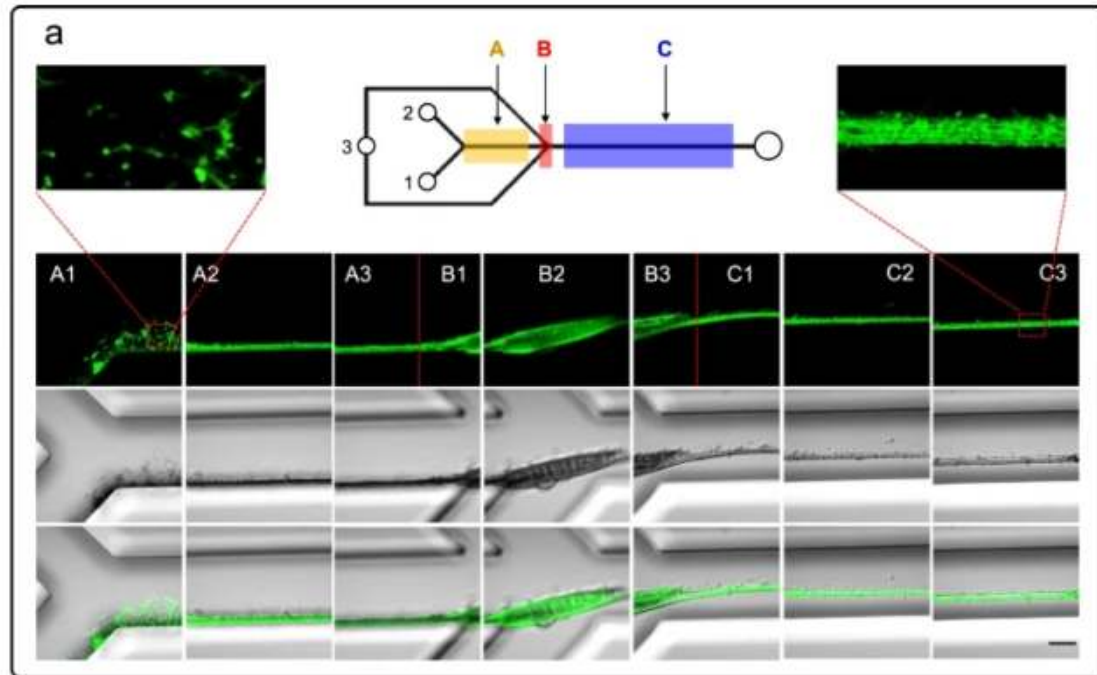
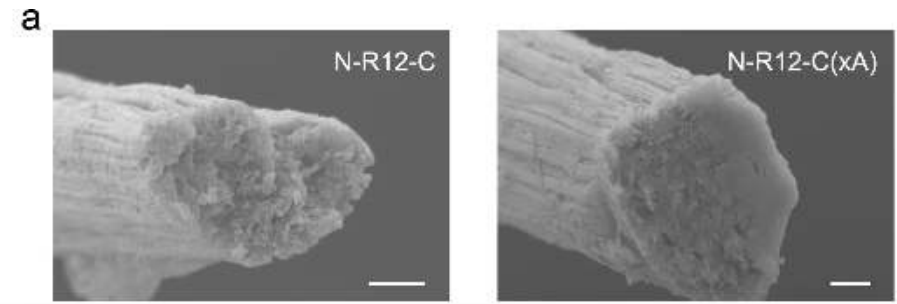
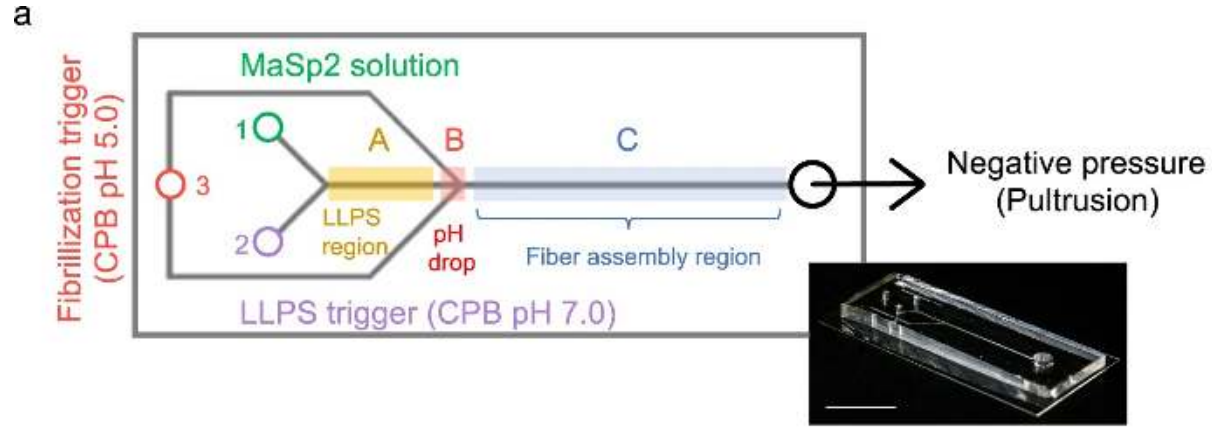
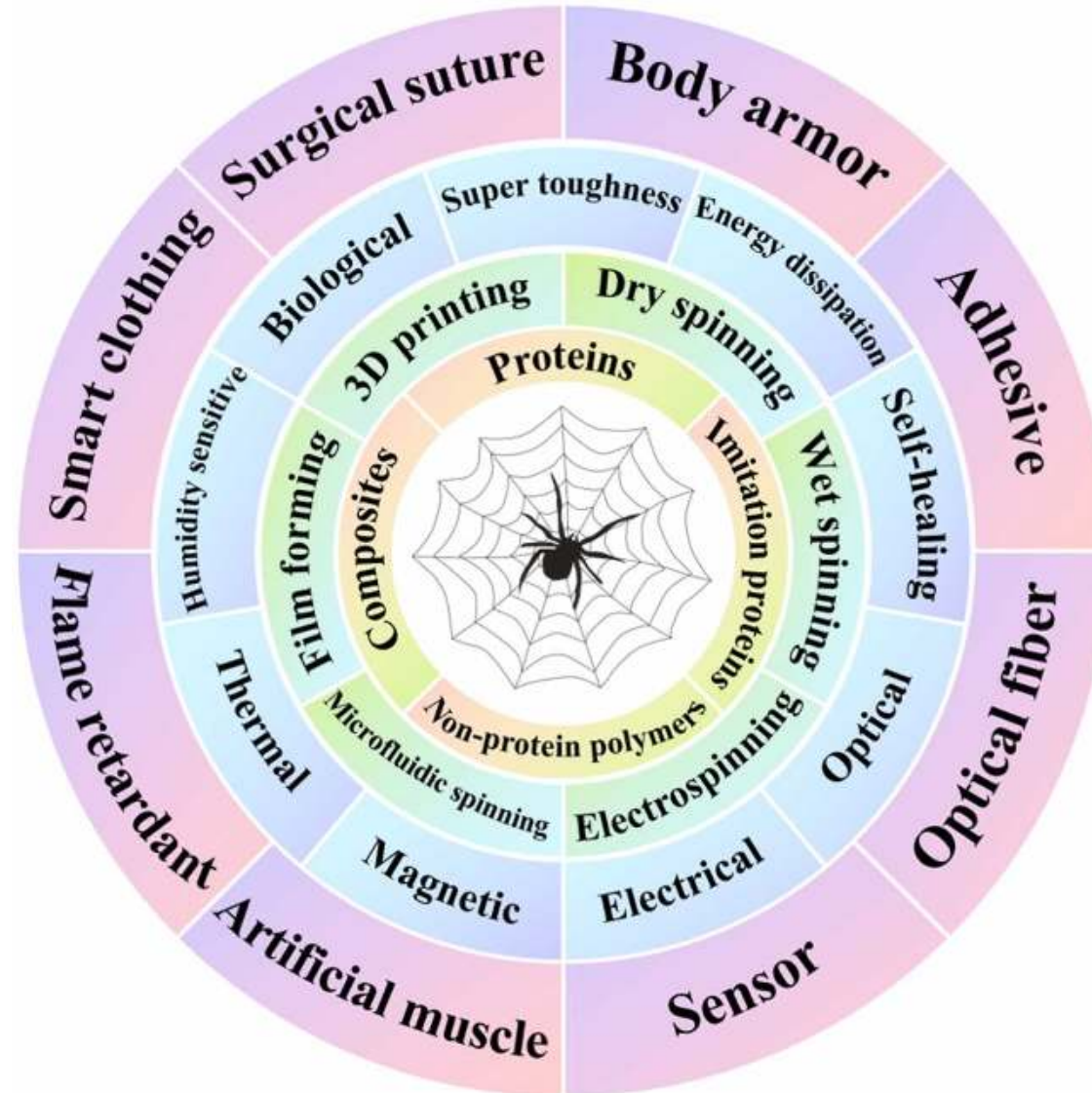


FIGURE 3 | Schematic overview of spider silk protein production in *Physcomitrella*.

