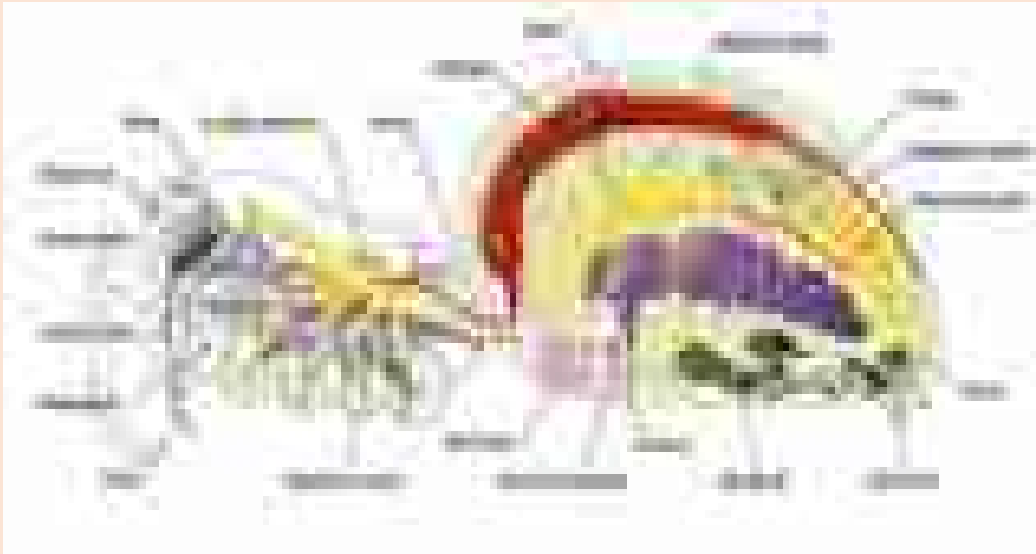


Module# 138 Morphology of spider's Abdomen



- The abdomen is also known as the **opisthosoma.**
- On the ventral side of the abdomen
are two hardened plates covering
the book lungs.

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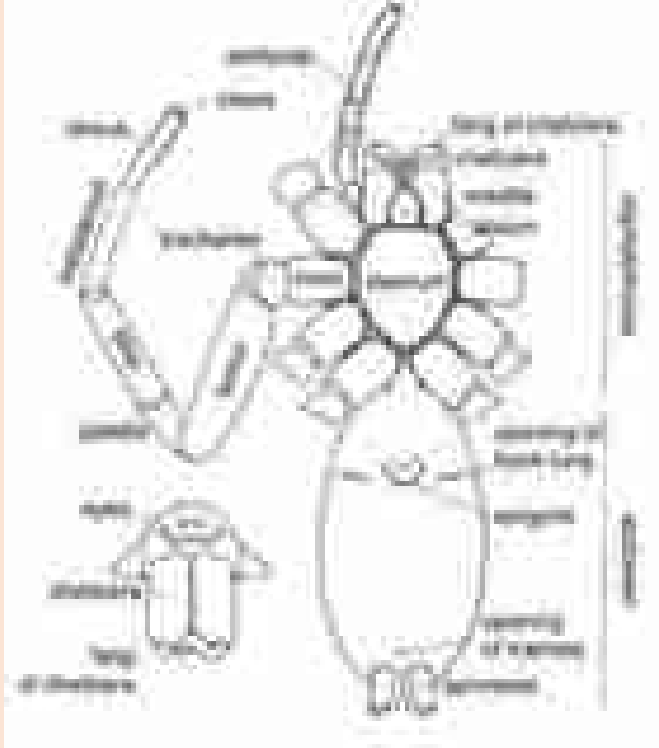
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Morphology of spider's Abdomen plates.

- These are called the **epigastric**

der's Abdomen
plates.



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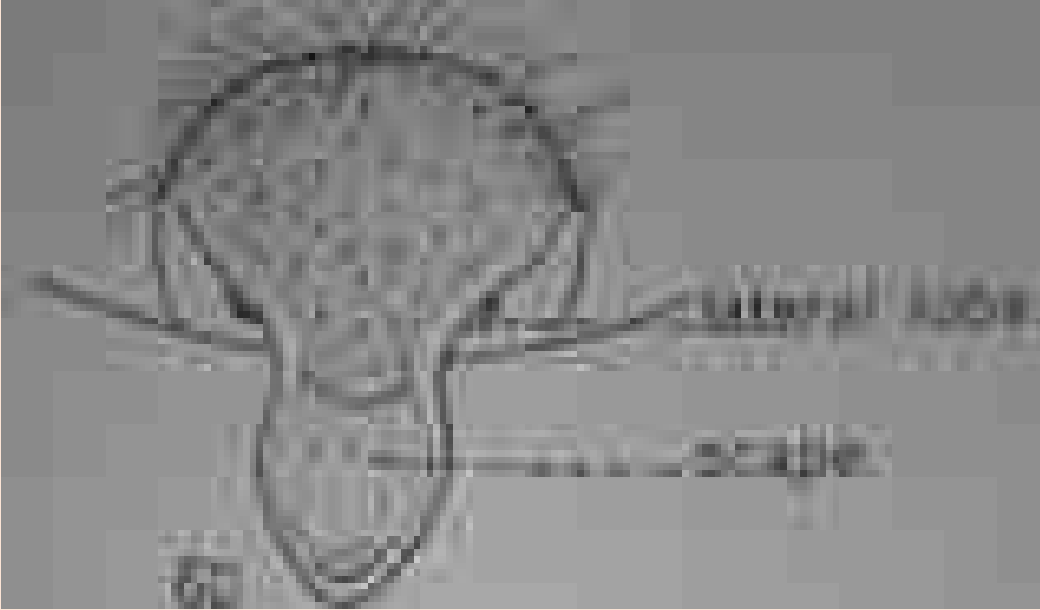
- Females genital organ is also present on ventral side of the abdomen.
- It is called epigyne.

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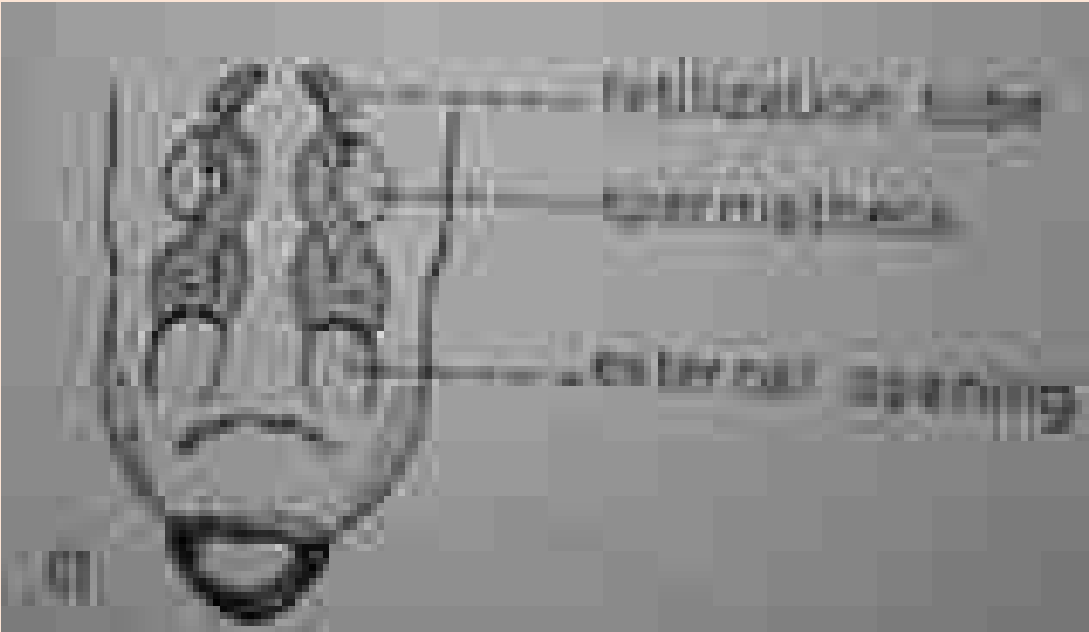
Morphology of spider's Abdomen



- In many cases epigyne is provided with a tongue like sclerotic projection called scape.
- Scape often have paired lateral lobes as in Neoscona

Tikadar, 1982. The Funa of India

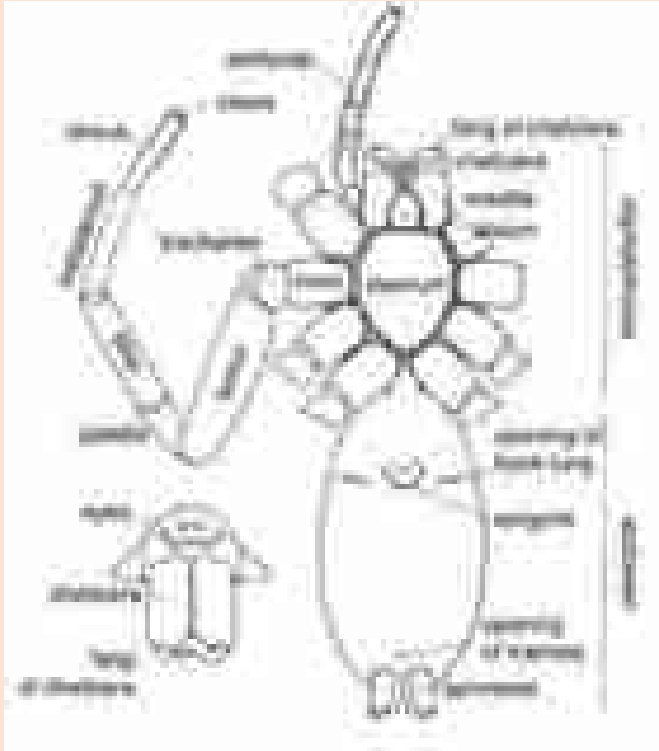
Morphology of spider's Abdomen



Tikadar, 1982. The Funa of India

- Epigine has two external openings which lead to spermathecae inside and paired of narrow curved tubes called fertilization tube
- Scape often have paired lateral lobes as in Neoscon

Morphology of spider's Abdomen



- A fold, known as the epigastric furrow, separates the region of the book lungs and epigyne.

- In the middle of this furrow is the opening of the oviduct (in females) and at either end are

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the

lung slits.

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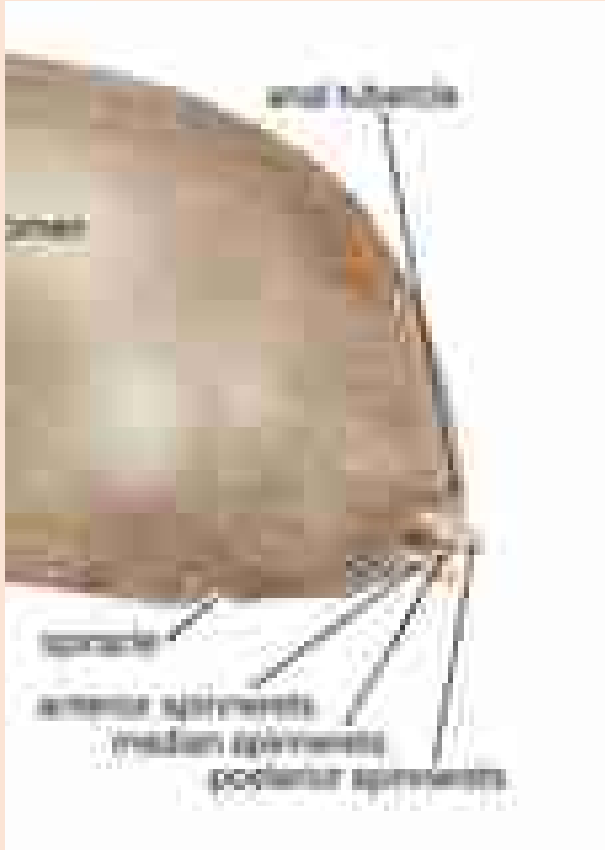
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Morphology of spider's Abdomen

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Morphology of spider's Abdomen

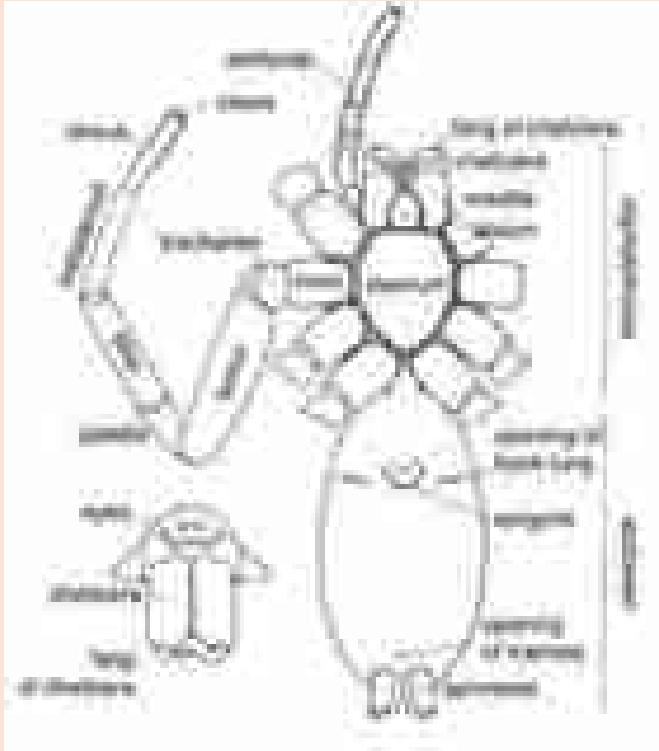


- On posterior side of the abdomen there is conical anal tubercle that bear three pairs of spinnerets ventrally.
- On ventral side there are two pairs of book lungs.

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Morphology of spider's Abdomen



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Morphology of spider's Abdomen

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Morphology of spider's Cephalothorax

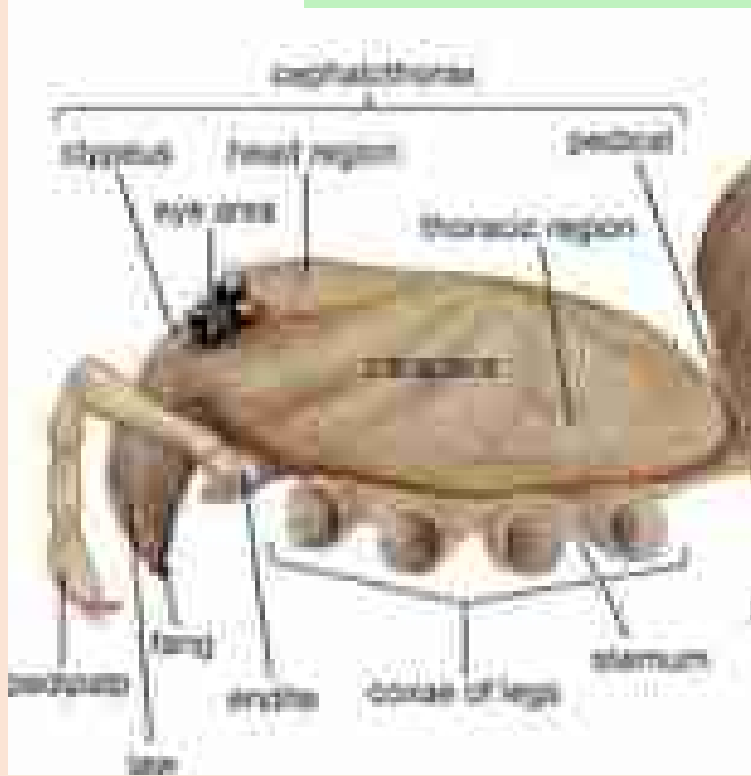
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(heterogeneous)

Usually arranged in

- two rows

Morphology of spider's Cephalothorax



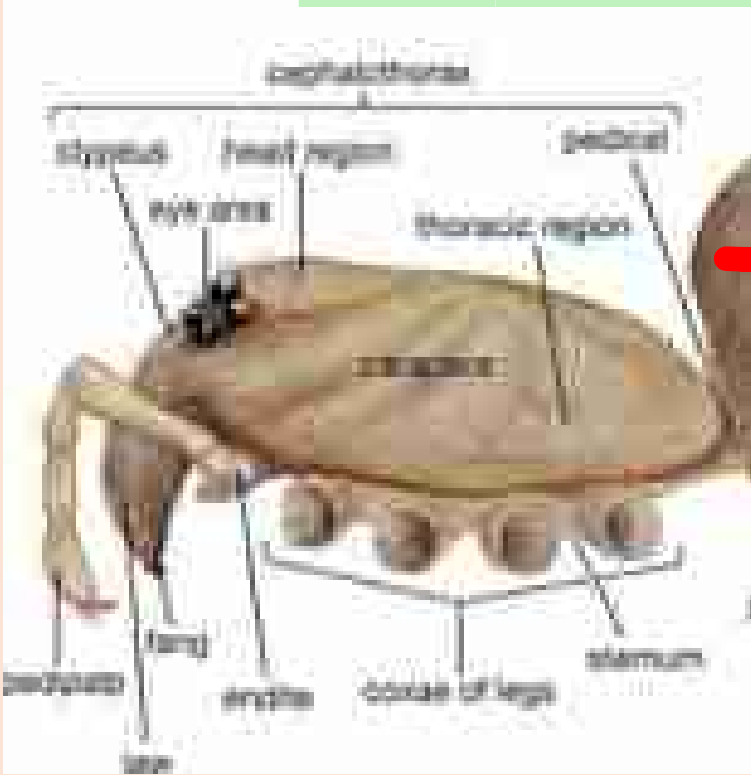
- Each row usually contain 4 eyes.
- Rows of eyes are frequently curved.
- Anterior median/Anterior lateral
- Posterior median/Posterior lateral

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• Cephalic area of eyes is called **ocular area**.

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Morphology of spider's Cephalothorax



- Area of four median eyes is called ocular

quad.

- The area between anterior row of eyes and

- The depression in the middle of

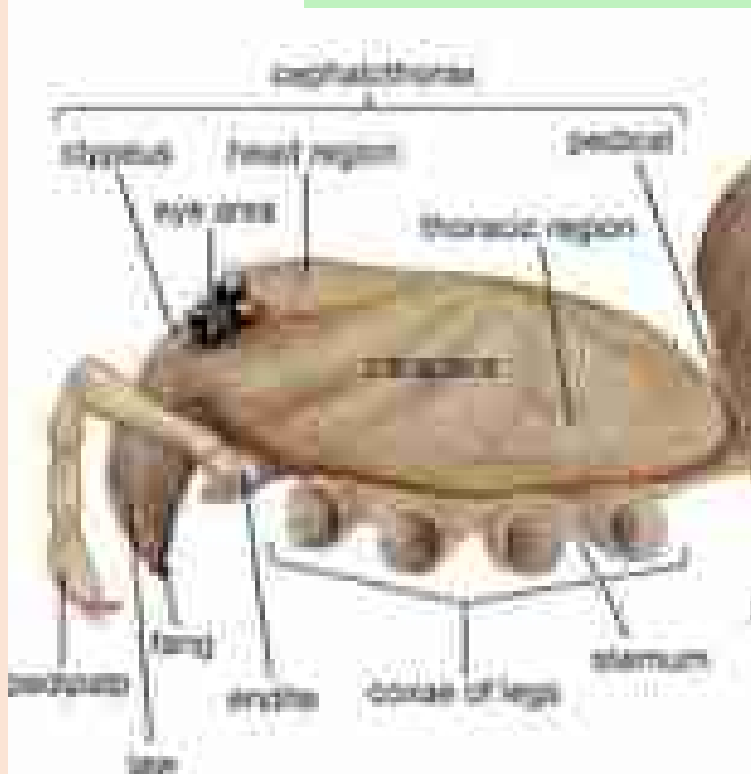
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thorax is called **thoracic**

groove

or fovea.

Morphology of spider's Cephalothorax



- Appendages
- Chelicerae/Fangs
- Palpal (2nd pair of appendages)
- Palp has six parts/metatarsus missing.
- In males tarsus/modified

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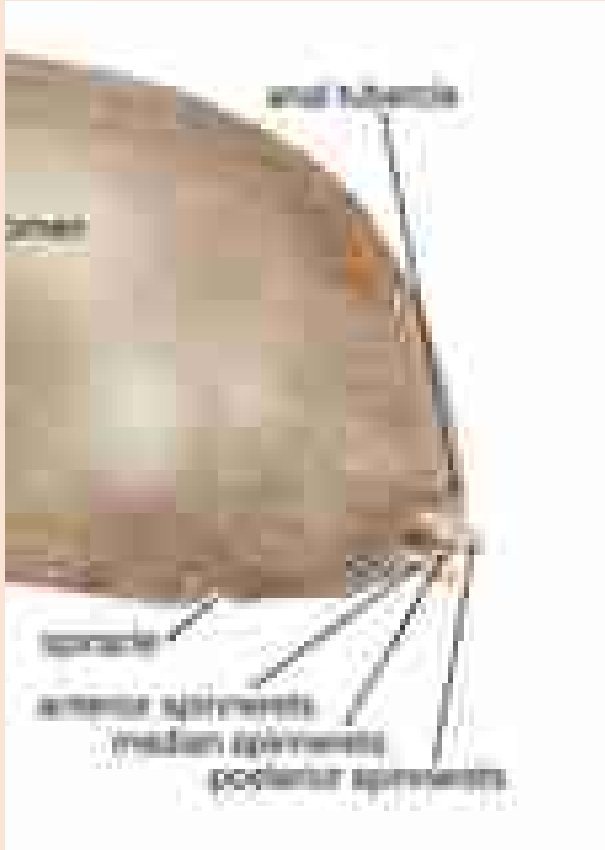
Morphology of spider's Cephalothorax

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- Ventral side is sternum
- Oval/heart shape

Module# 140 Morphology of spider's Spinnerets



- The abdomen of spiders has modified pairs of movable telescoping organs called **spinnerets**, which produce silk.
- The suborder **Mesothelae** is unique in having only two types

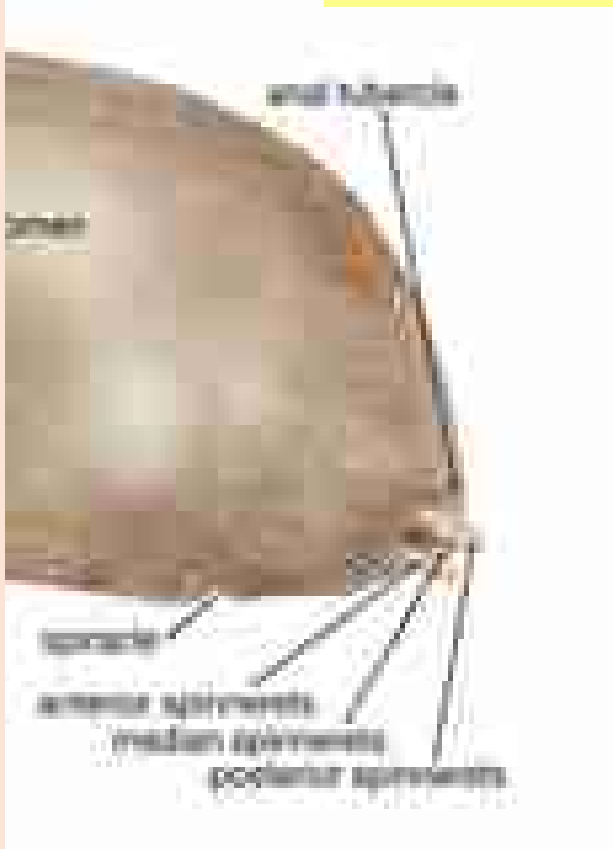
Morphology of spider's Spinnerets

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of silk glands – thought to be
the
ancestral condition.

Morphology of spider's Spinnerets



- Depending on the complexity of the species, spiders will have two to eight spinnerets, usually in pairs.

- Behind each spinneret visible on the surface of the spider lies a

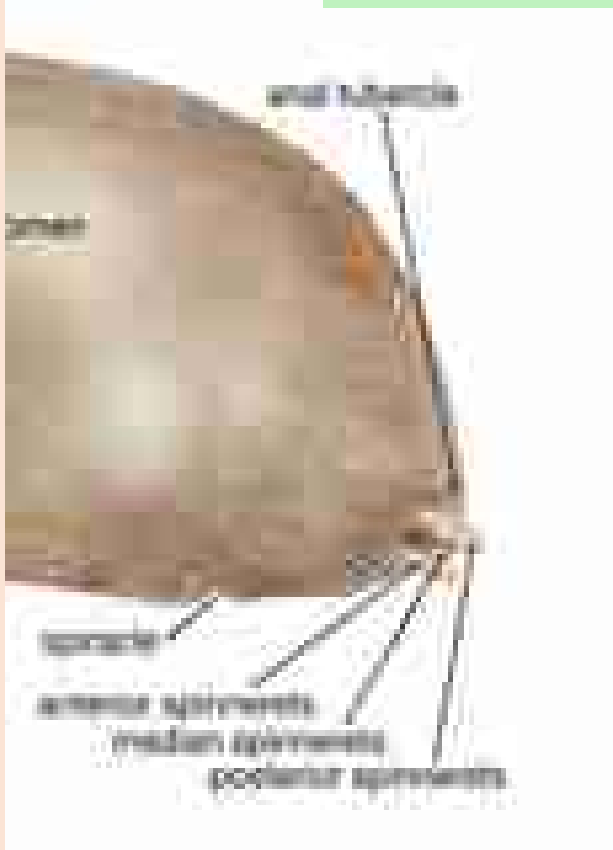
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gland.

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Morphology of spider's Spinnerets



- Each spigot has a valve that controls the thickness and speed of the extruded material. As the spigots pull the fibroin protein molecules out of the ducts and extrude them into the air, the

Morphology of spider's Spinnerets

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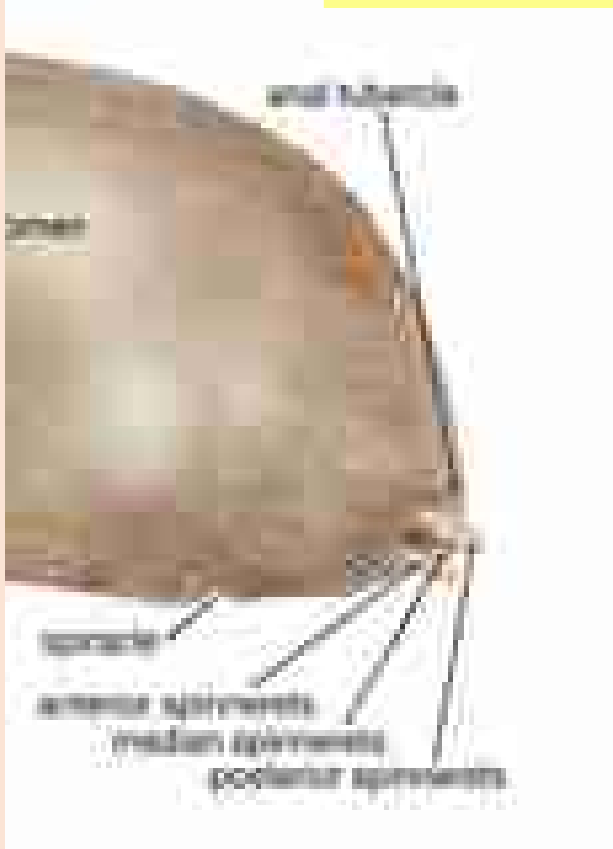
molecules are stretched out

and

linked together to form long

strands.

Morphology of spider's Spinnerets



for

- The spinnerets wind these strands together to form the sturdy silk fiber.

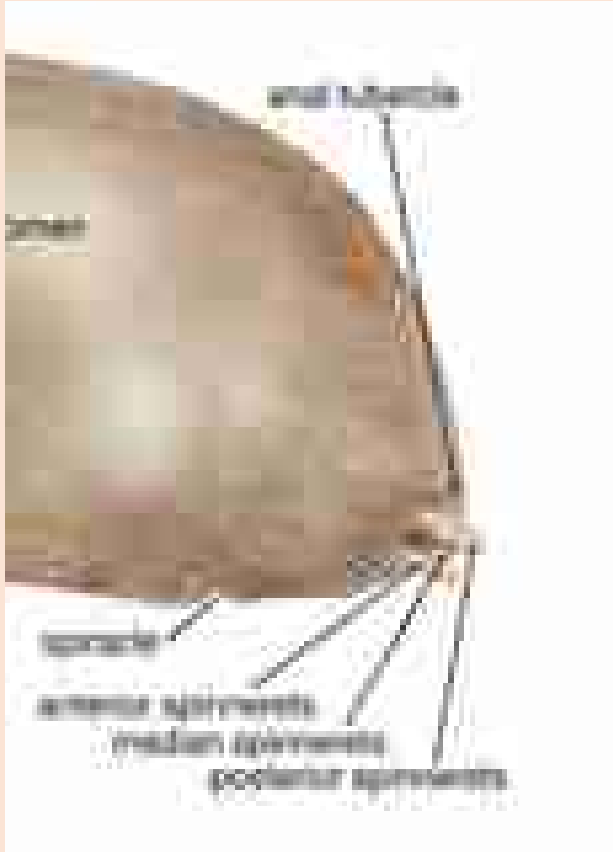
- Most spiders have multiple silk glands, which secrete different types of silk material optimized

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different purposes.