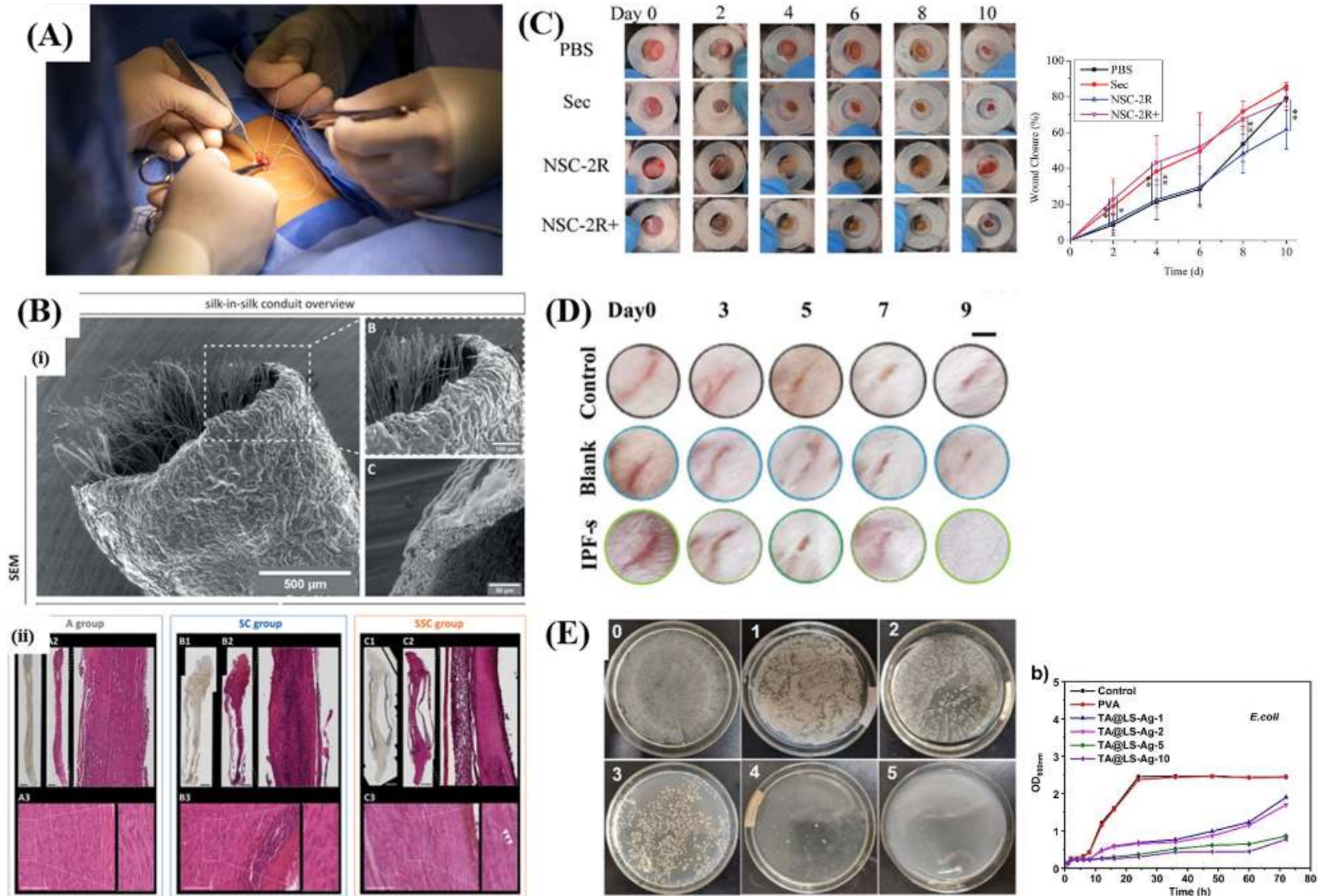
# Replicating shear-mediated self-assembly of spider silk through microfluidics



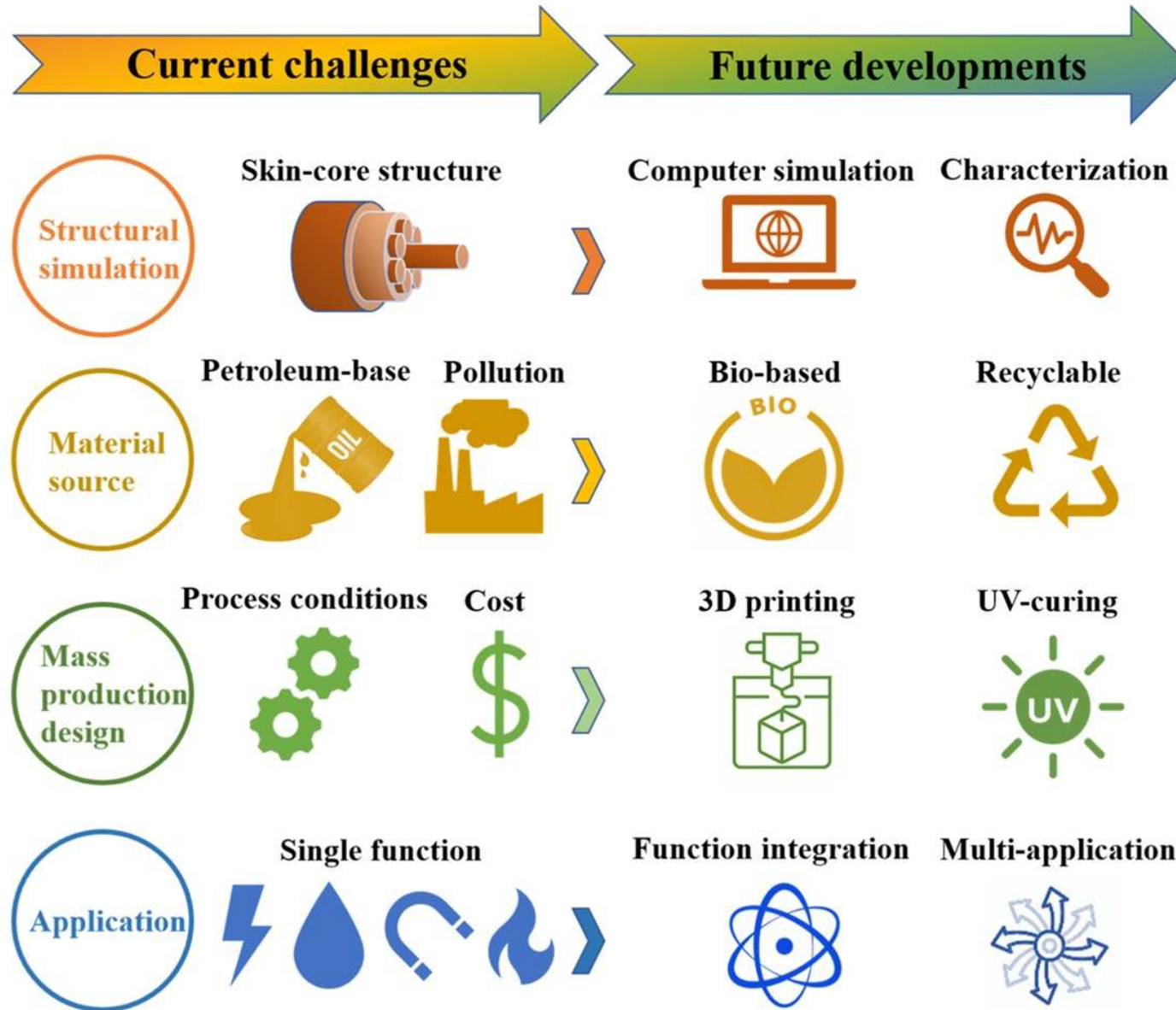
# Synthesis, processing, functions, and applications of tough materials inspired by spider silk