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Morphology of spider's Spinnerets



- Spider silk is incredibly strong and flexible. Five times as strong as an equal mass of **steel** and twice as strong as an equal mass of **Kevlar.**
- Elasticity

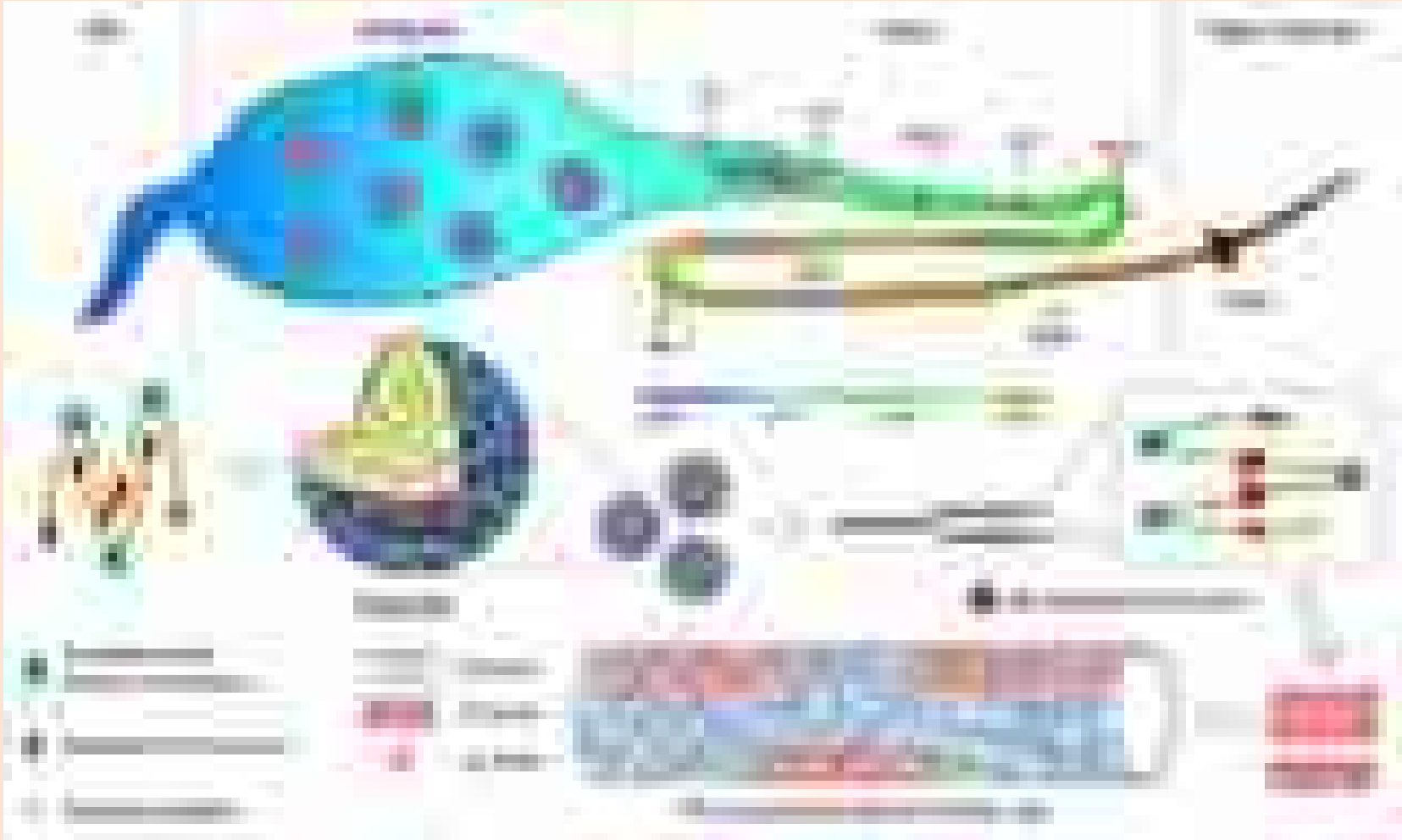
Morphology of spider's Spinnerets

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- Size

- Temperature/PH/uses

Morphology of spider's Spinnerets



Morphology of spider's Spinnerets

https://en.wikipedia.org/wiki/Spider_silk

Module# 141 Introduction to Scorpions



- **Scorpions** are predatory arachnids of the order **Scorpiones**.
- They have eight legs, and are easily recognized by a pair of grasping pincers and a narrow, segmented tail, often carried in a characteristic forward curve over the back and ending with

<https://en.wikipedia.org/wiki/Scorpion>

Introduction to Scorpions



- Scorpions primarily prey on insects and other invertebrates, but some species take vertebrates.
- They use their pincers to restrain and kill prey.

<https://en.wikipedia.org/wiki/Scorpion>

Introduction to Scorpions



- The vast majority of species do not represent a serious threat to humans, and healthy adults usually do not need medical treatment after being stung.
- Poisonous scorpions
- Habitat/desert/Mountains
- Collection/UV/Turning stone/pitfalls

<https://en.wikipedia.org/wiki/Scorpion>

Module# 142 Introduction to Scorpions



- Scorpion bites are highly painful
- Venom peptides
- Type/Long chain/Short chain
- Medical importance/Buthidae
- Treatment of diseases
- Cancer treatment
- Venom price
- Venom collection

<https://en.wikipedia.org/wiki/Scorpion>

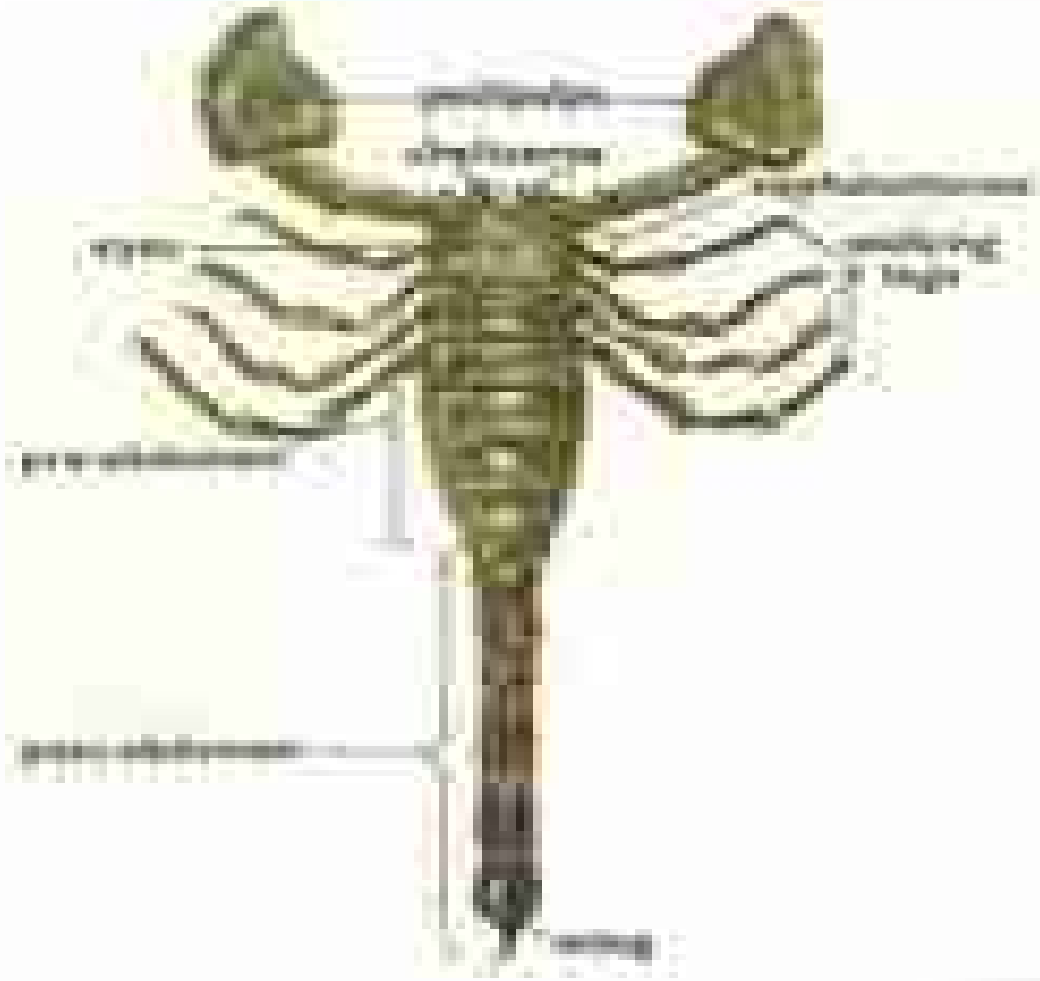
Introduction to Scorpions



- How to collect venom
- Effect of temperature on venom production
- Amount of venom
- Method of venom collection

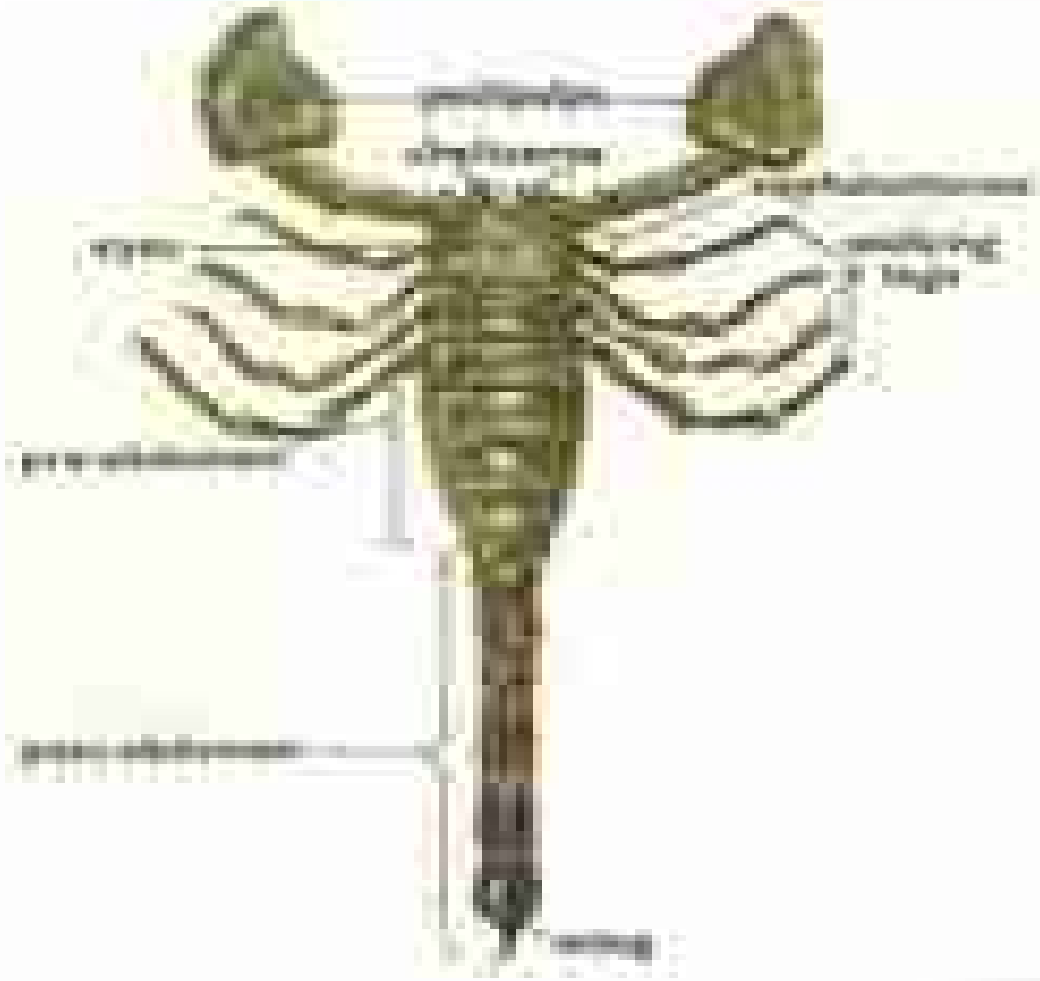
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Module# 143 Morphology of Scorpions



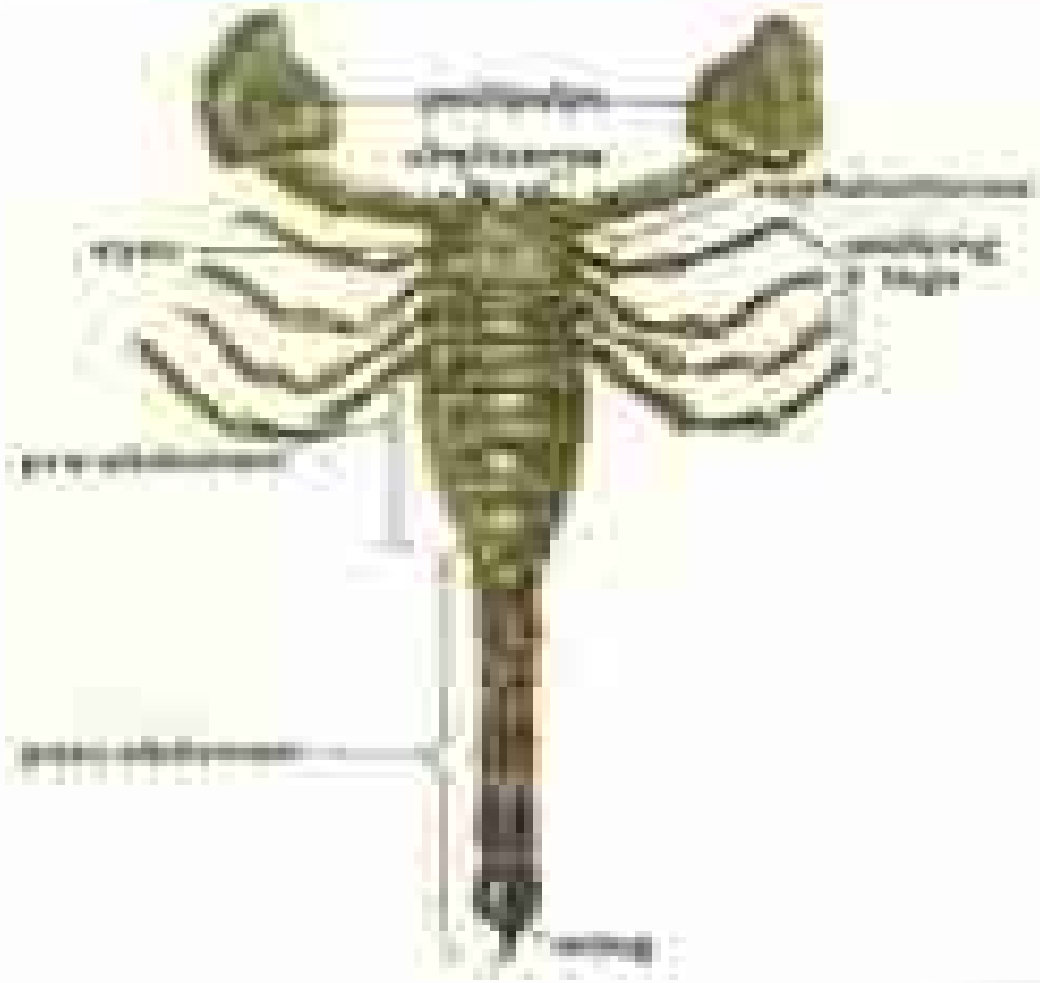
- Cephalothorax
- Padipal
- Chelicera
- Abdomen
- Walking legs
- Sting
- Body is covered with a cuticle consisting of chitin and tanned proteins

Morphology of Scorpions



- 8.5-23mm
- The opisthosoma is subdivided into a broad anterior portion, the mesosoma or pre-abdomen, and a narrow tail-like posterior, the metasoma or post-abdomen.
- Most species are nocturnal.
- Feeding habit/cannibalism

Morphology of Scorpions



- The telson includes the vessicle, which contains a symmetrical pair of venom glands.
- Externally it bears the curved stinger, the hypodermic aculeus, equipped with sensory hairs.
- Abdominal segments These segments have keels, setae and bristles which may be used for

Morphology of Scorpions

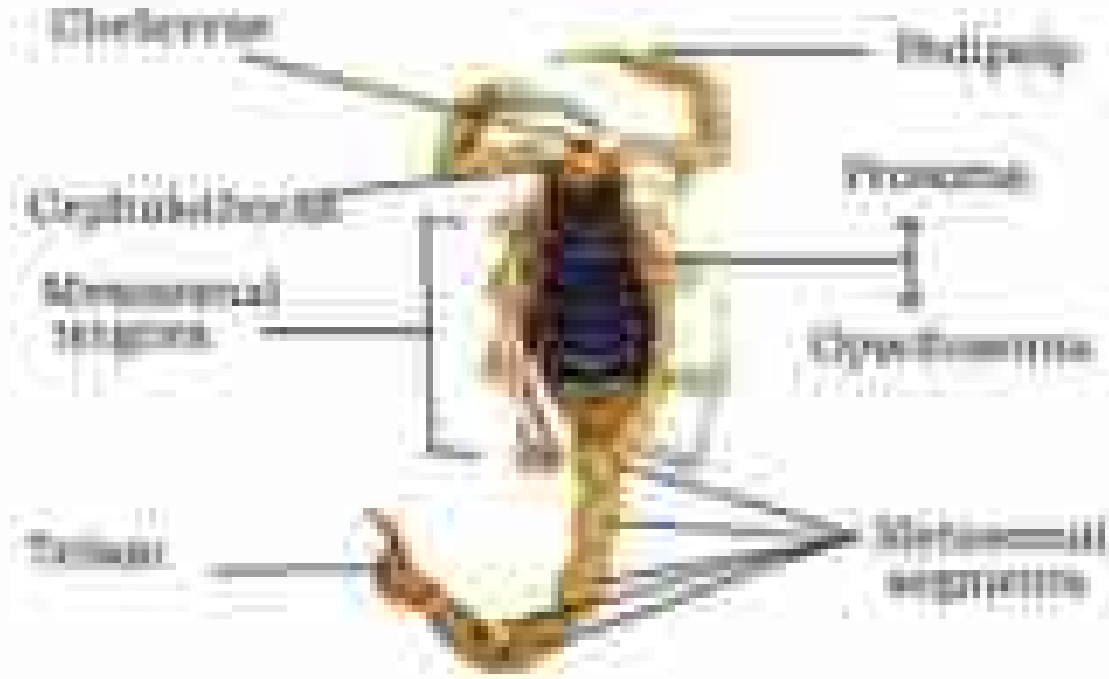


<https://en.wikipedia.org/wiki/Scorpion>

- Each of the venom glands has its own duct to convey its secretion along the aculeus from the bulb of the gland to immediately subterminal of the point of the aculeus.