# Representative research of spider silk-inspired materials with biological function



# Current challenges and future developments of spider silk-inspired tough materials



**2.**

**Arachnids × Medicine:**

The "Venom Medicine Cabinet" of Scorpions and Spiders

# Which One is the Killer Spider?



地窖蜘蛛



棕色隐士蜘蛛



普通蜘蛛



狼蛛



囊蜘蛛



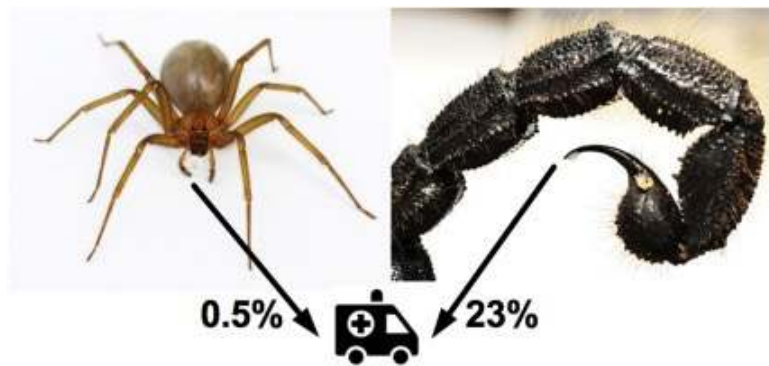
黑寡妇蜘蛛



跳跃蜘蛛



流浪汉蜘蛛



以色列金蝎

Ld50最低值: 0.16mg/kg



希腊齿钳蝎

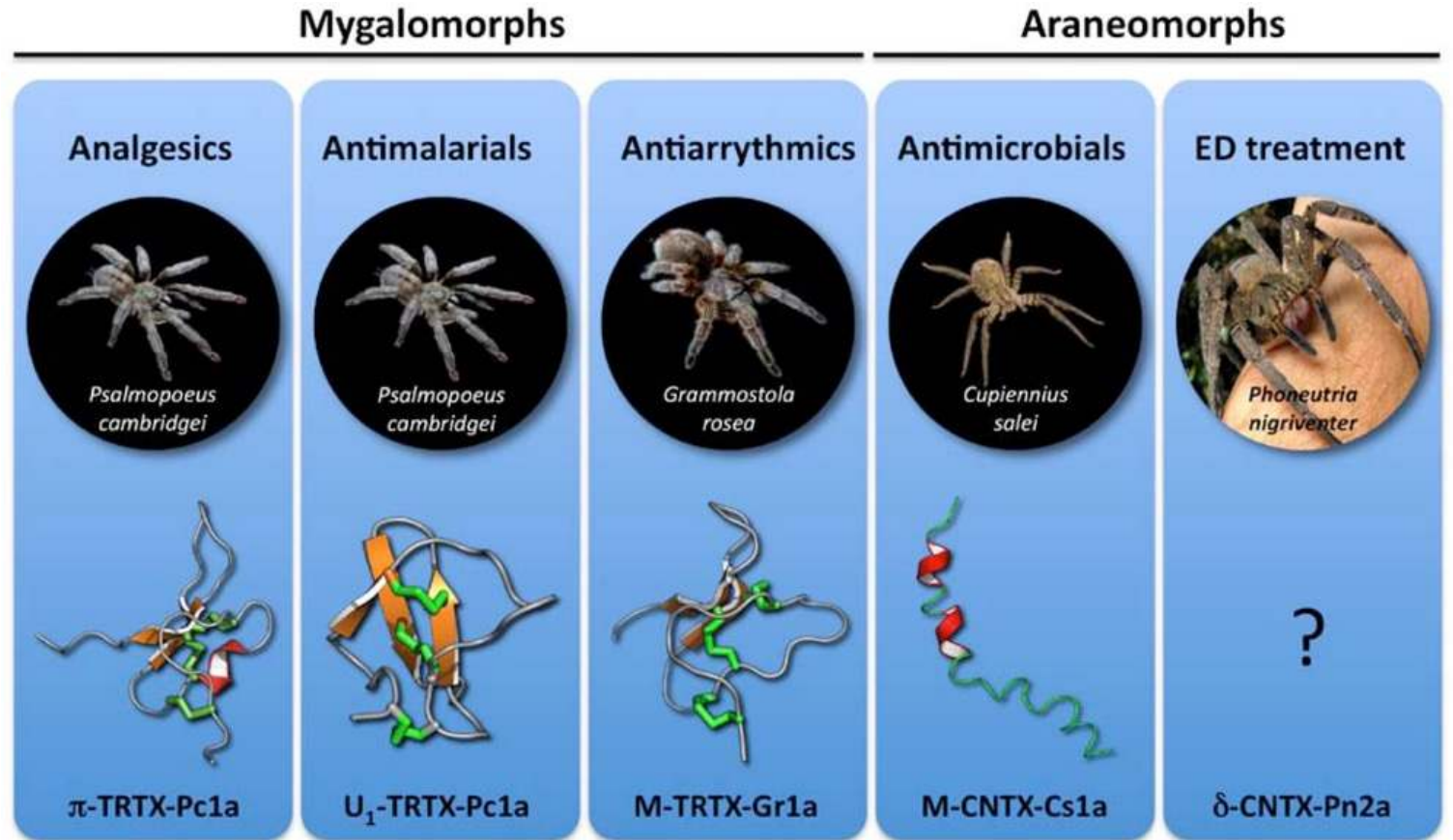
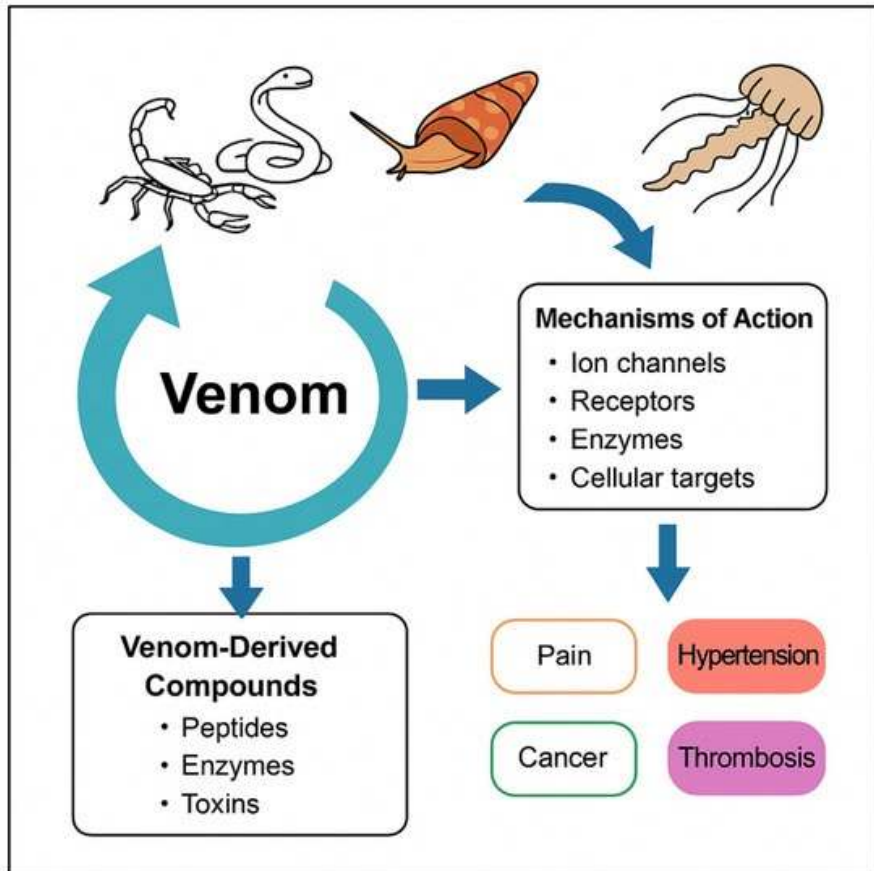
Ld50最低值: 0.19mg/kg



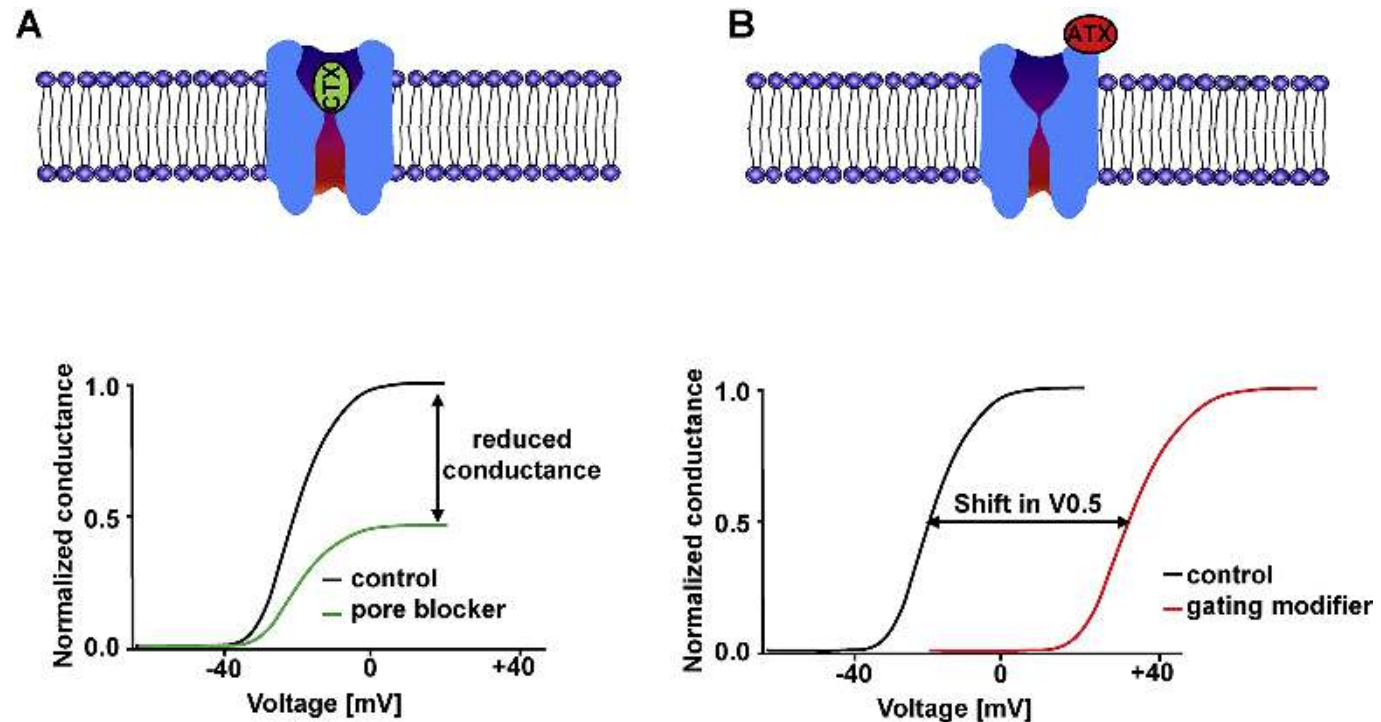
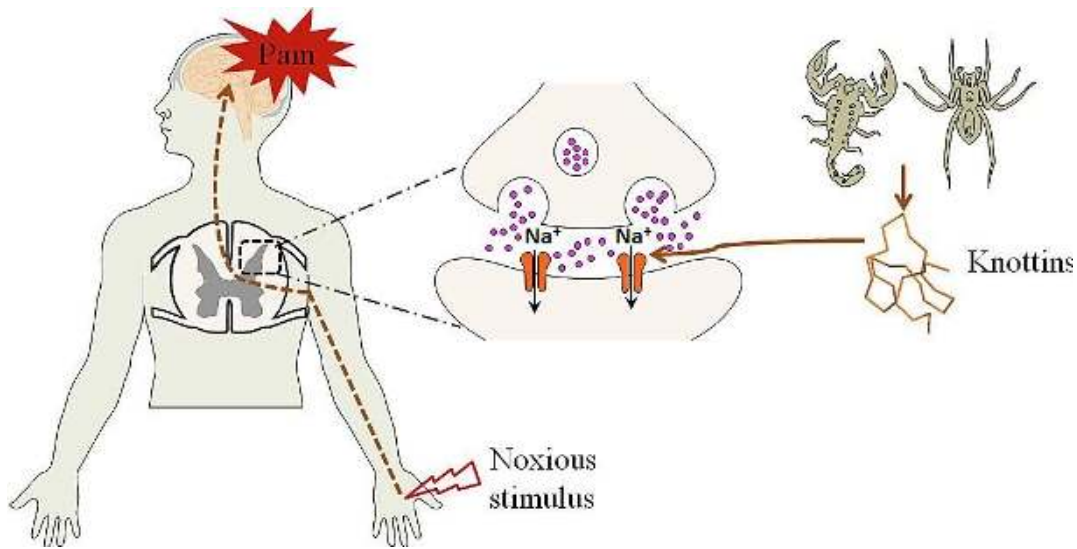
北非黑肥尾蝎