Morphology of Scorpions

- Parts of scorpion body

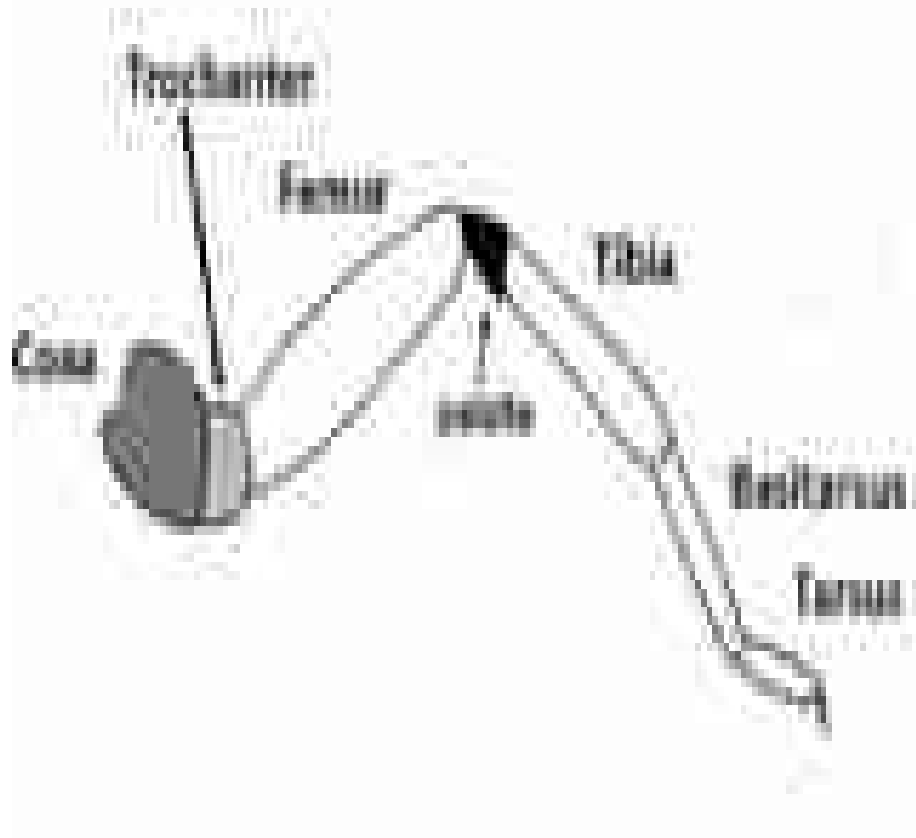


<https://en.wikipedia.org/wiki/Scorpion>

Morphology of Scorpions

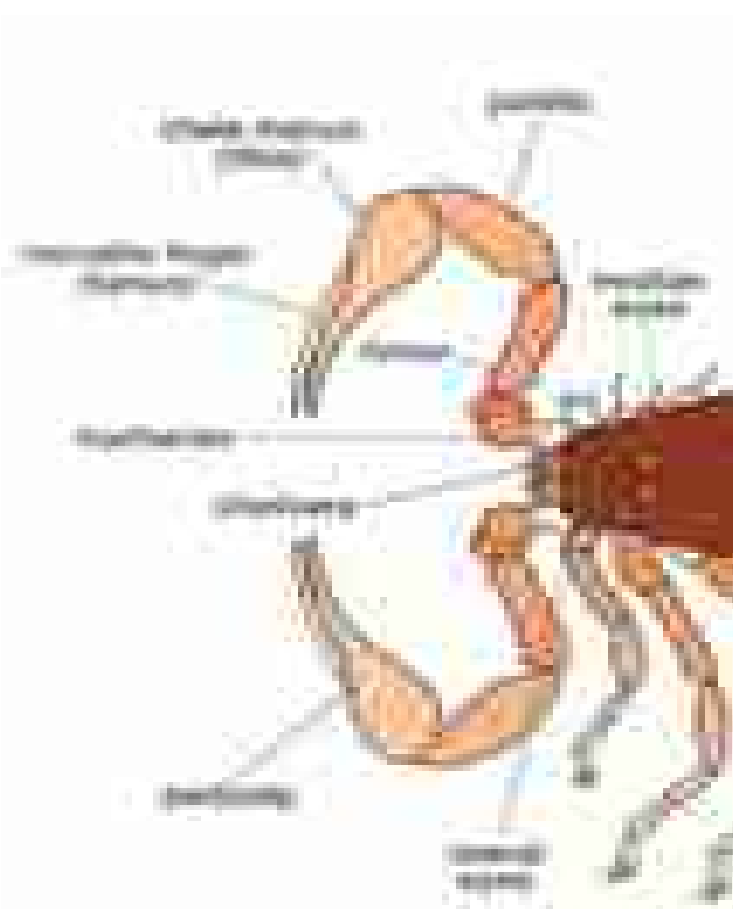
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Module# 144 Morphology of Scorpion Leg



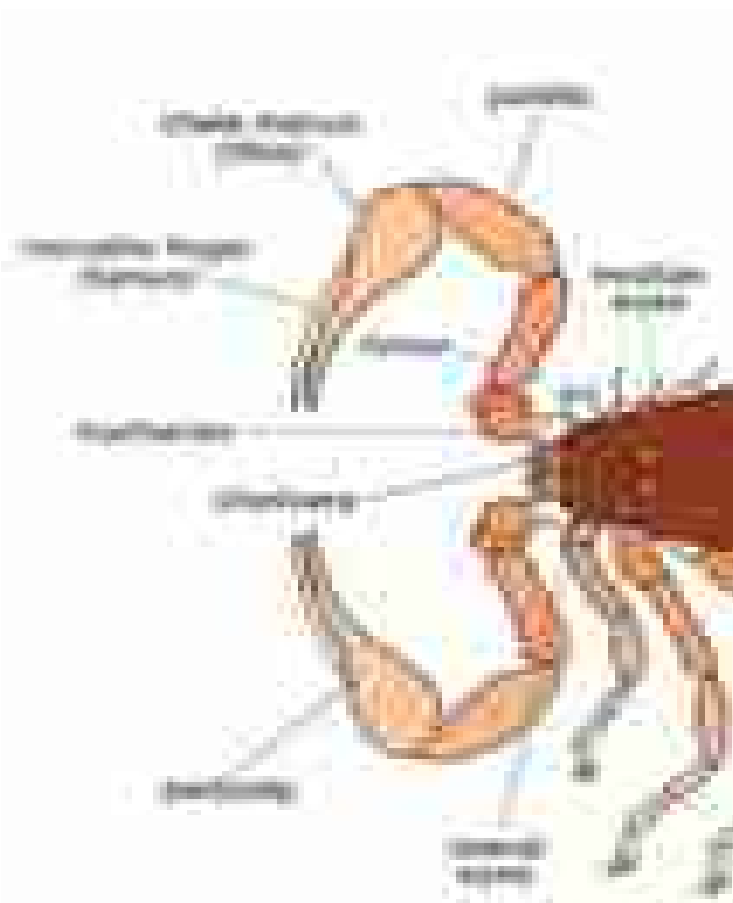
- Four pairs of legs
- Each leg is terminating in a pair of claws.
- A series of trichobothria, the number and positions of which are taxonomically informative, is present on the pedipalp femur, patella, and tibia.

Morphology of Scorpion Leg



- Each chelicera comprises three segments, including a chela manus with fixed finger and a movable finger.
- Each pedipalp comprises a coxa, trochanter, femur, patella, chela manus with fixed finger (tibia), and movable finger (tarsus).

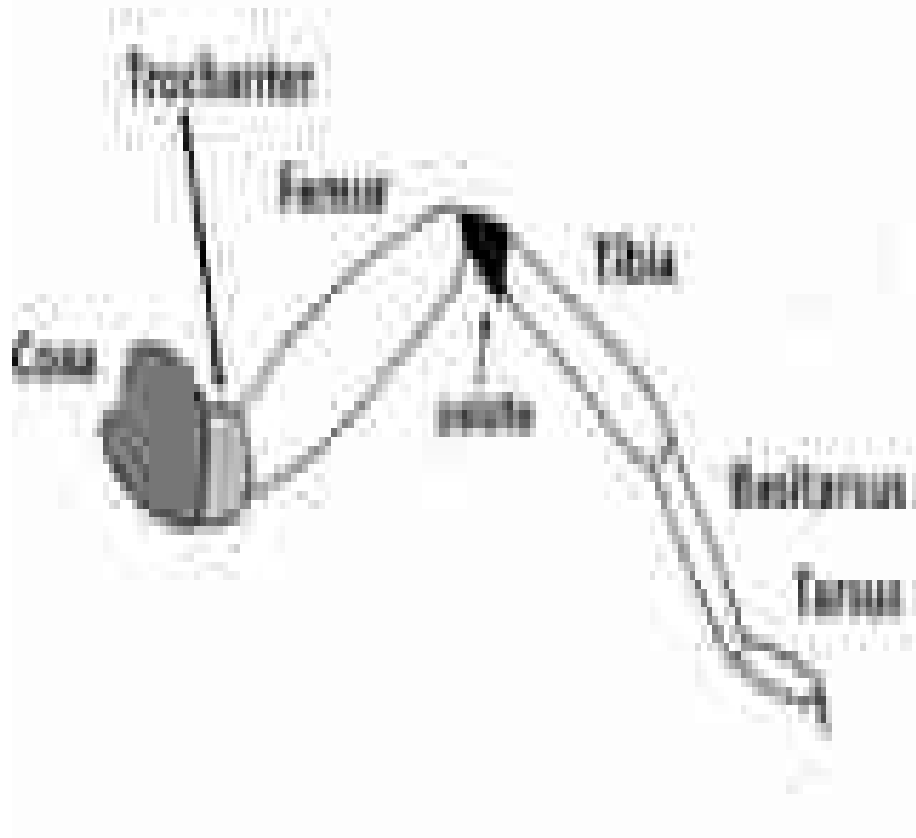
Morphology of Scorpion Leg



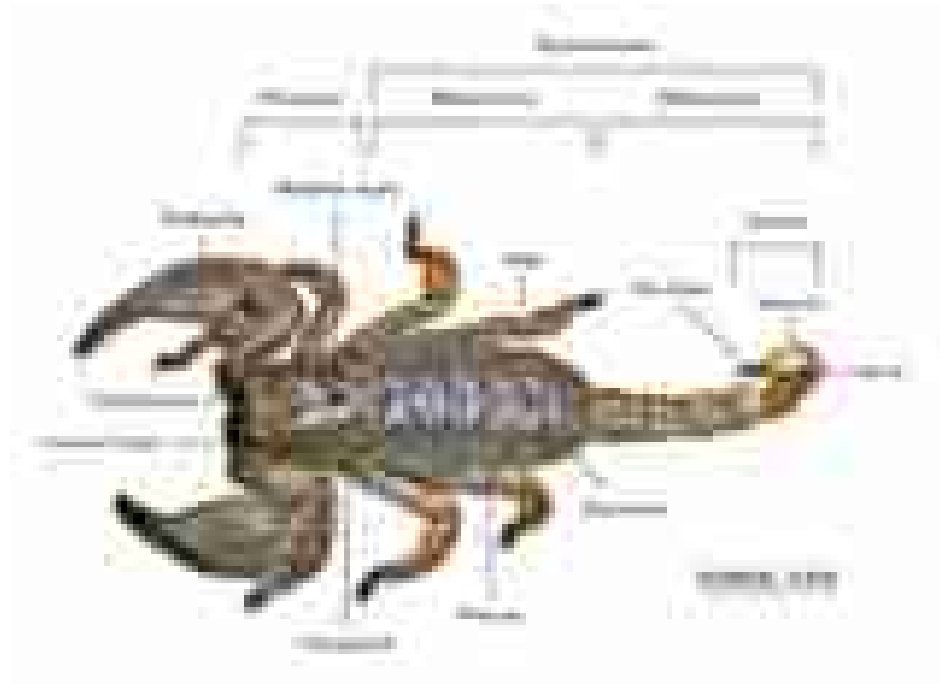
- **Setae** are thick hairs which cover the legs, body, and pedipalps (leg-like mouthparts).
- They are sensitive to the touch.
- Also located on the pedipalps are smaller hairs known as **trichobothria**, which sense air vibrations.

Morphology of Scorpion Leg

- Ground vibrations are sensed by other organs located on the tip of the legs.



Module# 145 Morphology of Scorpion Telson



https://www.google.com/search?q=morphology+of+scorpion+telson&hl=en&sxsrf=ALeKk00bUZaJahtD8rnr_xX1clbP2SysKw:1609048010091&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiJmcX4u3tAhXmEWMBHYpGCwgQ_AUoAXoECA0QAw&biw=1360&bih=657#imgrc=B-pr-vIW4zl8PM&imgdii=co-WyQk3qjdGRM

- The telson is present in Metasoma.
- Metasoma is also called as post-abdomen.
- The postabdomen includes five metasomal segments, the last of which contains the anus and bears the telson.