Ld50最低值: 0.31mg/kg

# Spider-venom peptides as therapeutics

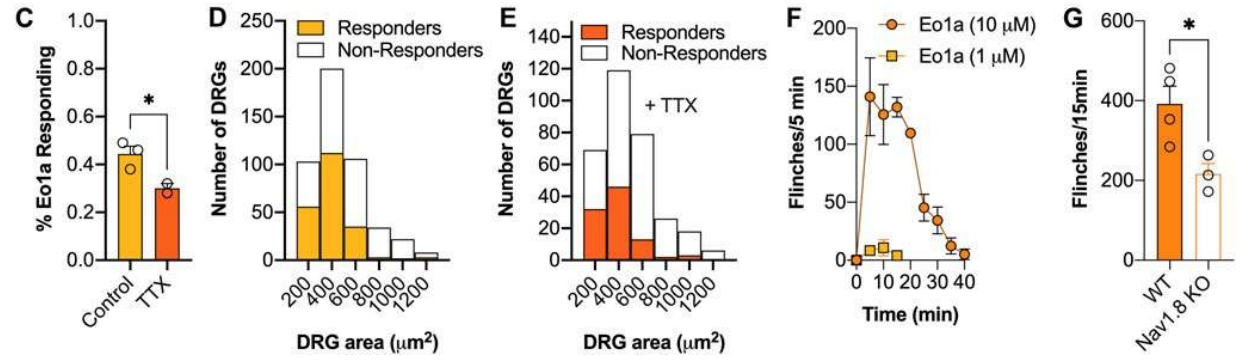
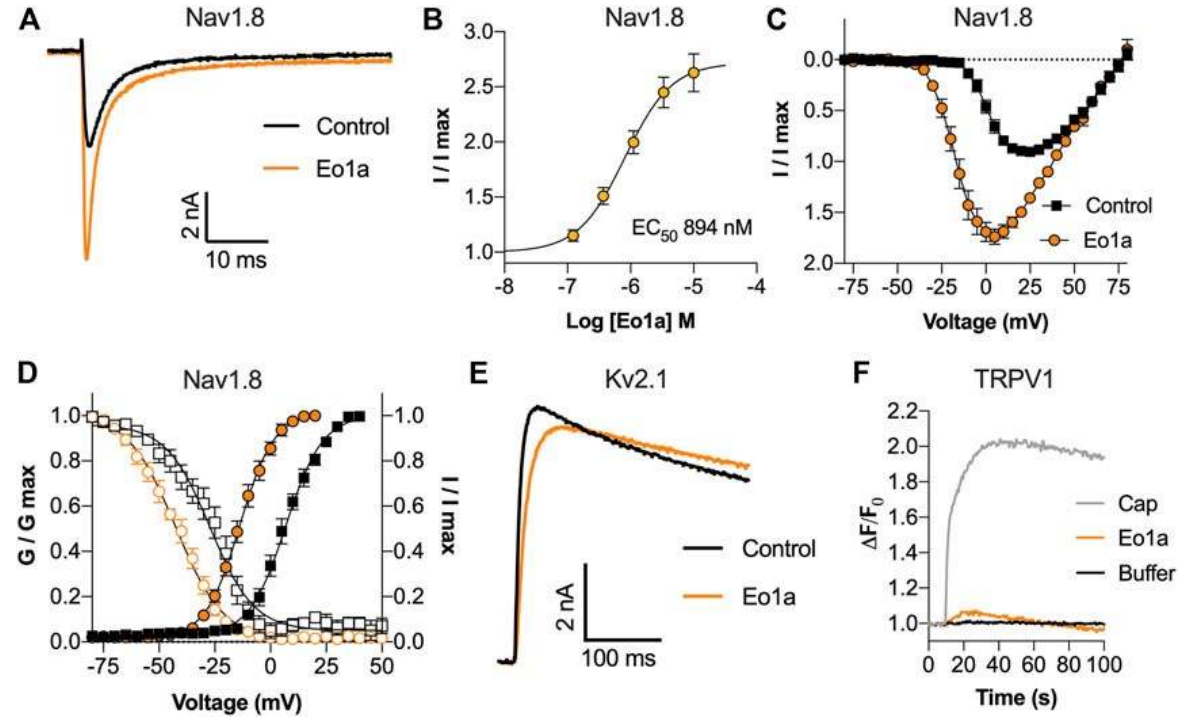
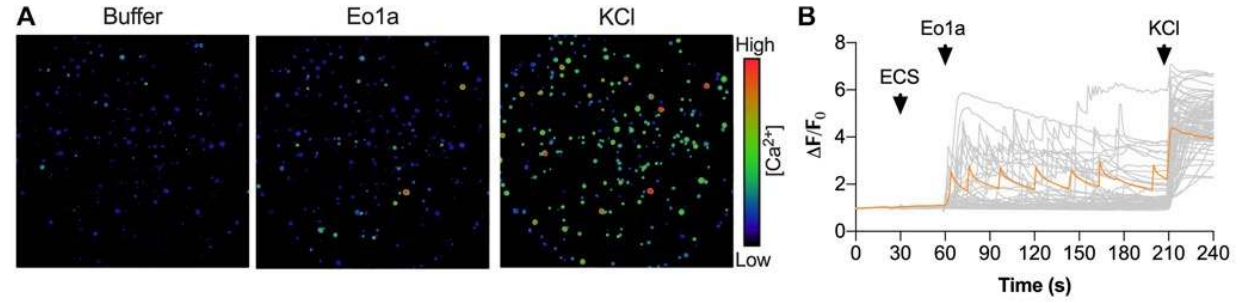
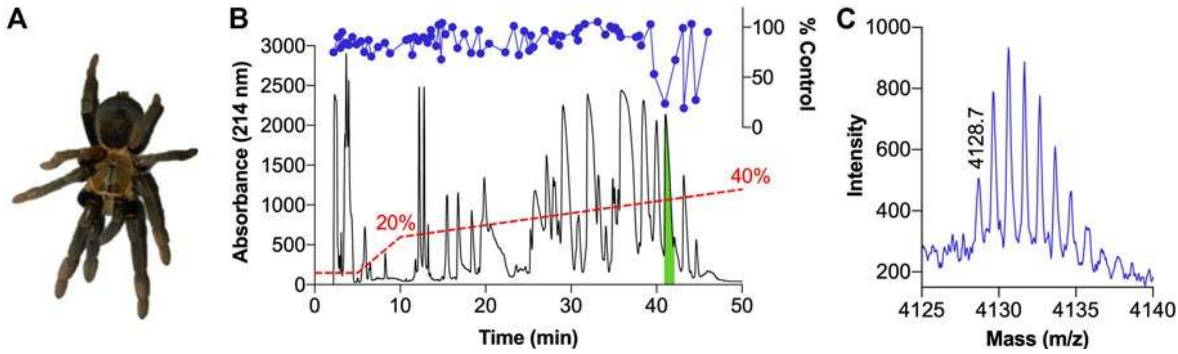


# Spider and scorpion knottins targeting voltage-gated sodium ion channels in pain signaling

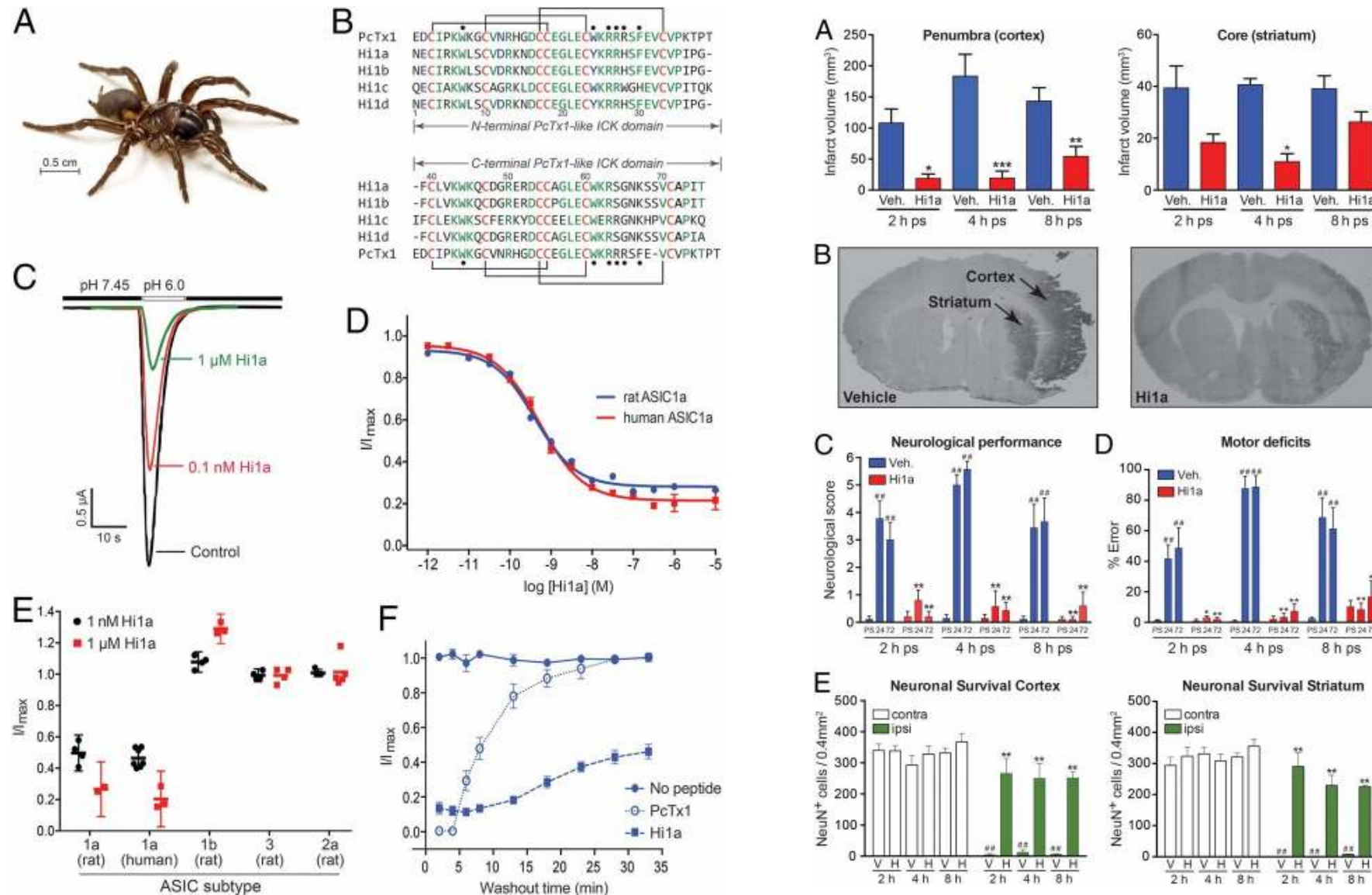


Bourinet E, Zamponi GW. Neuropharmacology. 2017

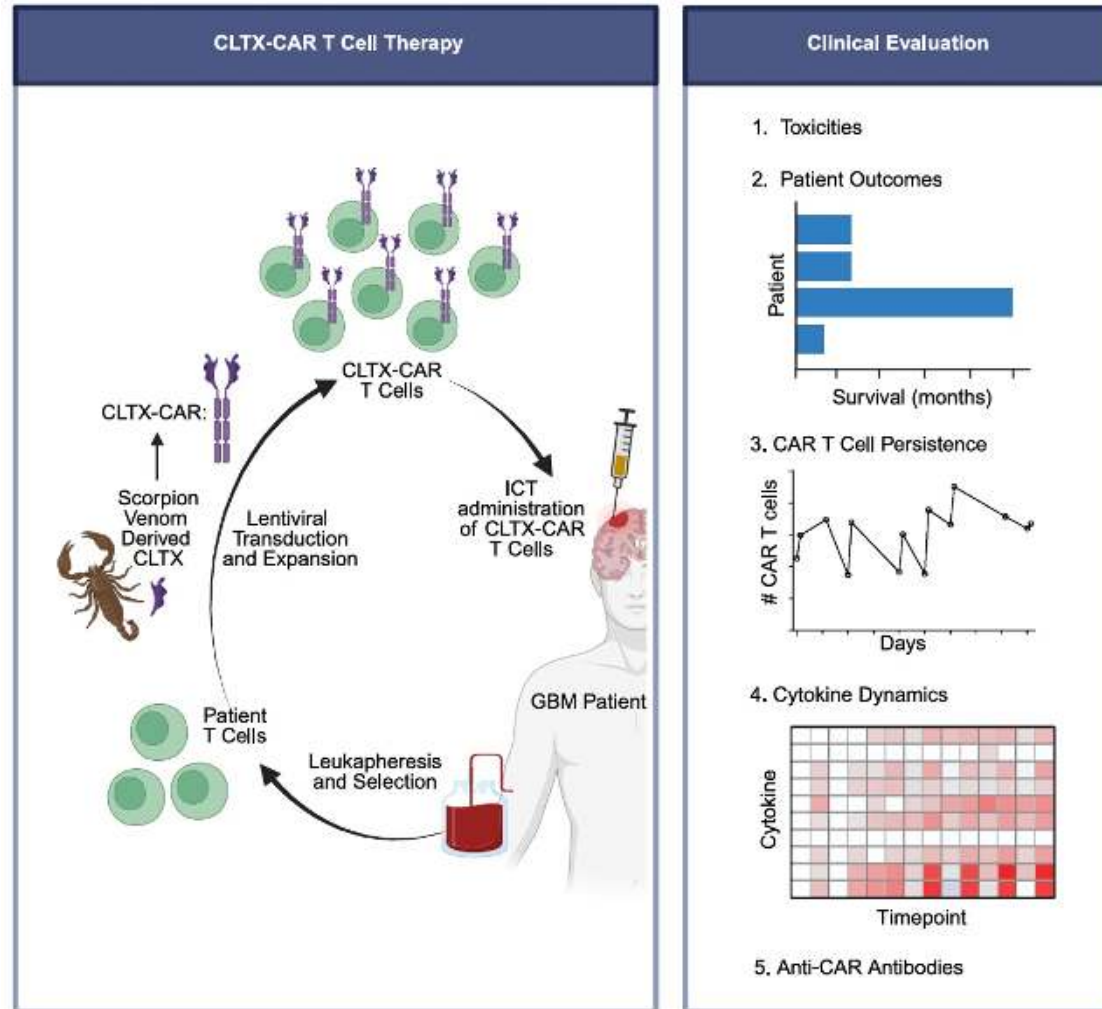
# Isolation of the novel peptide $\beta$ -TRTX-Eo1a from the venom of *Encyocratella olivacea*



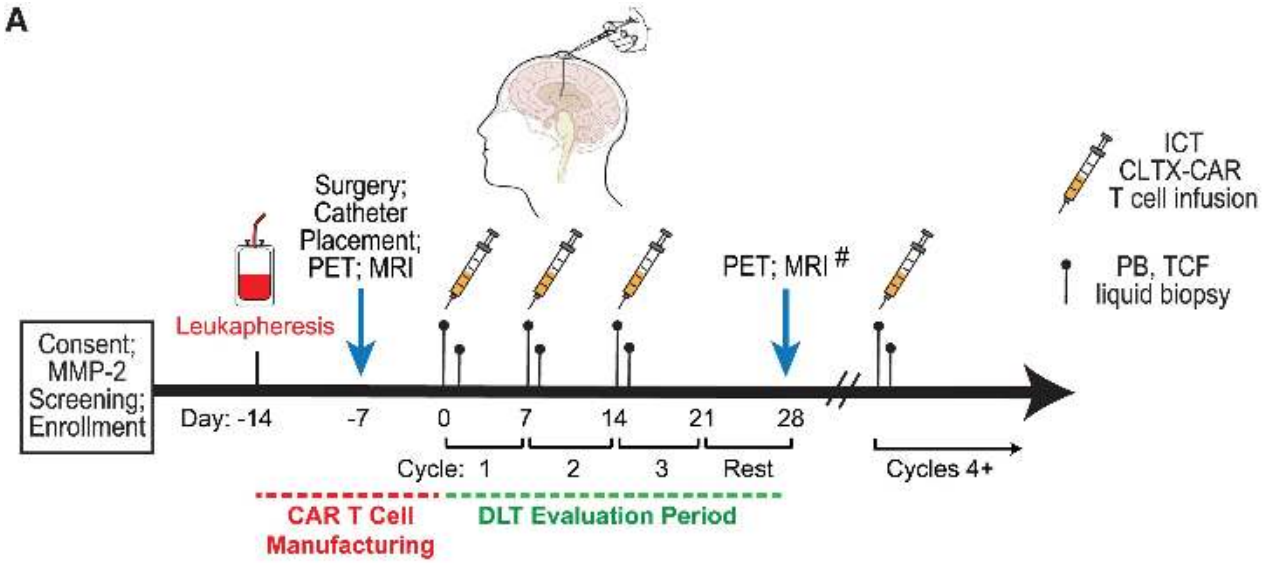
# Potent neuroprotection after stroke afforded by a double-knot spider-venom peptide that inhibits acid-sensing ion channel 1a