Morphology of Scorpion Telson



- The telson consists of the vesicle, which holds a pair of venom glands, and the hypodermic **aculeus**, the venom-injecting sting.

https://www.google.com/search?q=morphology+of+scorpion+telson&hl=en&sxsrf=ALeKk00bUZaJahtD8rnr_xX1clbP2SysKw:1609048010091&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiJmcX4u3tAhXmEWMBHYpGCwgQ_AUoAXoECA0QAw&biw=1360&bih=657#imgsrc=B-pr-vIW4zl8PM&imgdii=co-WyQk3qjdGRM

Morphology of Scorpion Telson



https://www.google.com/search?q=morphology+of+scorpion+telson&hl=en&sxsrf=ALeKk00bUZaJahtD8rnr_xX1clbP2SysKw:1609048010091&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiJmcX4u3tAhXmEWMBHYpGCwgQ_AUoAXoECA0QAw&biw=1360&bih=657#imgrc=B-pr-vIW4zl8PM&imgdii=co-WyQk3qjdGRM

- Each of the venom glands has its own duct to convey its secretion along the aculeus from the bulb of the gland to immediately subterminal of the point of the aculeus, where each of the paired ducts has its own venom pore

Morphology of Scorpion Telson



https://www.google.com/search?q=morphology+of+scorpion+telson&hl=en&sxsrf=ALeKk00bUZaJahtD8rnr_xX1clbP2SysKw:1609048010091&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiJmcX4u3tAhXmEWMBHYpGCwgQ_AUoAXoECA0QAw&biw=1360&bih=657#imgsrc=B-pr-vIW4zl8PM&imgdii=co-WyQk3qjdGRM

- An **extrinsic muscle system** in the tail moves it forward and propels and penetrates with the aculeus, while an **intrinsic muscle system** attached to the glands pumps venom

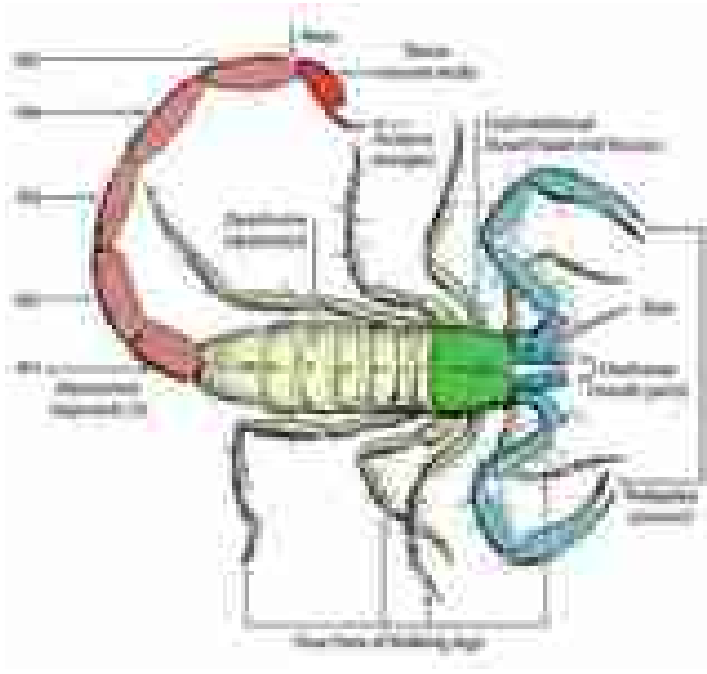
Morphology of Scorpion Telson



- All scorpion species possess venom, which is used to kill or paralyze prey and as a defense against predators.

https://www.google.com/search?q=morphology+of+scorpion+telson&hl=en&sxsrf=ALeKk00bUZaJahtD8rnr_xX1clbP2SysKw:1609048010091&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiJmcX4u3tAhXmEWMBHYpGCwgQ_AUoAXoECA0QAw&biw=1360&bih=657#imgrc=B-pr-vIW4zl8PM&imgdii=co-WyQk3qjdGRM

Module# 146 Morphology of Cheliceræ and Abdomen



https://www.google.com/search?q=chelicerae+of+scorpion&hl=en&sxsrf=ALeKk038xnnZQit8v9nSosB_7rPe5ABxcQ:1609049933235&source=Inms&tbm=isch&sa=X&ved=2ahUKEwiJxcINwu3tAhXNWxUIHeYLDIUQ_AUoAXoECBoQAw&biw=1360&bih=657#imgsrc=EzHwRyQb55Ah_M

- The chelicerae of scorpion is present in cephalothorax region.
- They are scorpions jaws.
- Each chelicera comprises three parts a **coxa**, **tibia** which has a fixed finger, and the **tarsus** forming a moveable finger.

Morphology of Chelicerae and Abdomen

https://www.google.com/search?q=chelicerae+of+scorpion&hl=en&sxsrf=ALeKk038xnnZQit8v9nSosB_7rPe5ABxcQ:1609049933235&source=Inms&tbm=isch&sa=X&ved=2ahUKEwiJxcINwu3tAhXNWxUIHeYLDIUQ_AUoAXoECBoQAw&biw=1360&bih=657#imgsrc=ElizabethHwRyQb55Ah_M

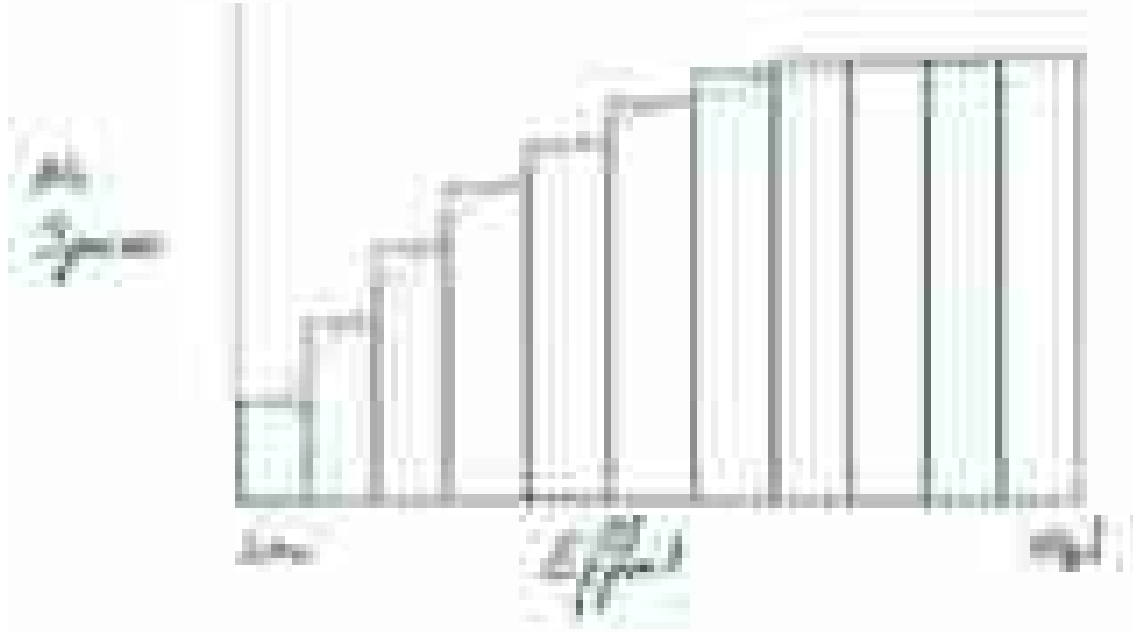
Morphology of Chelicerae and Abdomen

- Within the abdomen are the scorpion's respiratory system, which is a set of thin plates called **book lungs**.
- A spiracle leads to each pair of book lungs on each segment.
- The opisthosoma has eight legs arranged into four pairs.

https://www.google.com/search?q=chelicerae+of+scorpion&hl=en&sxsrf=ALeKk038xnnZQit8v9nSosB_7rPe5ABxcQ:1609049933235&source=Inms&tbm=isch&sa=X&ved=2ahUKEwiJxcINwu3tAhXNWxUIHeYLDIUQ_AUoAXoECBoQAw&biw=1360&bih=657#imgrc=EzHwRyQb55Ah_M

Module# 147 Accumulation Curve

Species accumulation curve



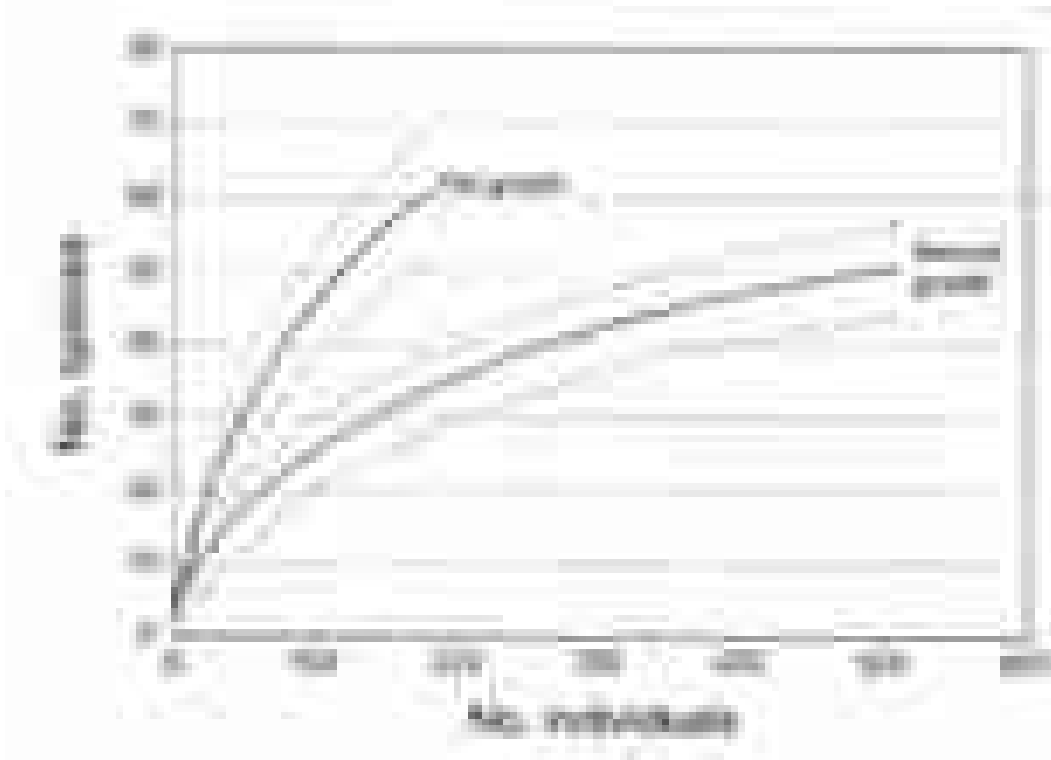
https://www.youtube.com/watch?v=Jj7LYrU_6RA

- The species discovery curve or species accumulation curve is a graph recording the cumulative number of species of living things recorded in a particular environment as a function of the cumulative effort expended searching for them.

Accumulation Curve

<https://besjournals.onlinelibrary.wiley.com/doi/full/10.1046/j.1365-2656.2003.00748.x>

Accumulation Curve



https://www.youtube.com/watch?v=Jj7LYrU_6RA

- Types of accumulation curve
- Importance of accumulation curve
- Accumulation curve vs trapping effort
- Accumulation curve vs trapping method
- Accumulation curve vs biasness

Module# 148 Calculation of Allelic and Genotypic Frequency

$$p + q = 1$$

$$(p + q)^2 = 1$$

$$p^2 + 2pq + q^2 = 1$$

Hardy-Weinberg Equilibrium Model

- P = frequency of Allele A
- q = Frequency of Allele a
- P^2 = Frequency of AA genotype
- $2pq$ = Frequency of Aa genotype
- q^2 = Frequency of aa genotype

Calculation of Allelic and Genotypic Frequency

	AA	Aa	aa	Total
AA	10	20	10	40
Aa	20	40	20	80
aa	10	20	40	70
Total	40	80	70	190

<http://eweb.furman.edu/~wworthen/bio102/evolution219b.htm>

Module# 149 Calculation of Allelic and Genotypic Frequency

Hardy-Weinberg Equilibrium Model

- In a population there are 320AA individuals, 160 heterozygous (Aa) and 20aa individuals.
- Calculate the genotypic and allelic frequencies.

Calculation of Allelic and Genotypic Frequency

Hardy-Weinberg Equilibrium Model

- In a population there are 320AA individuals, 160 heterozygous (Aa) and 20aa individuals.
- Calculate the genotypic and allelic frequencies.

Alleles = A, a

Genotypes = AA, Aa, aa

Frequency of allele A: $f(A) = \frac{2AA + Aa}{2N} = \frac{640 + 160}{640} = 0.25$

Frequency of allele a: $f(a) = \frac{2aa + Aa}{2N} = \frac{40 + 160}{640} = 0.25$

Calculation of Allelic and Genotypic Frequency

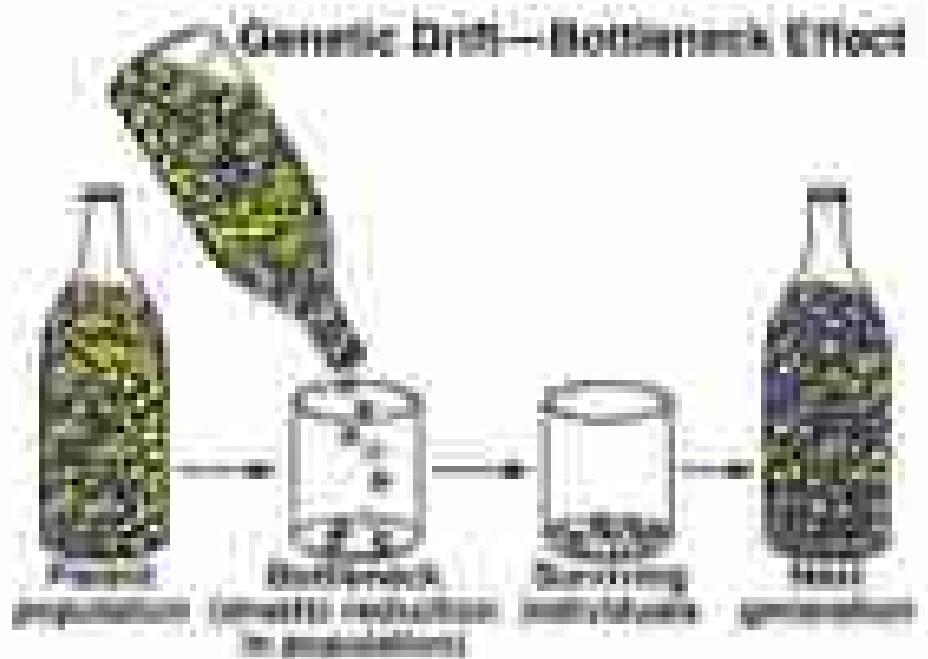
Genotypes	AA	Aa	aa
Number of individuals	320	160	20
Genotypic frequencies	$320/500=0.64$	$16/500=0.32$	$20/500=0.04$

Allelic Frequencies	
A	$320+320+160/1000 = 0.8$
a	$160+40/1000 = 0.2$

Hardy-Weinberg Equilibrium Model

- In a population there are 320AA individuals, 160 heterozygous (Aa) and 20aa individuals.
- Calculate the genotypic and allelic frequencies.