# Chlorotoxin-directed CAR T cell therapy for recurrent glioblastoma



A

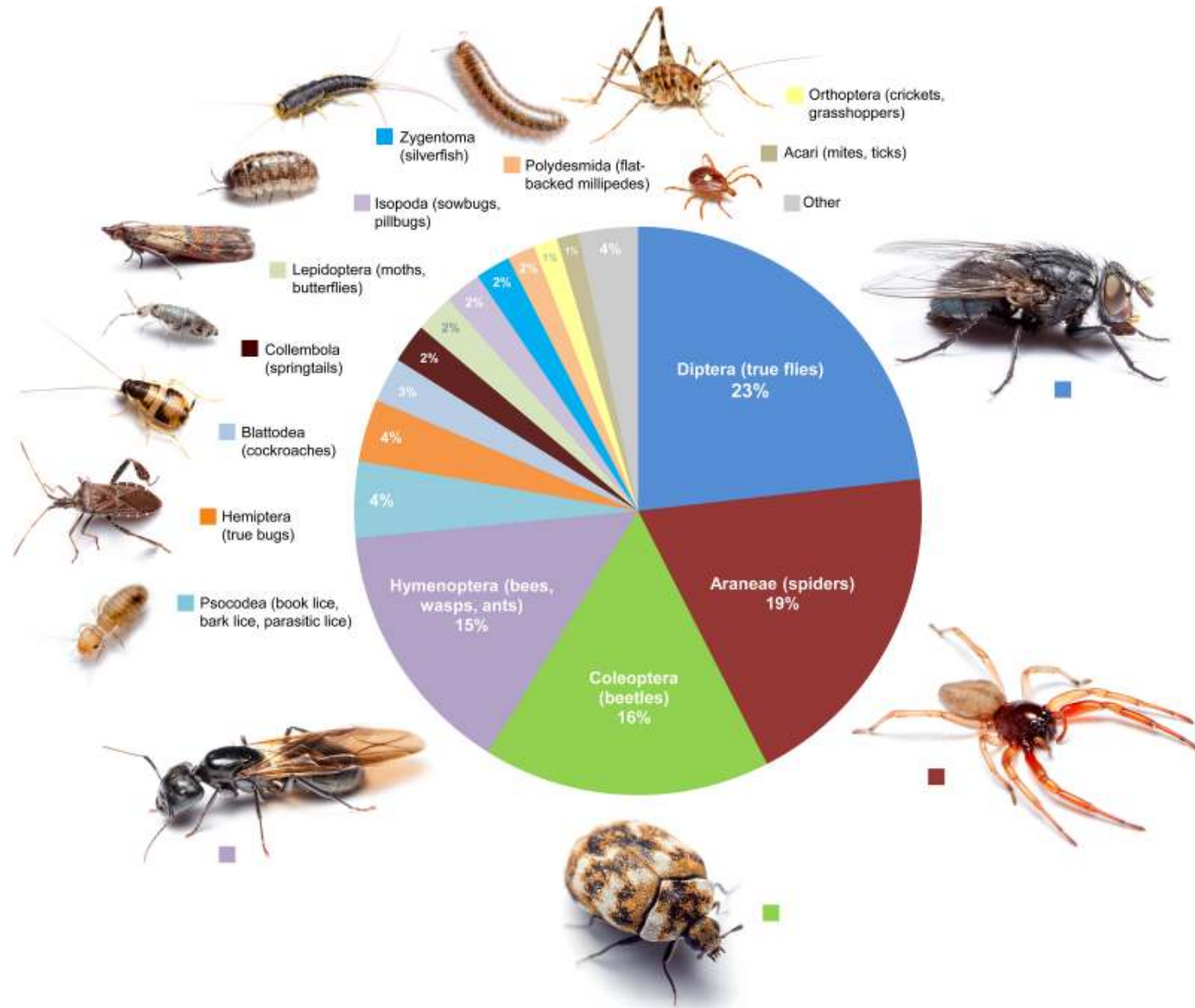


**3.**

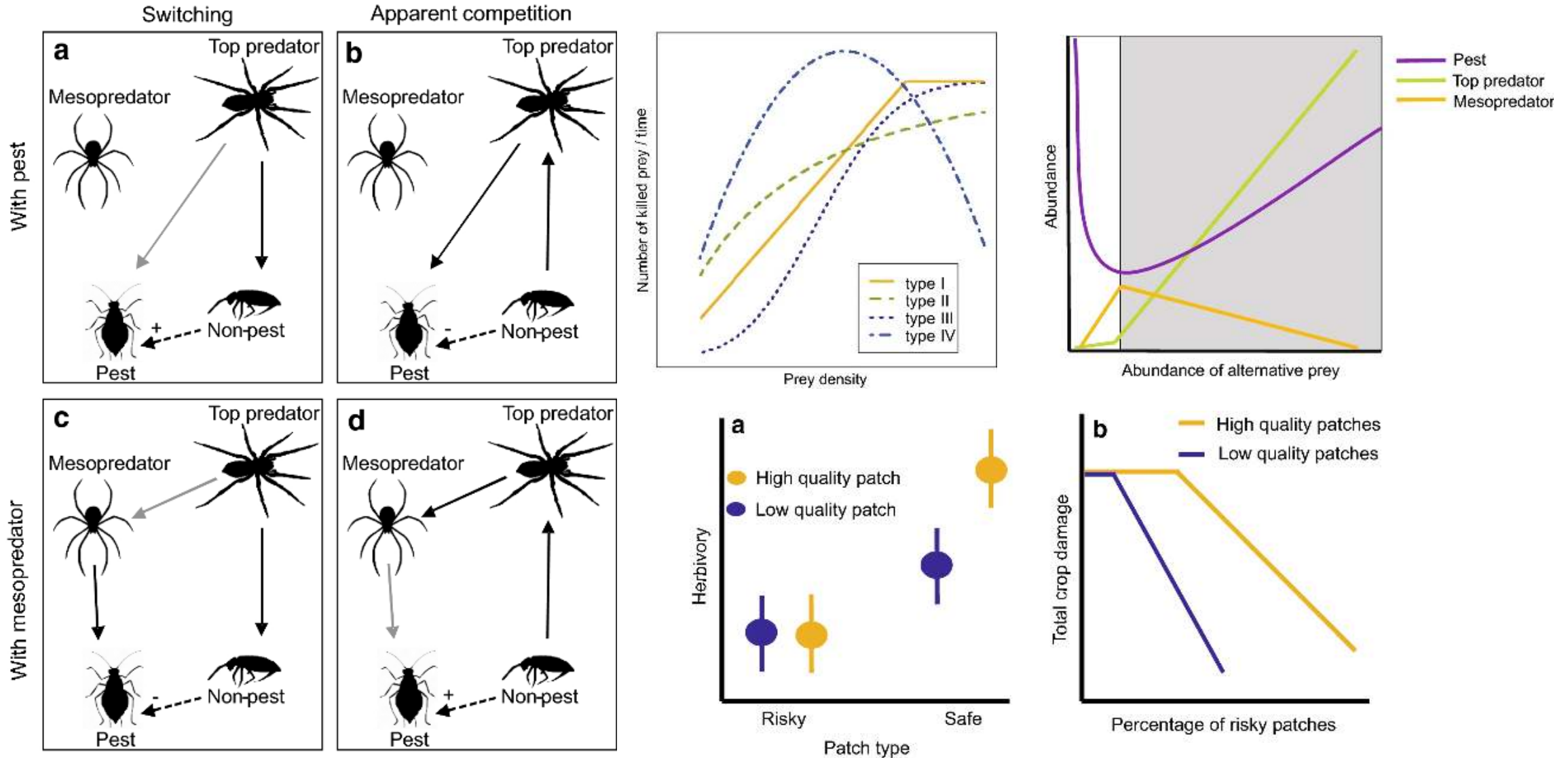
**Arachnids × Ecology:**

The Ecosystem's "Superheroes" Living Among Us

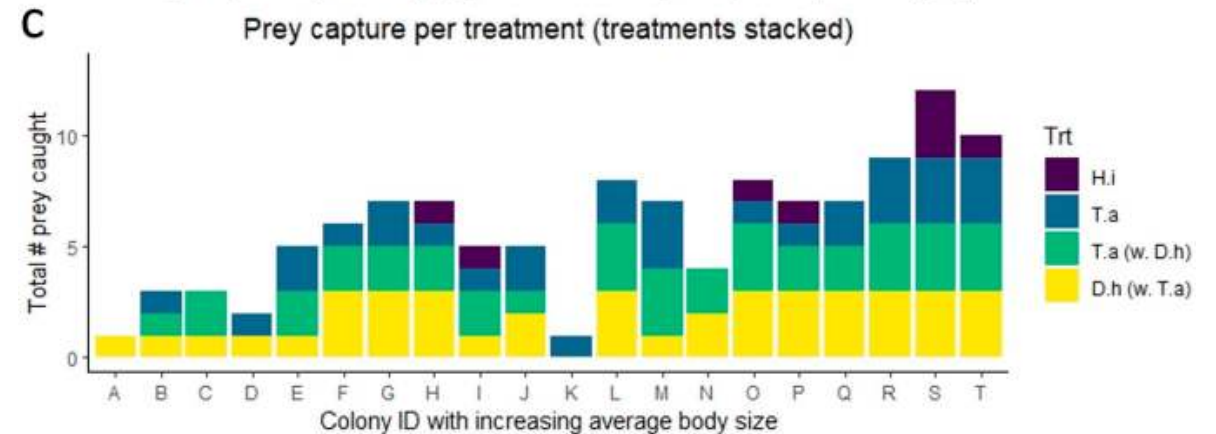
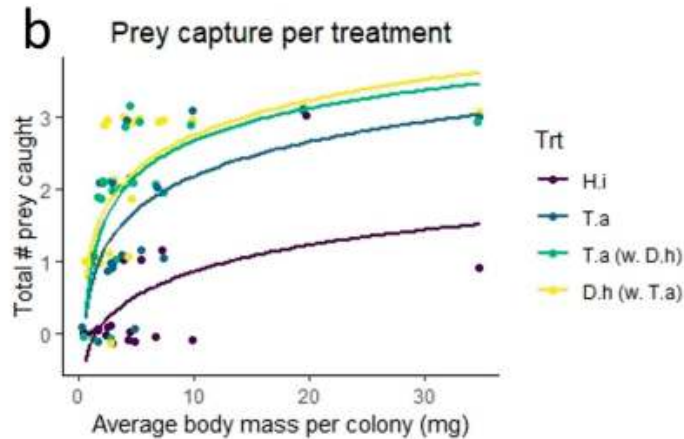
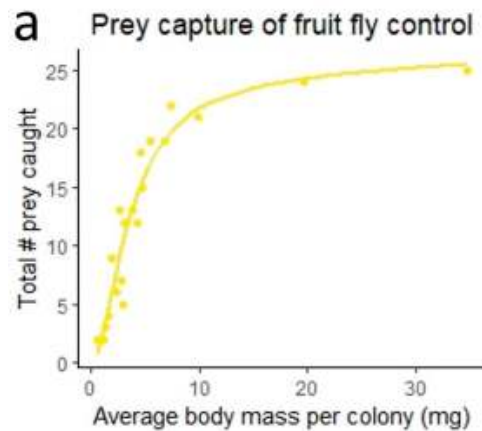
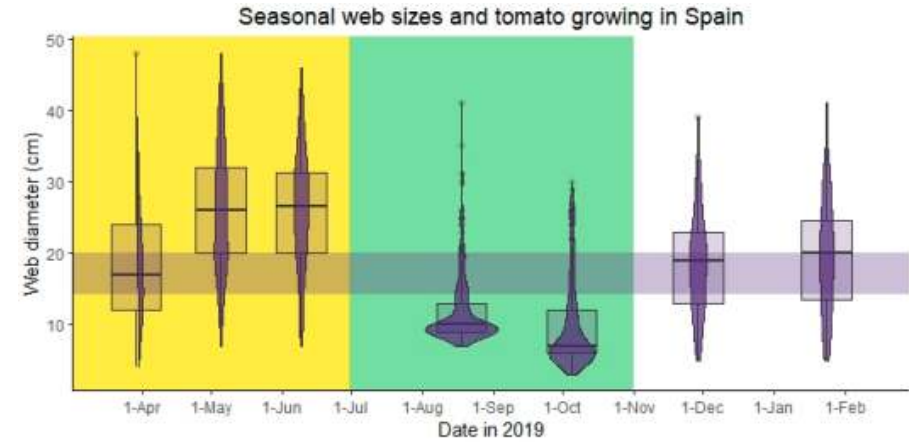
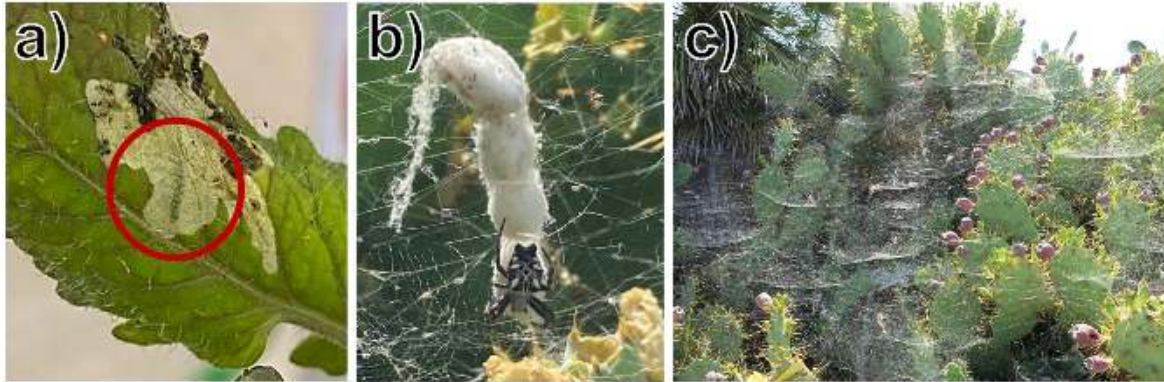
# Breadth of habitats colonized by subterranean spiders across the world



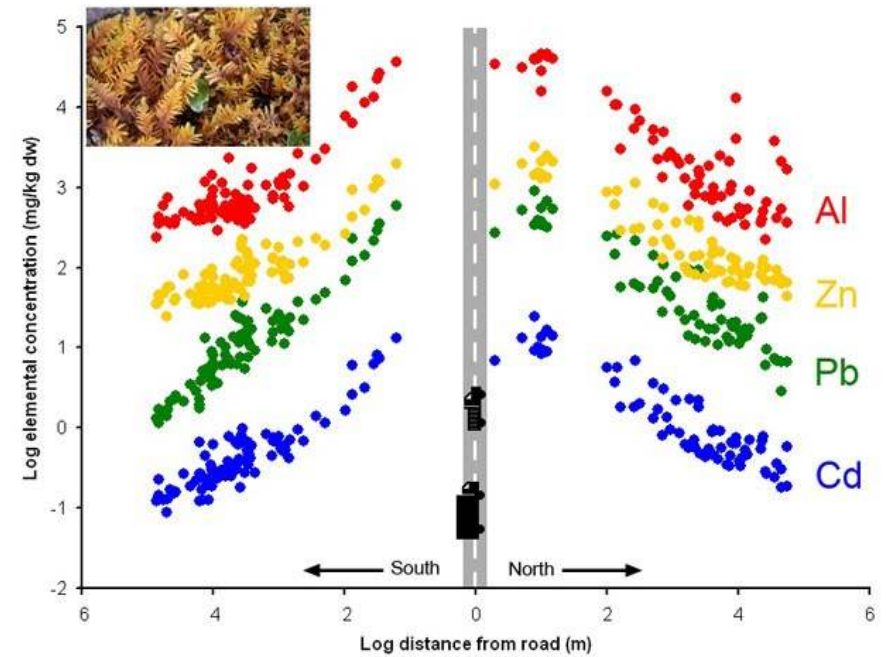
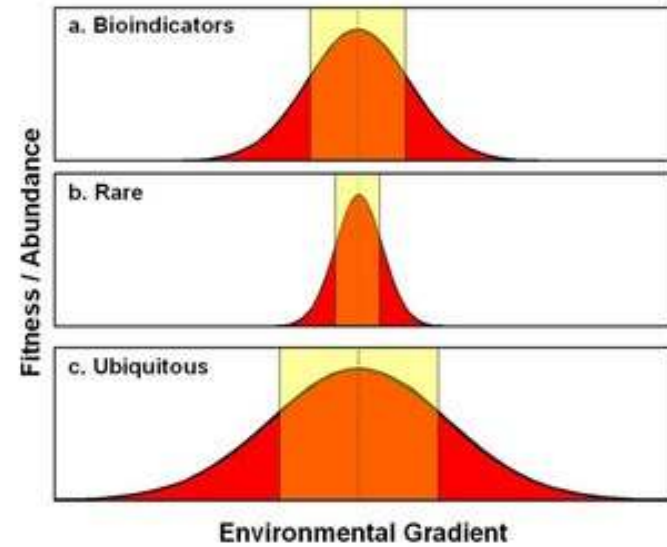
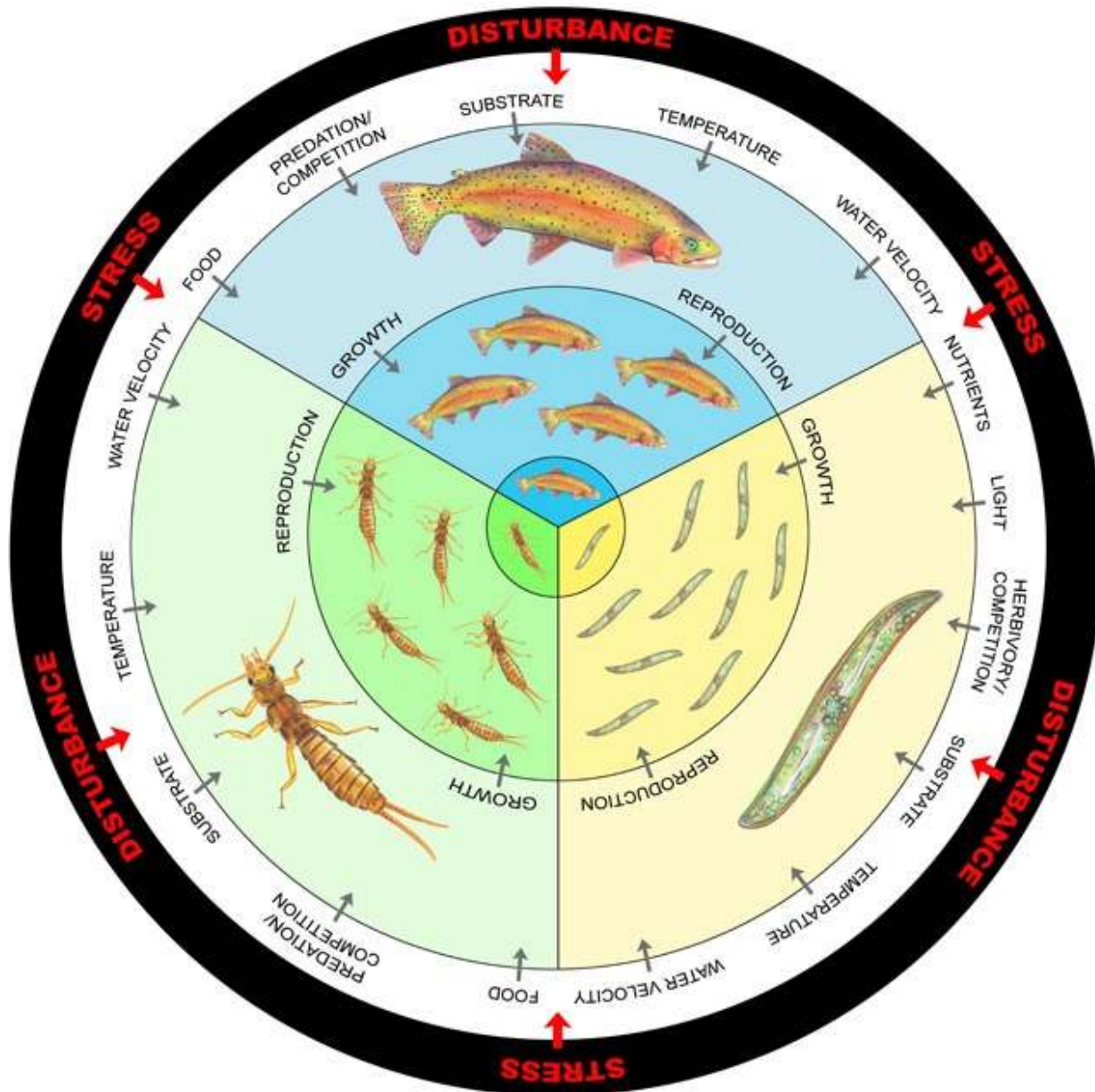
# Spiders are among the most abundant predators in many agroecosystems and are most diverse generalist predators



# Group-Living Spider *Cyrtophora citricola* as a Potential Novel Biological Control Agent of the Tomato Pest *Tuta absoluta*



# Bioindicators



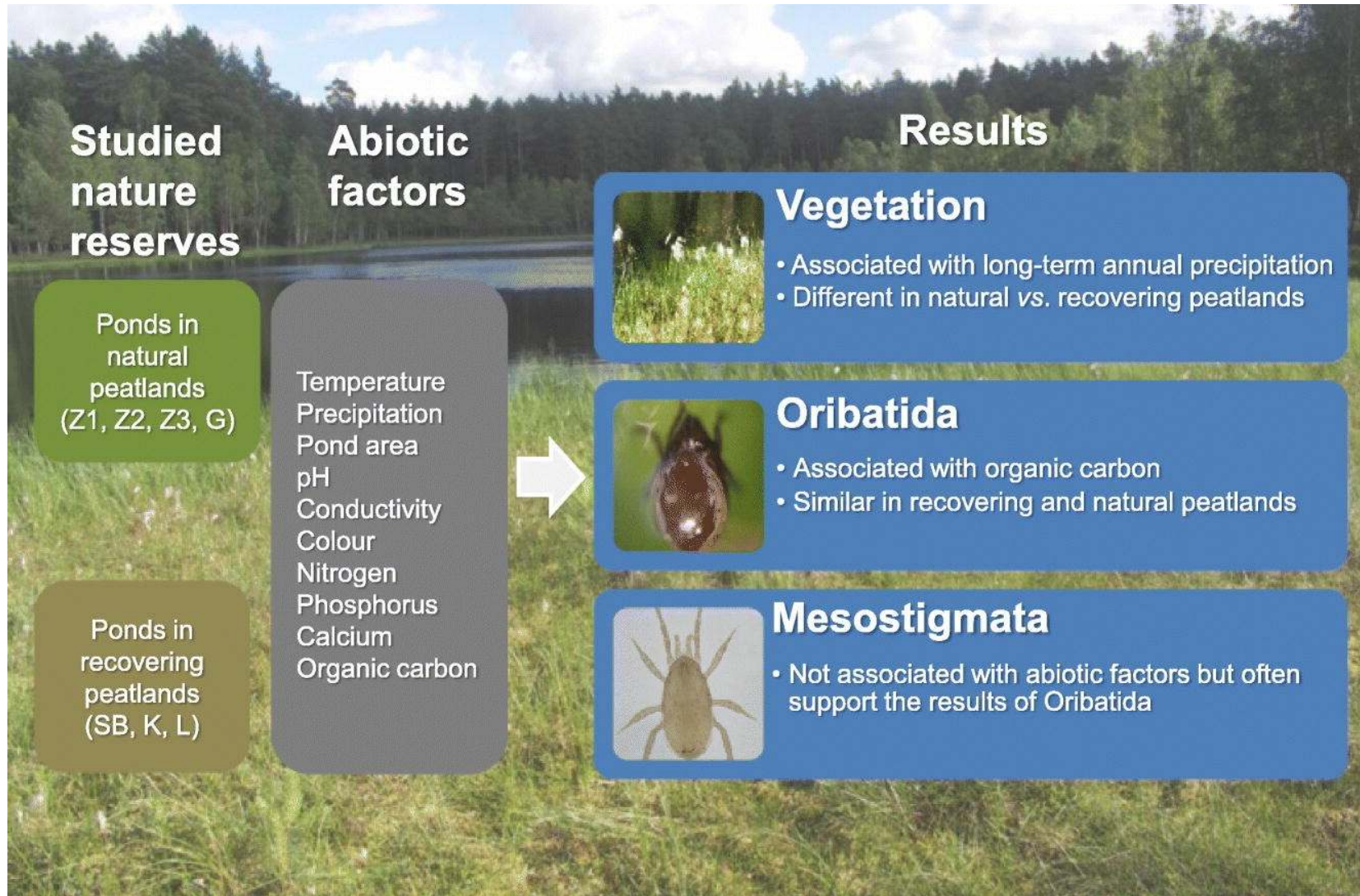
# Arachnids occupy a wide range of habitats