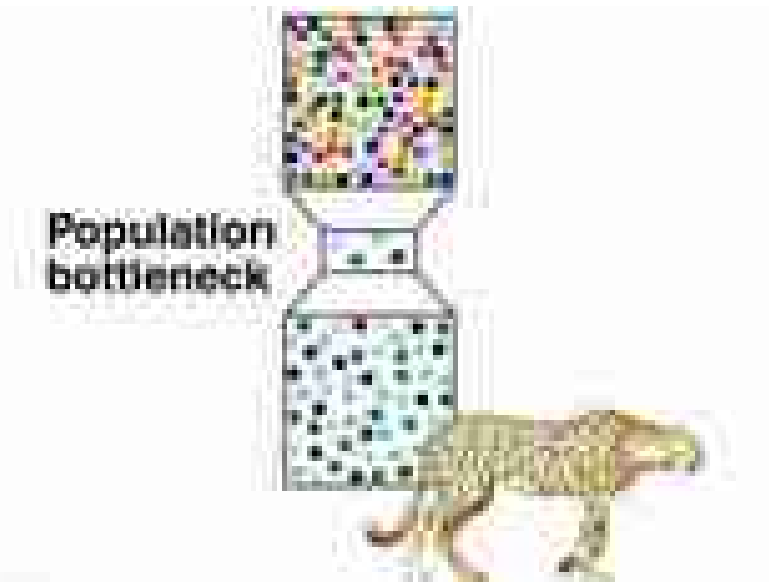
Module# 150 Genetic Drift and its impact on Allele Frequency



https://www.google.com/search?q=genetic+drift&tbm=isch&ved=2ahUKEwjVurHI-evtAhVPw4UKHYbCBvoQ2-cCegQIABAA&oeq=genetic+&gs_lcp=CgNpbWcQARgAMgQIABBDMgQIABBDMgQIABBDMgIADICCAyAggAMgIADICCAyAggAMgIADoFCAAQsQM6BAgjECc6BwgAELEDEENQ3KsjWNe6I2D6zCNoAHAAeACAAfUDiAGCE5IBCTItNi4wLjEuMZgBAKABAaoBC2d3cy13aXotaW1nwAEB&scient=img&ei=BVXnX5WkA8-GlwSGhZvQDw&bih=657&biw=1360#imgsrc=bg-AkcfJaUxBGM

- Change in allele frequency which occur by chance.
- Loss in alleles
- Loss in genetic diversity
- Lost genes for ever
- Bottle neck effect
- Unique genes
- Examples

Genetic Drift and its impact on Allele Frequency



https://www.google.com/search?q=genetic+drift&tbm=isch&ved=2ahUKEwjVurHI-evtAhVPw4UKHYbCBvoQ2-cCegQIABAA&eq=genetic+&gs_lcp=CgNpbWcQARgAMgQIABBDMgQIABBDMgQIABBDMgIIADICCAyAggAMgIIADICCAyAggAMgIIADoFCAAQsQM6BAgJECC6BwgAELEDEENQ3KsjWN6l2D6zCnOAHAAeACAfUDiAGCE5IBCTItNi4wlJEuMZgBAKABAAoBC2d3cy13axotaW1nwAEB&scient=img&ei=BVXnX5WkA8-GlwSGhZvQDw&bih=657&biw=1360#imgrc=bg-AkcfJaUxBGM

- Change in allele frequency which occur by chance.
- Loss in alleles
- Loss in genetic diversity
- Lost genes for ever
- Bottle neck effect
- Unique genes
- Examples

Module# 151 Principles of Systematics

Concept of Fitness

Concept of fitness

Genetic Load = Max. fit individual - Ave. fitness of population

Genetic Load = $5/6 = 0.83$

- Survival+ reproductive success
- Relative fitness
- Ideal population
- Maximum value of fitness
- Genetic load/Genetic burden
- Population with high load
- Population with low load
- Variability in fitness

Module# 152 Taxonomic publications

Kinds of publications

- Short research paper
 - Synopsis & Reviews
 - Revisions
 - Monographs
 - Faunal/Floral Work
 - Field guide/Manuals
 - Catalogues & Check lists
- No taxonomic study is complete until its results are published.
 - Advances in any area of science is made through publications.
 - Taxonomic publications range from short description of species (may be one page) to monograph or handbook (several volumes)

Taxonomic publications

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- Monographs
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- They are ordinary descriptive papers of new species, subspecies or combined all of these or some.
- May or may not contain key for identification.
- May contain a brief check list.

Taxonomic publications

Kinds of publications

- Short research paper
- **Synopsis & Reviews**
- Revisions
- Monographs
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- They are brief summaries of current knowledge of a group.
- Not necessary to include new material or new interpretations.
- Such work bring scattered work together
- Helpful for Revisionary or monographic work.

Module# 153 Taxonomic publications

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- Monographs
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- Revisions are representations of new material or new interpretations that have been integrated with previous knowledge with brief summaries i.e.
- Restudy of complete unit of particular group of Taxa.

Taxonomic publication

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- Monographs
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- Revisions usually include super families, families or part of families.
- It can also deal with genus or species.
- Generic revision
- Species revision

Taxonomic publications

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- Monographs
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- It include re-description or diagnosis of little known taxa, list of synonymy, new names along with keys.

Taxonomic publications

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- **Monographs**
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- A comprehensive systematic study of a particular taxonomic group.
- Always taxon-based, not geography-based.
- Its preparations require more complete material than other types of publications.

Taxonomic publications

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- **Monographs**
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- 3-5 years for completion.
- Monographs try to review all the facts about a taxonomic group.
- A **Monograph** is a complete global account of a **taxon** of any rank – family, genus or species at a given time.
- Book format

Taxonomic publications

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- Monographs
- Atlases
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- They show comprehensive characters of animals in picture form.
- Purpose of atlases are purely taxonomic
- Very helpful taxonomist for identification
- Comparison of species

Module# 154 Taxonomic publications

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- Monographs
- Atlases
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- It deals with detail description faunal/Floral work of particular region.
- It may include information on geographical distribution.
- Also include quantitative data and ecological comments.
- Only experience specialists.

Taxonomic publications

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- Monographs
- Atlases
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- Example: Atlas of scale insects of North America
- Some works are done by taxonomists for non-taxonomists to help them identify common animals.
- Include easy and understandable simple key characters.

Taxonomic publications

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- Monographs
- Atlases
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- Manuals are also written in simple language.
- For students and layman

Taxonomic publications

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- Monographs
- Atlases
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- A catalogue is an index to taxa arranged in such a way to give a vivid picture of references for both zoological and nomenclature purpose:
- Catalogue contain following information:

Taxonomic publications

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- Monographs
- Atlases
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- Catalogue contain following information:
- The original description
- reference
- Later references
- Type locality
- Depository detail
- Type of genus

Taxonomic publications

Kinds of publications

- Short research paper
- Synopsis & Reviews
- Revisions
- Monographs
- Atlases
- Faunal/Floral Work
- Field guide/Manuals
- Catalogues & Check lists

- Taxa are written alphabetically
- Merits depends on completeness
- Its preparation is tedious job
- Useful to know many species/genera are reported from particular area.

Module# 155 Parts of thesis & Research paper

Thesis

- Abstract/Summary
- Introduction
- Review of literature
- Materials and Methods
- Results
- Discussion
- References

Parts of thesis & Research paper

Research paper

- Abstract
- Introduction
- Materials and Methods
- Results
- Discussion
- Acknowledgements
- References

END

Module# 156 Parts of thesis & Research paper

Parts of references

- Name of authors
- Year of publication
- Title/topic of article
- Name of Journal
- Volume number
- Issue number
- Page number

Parts of thesis & Research paper

Reference in Text

- Spider is carnivorous animal
(Tahir, 2009)
- Spider is carnivorous animal
(Tahir and Butt, 2009)

Parts of thesis & Research paper

Effect of Pesticides on agrobiont spiders in Laboratory and Field

Sher Muhammad Sherawat, Abida Butt and Hafiz Muhammad Tahir

Pakistan Journal of Zoology Vol 47, issue 4

pages: 120-129.

Reference in Text

- Spider is carnivorous animal
(Sherawat et al., 2009)
- Spider is carnivorous animal
(Tahir, 2008; Tahir, 2012;
Sherawat et al., 2009)

Parts of thesis & Research paper

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Sher Muhammad Sherawat, Abida Butt and Hafiz Muhammad Tahir

Pakistan Journal of Zoology Vol 47, issue 4

pages: 120-129.

Reference in Text

- Spider is carnivorous animal
(Sherawat et al., 2009^a)
- Spider is carnivorous animal
(Sherawat et al., 2009^b)

Module# 157 How to write References

Effect of Pesticides on agrobiont spiders in Laboratory and Field

Sher Muhammad Sherawat, Abida Butt and Hafiz Muhammad Tahir

Pakistan Journal of Zoology Vol 47, issue 4

pages: 120-129.

Full reference

- Serawat, S.M., Butt, A. and Tahir, H.M., 2009. Effect of pesticides on agrobiont spiders in laboratory and field. Pakistan Journal of Zoology, 42 (4): 120-129.

How to write references

Effect of Pesticides on agrobiont spiders in Laboratory and Field

Abida Butt and Hafiz Muhammad Tahir

Pakistan Journal of Zoology Vol 47, issue 4
pages: 120-129.

Full reference

- Butt, A. and Tahir, H.M., 2009.
Effect of pesticides on agrobiont
spiders in laboratory and field.
Pakistan Journal of Zoology, 42
(4): 120-129.

How to write References

Reference

- Tahir, H.M., 2009. Effect of pesticides on agrobiont spiders in laboratory and field. Thesis submitted to University of the Punjab, Lahore, Pakistan.

Effect of Pesticides on agrobiont spiders in Laboratory and Field

Hafiz Muhammad Tahir

Thesis submitted in 2009 to

Department of zoology, University of Punjab,
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Hafiz Muhammad Tahir

Thesis submitted in 2009 to

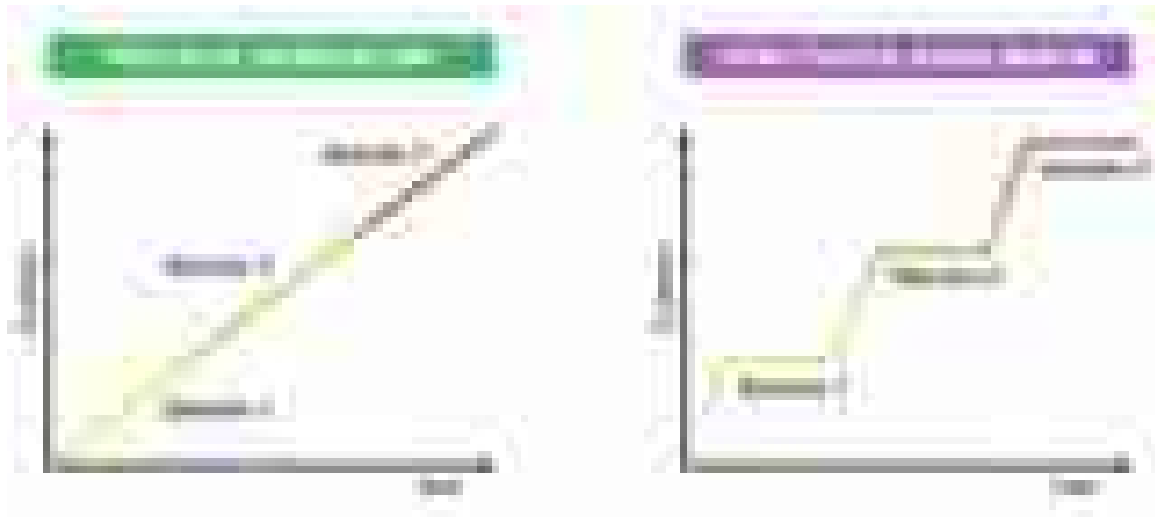
Department of zoology, University of Punjab,
Lahore

How to write References

Reference of Book

- Tahir, H.M., 2009. Effect of pesticides on agrobiont spiders in laboratory and field. Oxford University press, England. Pages. 120-129.

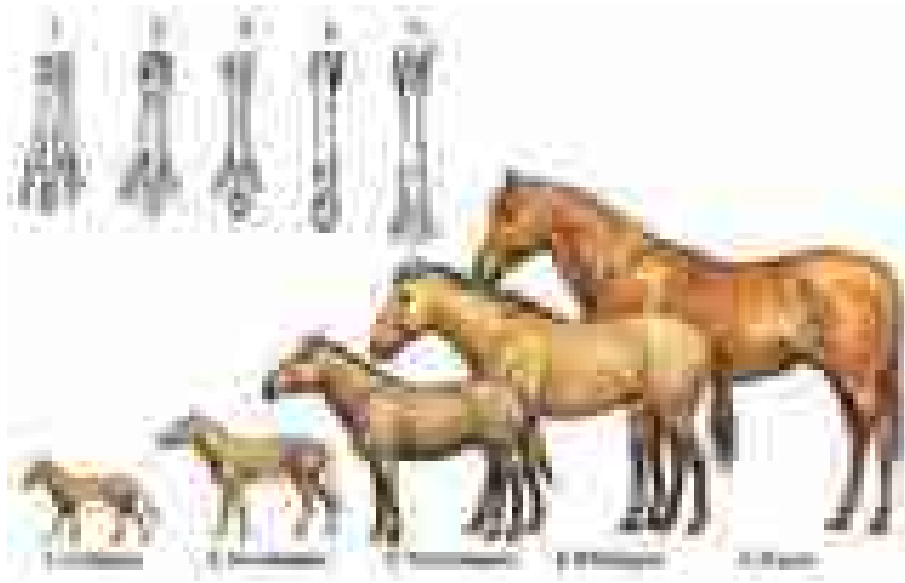
Module# 158 Phyletic Gradualism Vs Punctuated Equilibrium



Phyletic gradualism

- Evolution is a continuous process
- Bring small variation to particular species
- Occurred over a long period of time
- Describe as slow process
- Not proven by fossil record

Phyletic Gradualism Vs Punctuated Equilibrium

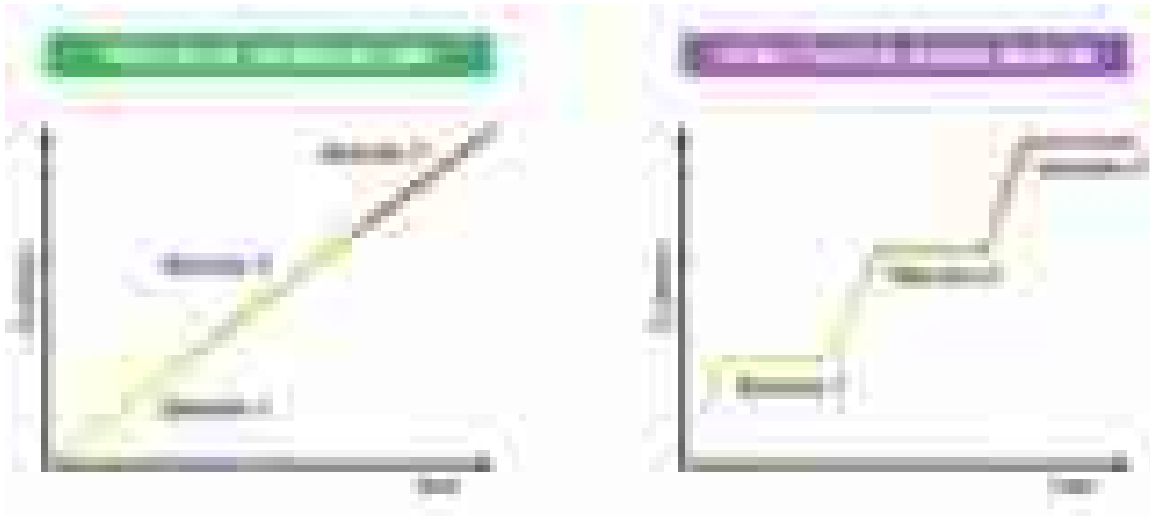


https://www.google.com/search?q=evolution+of+horses&sxsrf=ALeKk02aH8tIJqhmp23ipjOZarZGrJkUhA:1609052837923&source=lnms&tbn=isch&sa=X&ved=2ahUKEwig1tD2zO3tAhV-UxUIHTvEDe4Q_AUoAXoECB4QAw&biw=1360&bih=657

Phyletic gradualism

- It is natural theory of natural selection.
- Small changes are passed from one generation to other generation.
- Horses 50 million years (from small to model day horse)

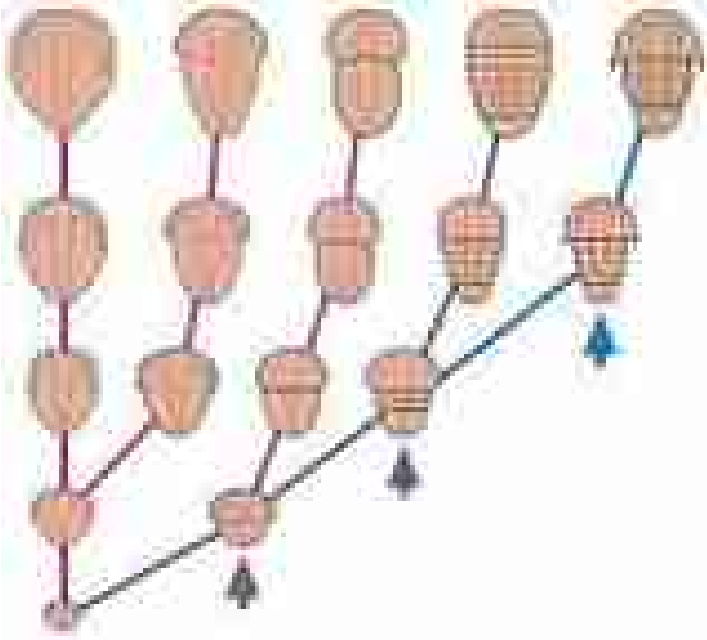
Phyletic Gradualism Vs Punctuated Equilibrium



Punctuated Equilibrium

- Evolution is not a continuous process/fast at one time and slow at other time
- Caused consistent and accumulative changes
- Occurred within short period of time

Phyletic Gradualism Vs Punctuated Equilibrium



https://www.google.com/search?q=evolution+of+trilobites&tbm=isch&ved=2ahUKEwjY7rH5zO3tAhUQ4oUKHUqKCnIQ2-cCegQIABAA&oq=evolution+of+trilobites&gs_lcp=CgNpbWcQAzICCAAyBAGAEBg6BAGjECc6BAGAEENQ_bkFWIzzBWCH9QVoAHAAeACAACQCiAHwK5IBBjltMTkuM5gBAKABAaoBC2d3cy13aXotaW1nwAEB&sclient=img&ei=qzLoX5jtKpDElwTKIKqQBw&bih=657&biw=1360

Punctuated Equilibrium

- Better model to describe species
- Evolution of Trilobites

Module# 159 Adaptation

- Adaptation refers to all the structural, functional and behavioral characteristics that enhance the organism's reproductive success in its natural environment.

Adaptation

Examples

- **Frogs:** Have adapted to freezing temperatures by evolving a glycol like substance in their bloodstreams - like antifreeze.
- **Bats:** Have adapted their hearing to hunt at night via sonic response.

Adaptation

- **Butterflies:** non toxic ones have adapted to look like their more poisonous cousins.
- **A behavioral adaptation** in the oceans is the use of loud, low-frequency calls by fin whale to communicate with other whales over great distances.

Adaptation

- **One physical adaptation** used in the intertidal zones is a crab's hard shell, which protects it from predators, drying out and being crushed by waves.

Module# 160 Taxonomy and Ecology of spiders

Phylum	Arthropoda
Class	Arachnida
Sub-class	Chelicerata
Class	Arachnida
Order	Araneae

- Spiders are poisonous, predacious and fluid feeding carnivorous animals.
- They are found all over the world.
- Body is divided into two main divisions (Prosoma and Opisthosoma)
- Connected by pedicel

Taxonomy and Ecology of spiders

Phylum Arthropoda

Sub-Phylum Chelicerata

Class Arachnida

- Prosoma is dorsally covered by carapace
- Ventrally covered by two chitinous plates (small labium and large sternum)
- Prosoma bears eyes and six pair of appendages
- Chelicerae are provided with poisonous gland
- Four walking legs having 7 segments

Taxonomy and Ecology of spiders

Phylum Arthropoda

Sub-Phylum Chelicerata

Class Arachnida

- Opisthosoma contains spinnerets, Female genital organ, book lungs
- May be nocturnal or diurnal
- Wolf spiders chase their prey
- Sit and wait predators
- Jumping spiders has largest eyes and keenest vision
- Crab spiders lurk among flower petals and fallen flowers, in wait of prey

Taxonomy and Ecology of spiders

Phylum Arthropoda

Sub-Phylum Chelicerata

Class Arachnida

- Mostly feed on insects
- Survive without food for many months
- Only few species are dangerous to man (i.e. Latrodectus)
- Power of regeneration (leg)
- Sexual dimorphism (male smaller)

Taxonomy and Ecology of spiders



- Female suck body sap of male after mating
- Some species carry cocoon on the back of abdomen

Module# 161 Taxonomy and Ecology of Lady beetle

Phylum	Arthropoda
Class	Insecta
Order	Coleoptera
Family	Coccinellidae

- Ladybugs, also called lady beetles or ladybird beetles, are a very beneficial group.
- They are natural enemies of many insects, especially aphids and other sap feeders.
- A single lady beetle may eat as many as 5,000 aphids in its lifetime.

Taxonomy and Ecology of Lady beetle



<https://entomology.ca.uky.edu/ef105>

- Adult lady beetles have very characteristic convex, hemispherical to oval shaped bodies that can be yellow, pink, orange, red, or black, and usually are marked with distinct spots.
- This is a type of **warning coloration** to discourage other animals that may try to eat them.

Taxonomy and Ecology of Lady beetle



<https://entomology.ca.uky.edu/ef105>

- Like many other brightly-colored insects, they are protected by an odorous, **noxious fluid that seeps out of their joints** when the insects are disturbed.

Taxonomy and Ecology of Lady beetle



<https://entomology.ca.uky.edu/ef105>

- Adult females usually lay clusters of eggs on plants close to aphid, scale, or mealybug colonies.
- The alligator-like larvae are also predators.

Taxonomy and Ecology of Lady beetle



<https://entomology.ca.uky.edu/ef105>

- The alligator-like larvae are also predators.
- They are spiny and black with bright spots.
- Although they look dangerous, lady beetle larvae are quite harmless to humans.
- After feeding on insect prey for several weeks, the larva pupates on a leaf.

Taxonomy and Ecology of Lady beetle



<https://entomology.ca.uky.edu/ef105>

- Some lady beetle species have several generations each year while others have only one.
- During the summer months, all stages often can be found at the same time.
- Adults of some species spend the winter clustered together in large groups under leaf litter, rocks, or other debris.

Taxonomy and Ecology of Lady beetle



<https://entomology.ca.uky.edu/ef105>

- Important biological control agents
- Should be conserved
- Learn to recognize the different stages of these beneficial insects.
- Make insecticide applications only when necessary and use selective insecticides or limited treatments to avoid killing lady

Taxonomy and Ecology of Lady beetle



<https://entomology.ca.uky.edu/ef105>

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Taxonomy and Ecology of Lady beetle



<https://entomology.ca.uky.edu/ef105>

- Birds are ladybugs' main predators, but they also fall victim to frogs, wasps, spiders, and dragonflies.
- Ladybugs are happy in many different habitats, including grassland, forests, cities, suburbs, and along rivers.

Taxonomy and Ecology of Lady beetle



<https://entomology.ca.uky.edu/ef105>

- Highly susceptible to pesticides
- Ladybugs are most active from spring until fall. When the weather turns cold, they look for a warm, secluded place to hibernate, such as in rotting logs, under rocks, or even inside houses. These hibernating colonies can contain thousands of ladybugs.
- 5000 species/different consumption rate

Module# 162 Taxonomy and Ecology of Green lacewing

Phylum	Arthropoda
Class	Insecta
Family	Chrysopidae
Genus	Chrysoperla
Species	C. carnea

- Green lacewings are an often under-appreciated group of beneficial insects.
- As with lady beetles, these natural enemies are important predators of many types of soft bodied insects and insect eggs.

Taxonomy and Ecology of Green lacewing



<https://entomology.ca.uky.edu/ef105>

- The adult green lacewing is about 3/4 inch long, light green and has a delicate appearance with lacy wings.
- One unusual characteristic are its eyes, they look like two golden hemispheres.
- They are weak fliers and are commonly found near aphid colonies.

Taxonomy and Ecology of Green lacewing



<https://entomology.ca.uky.edu/ef105>

- The **adults feed** mostly on nectar, pollen, and honeydew but with some species the adults will feed on insects.
- The eggs are either laid singly or in small groups. Each is always found perched on the tip of a hairlike stalk that is about 1/2 inch long.
- This helps to reduce cannibalism of the eggs by sibling larvae.

Taxonomy and Ecology of Green lacewing



<https://entomology.ca.uky.edu/ef105>

- Females will usually deposit the egg close a food source for the larvae.
- The larvae are brown and white and may grow up to about 1/2 inch in length.
- Larvae are called aphidlions, because they feed on other soft-bodied insects as well as aphids.
- They are voracious feeders, attacking with large, curved, hollow mandibles.

Module# 163 Taxonomy and Ecology of Stink bug

Phylum	Arthropoda
Class	Insecta
Order	Hemiptera
Family	Pentatomidae
Sub-Family	Asopinae

- **Pentatomidae** is a family of insects belonging to the order Hemiptera, generally called **shield bugs** or **stink bugs**.
- Pentatomidae has over 4700 species
- Have piercing sucking mouthparts
- Most are phytophagous, severe pests on agricultural crops.

Taxonomy and Ecology of Stink bug

Phylum	Arthropoda
Class	Insecta
Order	Hemiptera
Family	Pentatomidae
Sub-Family	Asopinae

- However, some species, particularly in the subfamily Asopinae, are predatory and may be considered beneficial.
- They have ability to release a pungent defensive spray when threatened, disturbed, or crushed.
- The composition of this spray may vary between species, and even by sex or age

Taxonomy and Ecology of Stink bug



<https://www.uky.edu/Ag/CritterFiles/casefile/insects/bugs/stinkbugs/stinkbugs.htm>

- but generally includes aldehyde and alkanes.
- Moderate to large size, ranging in length from 7 to 25 mm, and are broadly elliptical in shape.
- The subfamily Asopinae belongs to the family Pentatomidae of the suborder Heteroptera (true bugs).
- About 300 species in 69 genera have been described worldwide.

Taxonomy and Ecology of Green lacewing



<https://www.uky.edu/Ag/CritterFiles/casefile/insects/bugs/stinkbugs/stinkbugs.htm>

- Adult stink bugs are strong fliers and typically migrate into cotton from alternate hosts outside the field, including adjacent fields of maturing corn and soybean.
- Stink bugs are difficult to scout.
- Adults tend to aggregate, and the distribution of stink bugs within a field may be highly concentrated, particularly along borders.

Taxonomy and Ecology of Stink bug



<https://www.uky.edu/Ag/CritterFiles/casefile/insects/bugs/stinkbugs/stinkbugs.htm>

- Despite being relatively large insects, they can be difficult to see.
- Stink bugs can be scouted for visually, but most thresholds are based on drop cloth samples or the occurrence of internal symptoms of feeding damage to bolls.

Taxonomy and Ecology of Stink bug



<https://www.uky.edu/Ag/CritterFiles/casefile/insects/bugs/stinkbugs/stinkbugs.htm>

- Predatory stink bugs are a gardener's friend, feeding on more than 100 species of insect pests.
- Both nymphs and adults attack insects larger than themselves, and suck the body fluids from their prey with a needle-like beak.

Taxonomy and Ecology of Green lacewing



<https://www.uky.edu/Ag/CritterFiles/casefile/insects/bugs/stinkbugs/stinkbugs.htm>

- Predatory stink bugs tend to have a shorter, stouter beak than the long, thin beak of plant-feeding stink bugs.
- Adults overwinter in sheltered locations and leaf litter, emerging in early spring to stalk and devour their prey.

Taxonomy and Ecology of Stink bug



<https://www.uky.edu/Ag/CritterFiles/casefile/insects/bugs/stinkbugs/stinkbugs.htm>

- **Life stage(s) that feed on pests:** Nymphs and adults.
- **Insect(s) fed on:** Spined soldier bugs prefer larger insects such as grubs and the larvae of various beetles and moths, and are especially fond of caterpillars. Two-spotted stink bugs often eat the eggs and larvae of Colorado potato beetle, and smaller caterpillars and larvae.

Taxonomy and Ecology of Stink bug



<https://www.uky.edu/Ag/CritterFiles/casefile/insects/bugs/stinkbugs/stinkbugs.htm>

- 1st instar nymphs of two-spotted stink bugs feed on plant sap, as will adults in early spring before prey are available, but do no significant damage to plants.
- **Where to find:** Generally throughout the garden, particularly on apples, asparagus, beans, cole crops, cucurbits, eggplant, potatoes, onions, sweet corn and tomatoes.

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Taxonomy and Ecology of Stink bug



<https://www.uky.edu/Ag/CritterFiles/casefile/insects/bugs/stinkbugs/stinkbugs.htm>

- **How to attract and conserve:** Pheromones have been used to attract spined soldier bugs to the garden. Year-round ground cover in garden will provide overwintering sites and shelter, as well as plant sap to feed on early in the season. Avoid or reduce use of broad-spectrum insecticides.

Module# 164 Taxonomy and Ecology of parasitoid wasp

Phylum	Arthropoda
Class	Insecta
Order	Hymenoptera
Family	Eulophidae
Genus	Tamarixia
Species	<i>T. radiata</i>

- Wasps, a very large evolutionary group of hymenopteran insects,
- *Tamarixia radiata* is a species specific ectoparasitoid of the Asian citrus psyllid (ACP) *Diaphorina citri*.
- *Diaphorina citri* is an economically important pest of citrus in many citrus growing regions of the world (Halbert and Manjunath, 2004).

Taxonomy and Ecology of parasitoid wasp



<https://biocontrol.entomology.cornell.edu/parasitoids/Tamarixia.php>

- The psyllid vectors the phloem limited gram-negative bacterium *Candidatus Liberibacter asiaticus*, one of the causal organisms of the devastating citrus disease “**huanglongbing**” (HLB) or **citrus greening disease**. HLB is responsible for the decline of most trees seen in disease affected regions of the world

Taxonomy and Ecology of parasitoid wasp



<https://biocontrol.entomology.cornell.edu/parasitoids/Tamarixia.php>

- *Tamarixia radiata* was first imported to Florida from Taiwan and south Vietnam and limited numbers were released soon after psyllid was discovered in the state (Hoy et al., 1999).
- Successfully managed the pest
- Saved citrus industry of Florida
- *Tamarixia radiata* was first described from northwestern India (Punjab) which is now part of Pakistan.

Taxonomy and Ecology of parasitoid wasp



<https://biocontrol.entomology.cornell.edu/parasitoids/Tamarixia.php>

- *Tamarixia radiata* is not yet available commercially.
- The female usually deposits one and very rarely two eggs on the ventral side of the *D. citri* nymph, mostly in the groove between thorax and abdomen and close to the point of attachment of hind coxae.

Taxonomy and Ecology of parasitoid wasp



<https://biocontrol.entomology.cornell.edu/parasitoids/Tamarixia.php>

- The neonate larva sucks fluid from the site of attachment
- The parasitized nymph remain indistinguishable from unparasitized nymph for couple of days until almost all body contents of the parasitized nymph are consumed and only wing buds and dorsal covering are left.

Taxonomy and Ecology of parasitoid wasp



<https://biocontrol.entomology.cornell.edu/parasitoids/Tamarixia.php>

- At that point, the larva is mature and attaches itself to the leaf or shoot surface with a network of fine anchoring silken threads
- Pupation takes place underneath the mummified nymph and the adult emerges by chewing a circular exit hole in the integument of the thoracic region.

Taxonomy and Ecology of parasitoid wasp



- Development rate varies with temperature. It takes about 12 days to go from egg to adult at 25 °C and 14L:10D.
- A single female can lay up to 300 eggs at 25-30 °C (Chu and Chien, 1991; Étienne et al. 2001).

<https://biocontrol.entomology.cornell.edu/parasitoids/Tamarixia.php>

Taxonomy and Ecology of parasitoid wasp



Module# 165 Taxonomy and Ecology of Whitefly

TAXONOMY

Phylum	<u>Arthropoda</u>
Class	<u>Insecta</u>
Order	<u>Hemiptera</u>
Family	<u>Aleyrodidae</u>

- There are 1550 species worldwide under two subfamilies.
- 70 in Punjab Pakistan
- Cosmopolitan insects
- Most abundant in the tropical and subtropical countries of the world.

Taxonomy and Ecology of Whitefly



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Why called Whitefly?

- White appearance of adults due to deposition of wax on the on body and wings

Taxonomy and Ecology of Whitefly



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- Adult whiteflies are small, approximately 1-2 mm in length.
- Adults with wingspan less than 3mm.
- With a yellow body and two pairs of white wings.
- The compound eyes are red.