- Sensitive to environmental changes
- Occupying key positions in food webs
- Strong site fidelity with low dispersal capacity
- Relatively easy to sample and identify
- Responsive to different types of disturbance
- Backed by an established research foundation
- .....

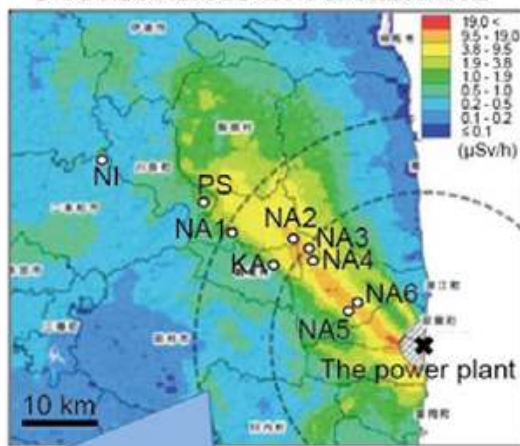
**Arachnids are excellent bioindicators!**

# Mites (Oribatida and Mesostigmata) and vegetation as complementary bioindicators in peatlands

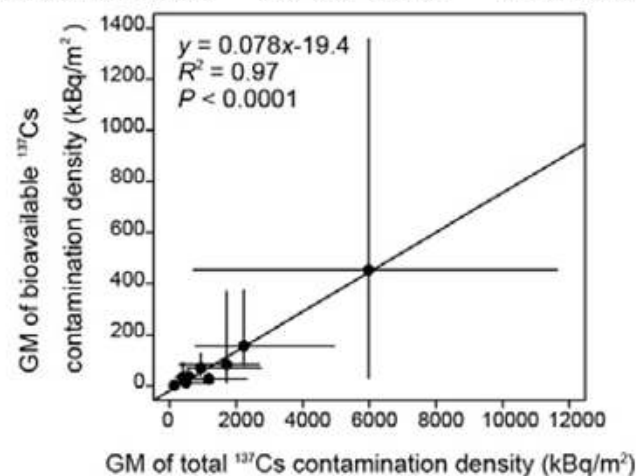


# Nephila clavata spiders indicate $^{137}\text{Cs}$ contamination in arthropods and bioavailable $^{137}\text{Cs}$ in Fukushima forest soils

9 forest sites in Fukushima



Bioavailable  $^{137}\text{Cs}$  vs. total  $^{137}\text{Cs}$  in soil



$^{137}\text{Cs}$  transfer pathways from soil to spider

The web-building spider (*Nephila clavata*)

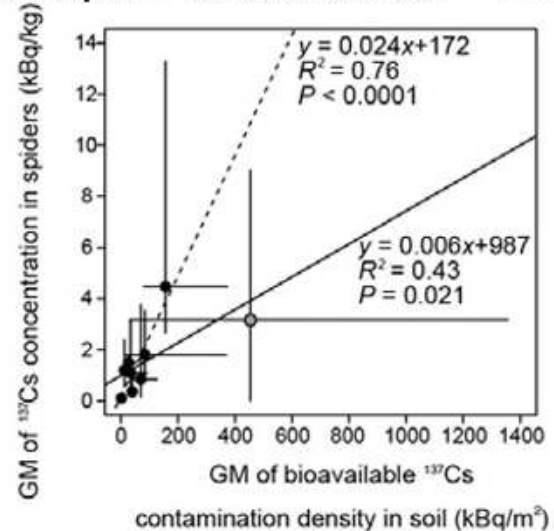


Grazing food chains

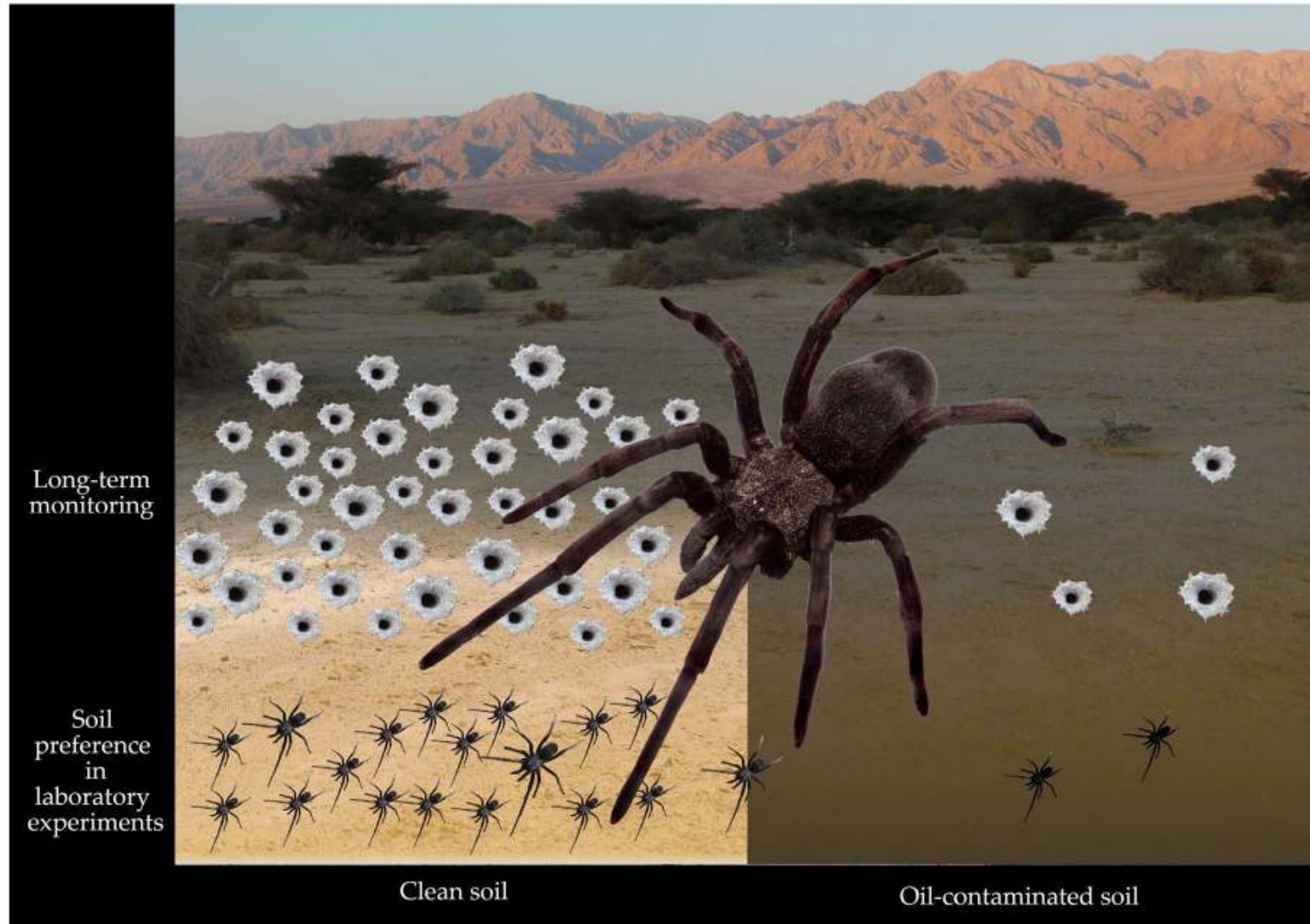
Detrital food chains

Bioavailable fraction of  $^{137}\text{Cs}$  in soil

$^{137}\text{Cs}$  in spider vs. bioavailable  $^{137}\text{Cs}$  in soil



# Five-Year Monitoring of a Desert Burrow-Dwelling Spider Following an Environmental Disaster Indicates Long-Term Impacts



# Take home message

- **Arachnids × Biomaterials:**

1. Spider silks have mechanical properties that outperform most natural and synthetic fibers;
2. Genetic engineering enables large-scale production of spider silk proteins;
3. Current applications and ongoing challenges of spider silk.

- **Arachnids × Medicine:**

1. Arachnid toxins show therapeutic potential in pain relief, stroke treatment, and cancer therapy.

- **Arachnids × Ecology:**

1. Arachnids are used in agriculture to control pest populations through predation;
2. Arachnids serve as bioindicators to monitor environmental quality.



# What can we learn from this report?

- Arachnids are a natural controlled experiment—multiple orders offer alternative solutions under shared constraints, separating general principles from lineage-specific tricks.
- The key is not “bigger brains,” but how computation is allocated—body and environment turn complexity into readable physics via extended phenotypes and sensors.
- Efficient behavior often comes from structured priors—stereotyped programs and mechanics reduce control dimensionality while preserving high performance.
- Arachnids turn “feared animals” into a transferable tech platform—silk, venom libraries, and ecological services converge on actionable bio-design principles.