Taxonomy and Ecology of Whitefly



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- Sucking and piercing mouthparts.
- Both sexes have functional mouth parts and two pairs of functional membranous wings.
- Nymphs are initially semi-transparent, later becoming creamy yellow to pale-green.

Taxonomy and Ecology of Whitefly



- The pupae or fourth nymphal stage bear 7 pairs of setae on their dorsum. It is called pseudopupa.

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Taxonomy and Ecology of Whitefly



- Produced large quantity of honeydew
- The honeydew emerges from the anus

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Taxonomy and Ecology of Whitefly



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- Present under surface of the leaves.
- Both nymphs and adults feed.
- It has **160 host** plants.
- Polyphagous feed on a large number of host plants like Field crops, Fruit trees, Vegetables, Ornamentals , Weeds etc

Taxonomy and Ecology of Whitefly



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- One of the most **noxious insect pest** attaching fields crops.
- Loss is due to activities of sucking the sap from the leaves that weaken the plants, resulting in low fruiting with reduced yield.
- They excrete large amounts of **honeydew** and throw it on different parts of plants.
- Honeydew attract sooty mold which **affect photosynthesis**

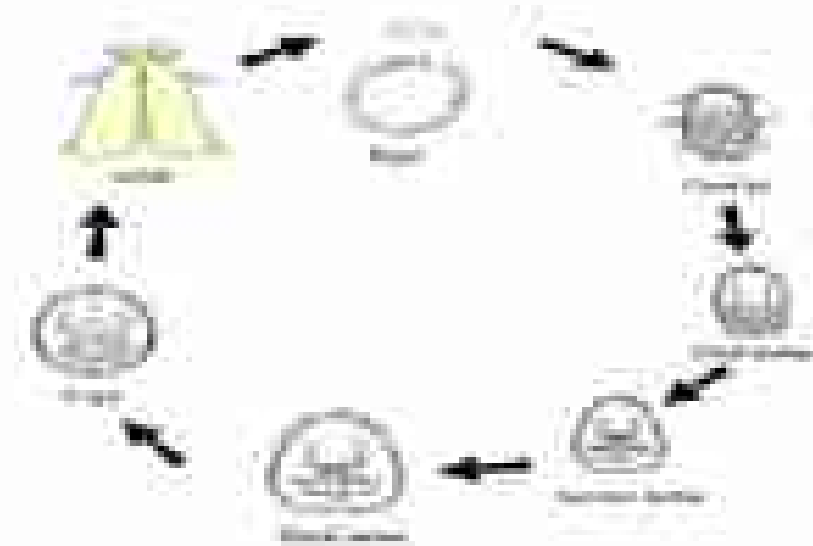
Taxonomy and Ecology of Whitefly



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- They also act as vectors of many plant viruses, which adversely affect the growth and yield of crops.
- Cotton leaf curl virus (CLCuV) disease in Pakistan
- Sweet potato mild mottle virus
- Yellow dwarf disease
- They inject toxic saliva which results in plant disorders

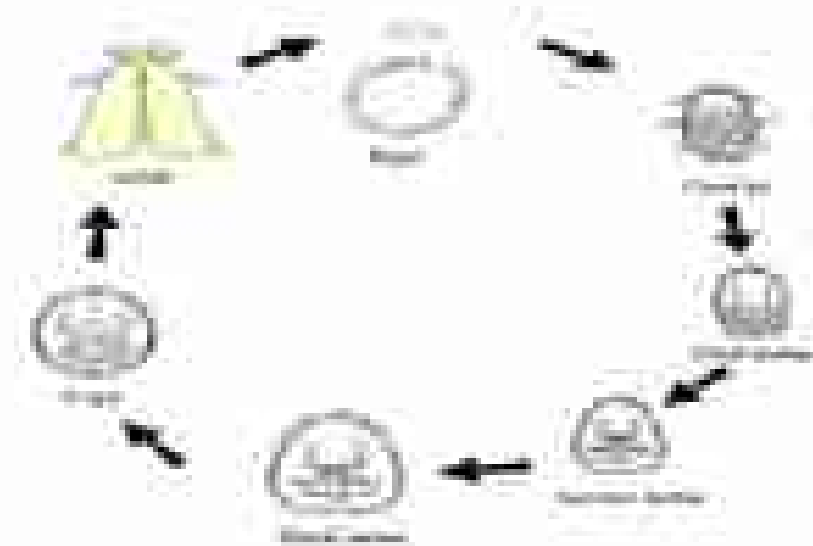
Taxonomy and Ecology of Whitefly



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- Females can lay 10-150 eggs in her lifetime, often in fairy rings
- Eggs hatch into mobile crawler after 6-8 days.
- Crawlers settle at feeding site and lose the ability to walk. They insert their mouthparts into the leaf to feed on sap.
- 18-28 days in warm months

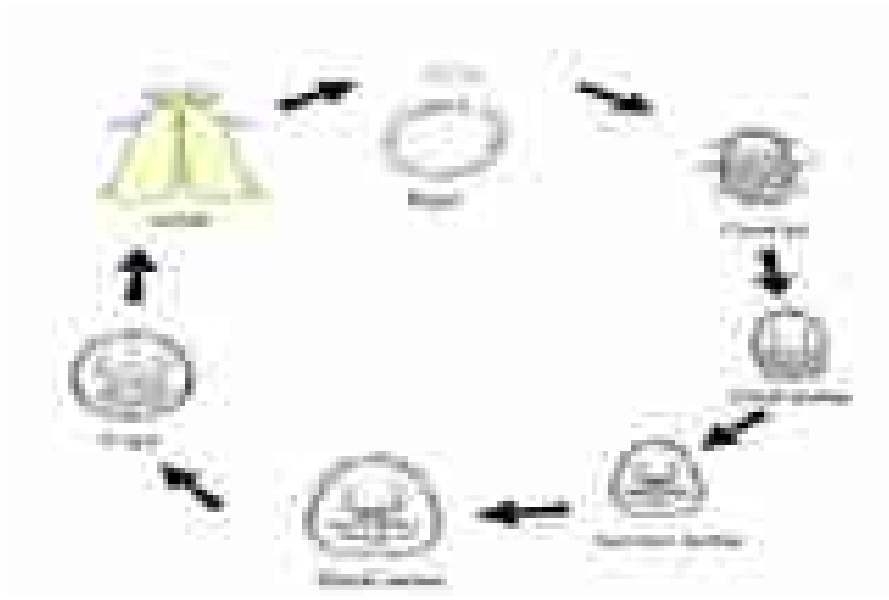
Taxonomy and Ecology of Whitefly



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- Females can lay 10-150 eggs in her lifetime, often in fairy rings
- Eggs hatch into mobile crawler after 6-8 days.
- Adults can live three weeks and are often found in meeting pairs.
- Females are larger than males
- Resistance against pesticides.
- Rotation of insecticides

Taxonomy and Ecology of Whitefly



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Biological control

- Small birds
- Spiders
- Lacewings
- Hoverflies
- Ground beetles
- Mirid bugs
- Damsel bugs and pirate bug

Module# 166 Taxonomy and Ecology of Mealy bug

Phylum	Arthropoda
Class	Insecta
Order	Hemiptera
Family	Pseudococcidae
Genus	Phenacoccus
Species	<i>P. solenopsis</i>

- Found in all parts of worlds
- Native to USA (Tinsley 1898)
- Mostly found in moist, warm climates
- Many species are considered pests as they feed on plant juices
- Act as a vector for several plant diseases.

Taxonomy and Ecology of Mealy bug



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- Vehari in 2005
- Now almost in all cotton growing areas
- Affecting crop yields
- In 2006 (Multan, Bahawalpur, Kanewal, Vhari) as epidemic

Taxonomy and Ecology of Mealy bug



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- Mealy bugs are sexually dimorphic
- Females are about 3 to 5 mm long.
- Their body is usually covered with a mealy waxy secretion, often extended into lateral and terminal filaments.
- They usually remain clustered around the terminal shoots, leaves or fruits.

Taxonomy and Ecology of Mealy bug



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- They are wingless and do not move unless disturbed.
- They often retain legs and can move.
- Females are provided with 9-segmented antennae.

Taxonomy and Ecology of Mealy bug



- There are 18 pairs of very short, lateral wax filaments, and several slightly longer caudal filaments

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Taxonomy and Ecology of Mealy bug



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- Female Mealybug eggs are very small and are laid under a white, loose woolly wax, which remains attached to the abdomen of the females.
- A female may lay between 50 to 600 eggs.

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Taxonomy and Ecology of Mealy bug



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Taxonomy and Ecology of Mealy bug



- Within 3-9 days crawlers come out and actively move and spread out and settle down for on plant parts and gradually develops waxy coating.

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Taxonomy and Ecology of Mealy bug



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- Males are smaller, gnat-like and have wings.
- Male mealy bugs do exhibit a radical change during their life cycle, changing from wingless, ovoid nymphs to wasp-like flying adults.

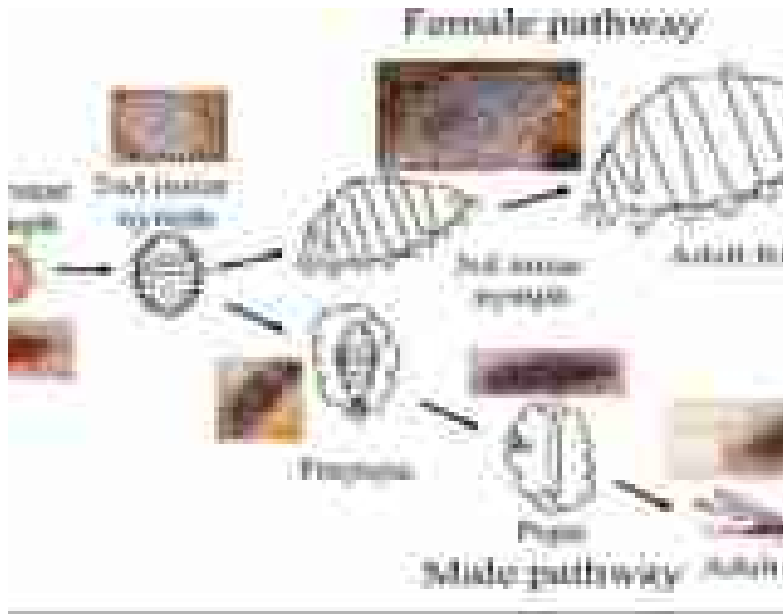
Taxonomy and Ecology of Mealy bug



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Taxonomy and Ecology of Mealy bug



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- Females feed on plant sap\Honey dew----Black sooty Moulds----Photosynthesis
- They attach themselves to the plant and secrete a powdery wax layer used for protection while they suck the plant juices.
- Honey dew---Ants—dispersal from plant to plant

Taxonomy and Ecology of Mealy bug



- The males on the other hand are short-lived as they do not feed at all as adults.
- They only live to fertilize the females.

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Taxonomy and Ecology of Mealy bug



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- The most venerable stage of the cotton mealy bug is larval stage.
- It can be control easily by applying different control measures.
- The control measures of cotton mealy bug are the traditional, biological, chemical.

Module# 167 Taxonomy and Ecology of Yellow stem borer

Phylum	Arthropoda
Class	Insecta
Order	Lepidoptera
Family	Pyralidae
Genus	Scirpophaga
Species	<i>S. incertula</i>

- Serious pests of rice
- Males are ochreous (natural soil colour, clay)
- The spot on the wings is inconspicuous
- Anal tuft is absent

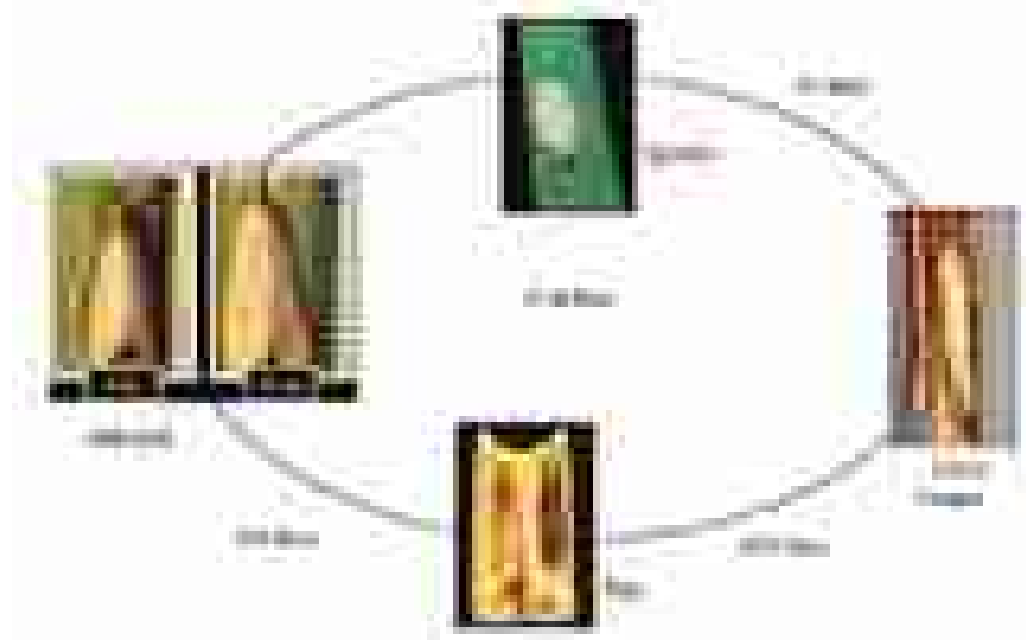
Taxonomy and Ecology of Yellow stem borer



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- Female are pale yellow with distinct dark spot on the front wings.
- Tip of the abdomen is equipped with tuft of white and brown colored hairs.
- Sexual dimorphism in this insect has often led to the conclusion that 2 different species are involved.

Taxonomy and Ecology of Yellow stem borer



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- Adults are active after dusk, mate
- Female lay eggs 120-150 underside leaves
- 2-5 clusters (60-100 eggs)
- Covered with yellowish brown hairs

Taxonomy and Ecology of Yellow stem borer



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- The larvae first feeds on the inside of leaf-sheath and bore into the plant stem as a result of which the central shoot of the young plant dries up causing “dead hearts”.
- In older plants the whole earheads become whitish and chaffy (white head).
- Loss caused to rice production by this very pest in different regions and seasons varies from 5-90%.

Taxonomy and Ecology of Yellow stem borer



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Control

- Destruction of weeds harbouring pests
- Pulling out infested rice plant
- Flooding the field after harvest
- Stubble (short cut stalks) left after harvest should be ploughed up and burn or submerged in water immediately after harvest
- Crop rotation

Taxonomy and Ecology of Yellow stem borer



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- Application of insecticides
- Collection and destruction of egg masses from nursery plants.
- Setting up of light traps to trap and destroy the moth.
- Destruction of seedlings with “dead hearts” while planting.

Module# 168 Taxonomy and Ecology of American Bollworm

Phylum	Arthropoda
Class	Insecta
Order	Lepidoptera
Family	Noctuoidea
Genus	Helicoverpa
Species	<i>H. armigera</i>

- American Bollworm is serious pest of cotton.
- It is distributed in Pakistan
- Central and southern Europe
- Temperate Asia and Africa

Taxonomy and Ecology of American Bollworm



<https://www.google.com/search?q=american+bollworm&tbm=isch&ved=2ahUKEwiTxO-q9v7tAhUJmhoKHUwTC7cQ2-cCegQIABAA>

- The body length varies between 12 and 20 millimeters with a wingspan of 30–40 millimeters.
- The fore wings are yellowish to orange in females and greenish-gray in males
- The hind wings are a pale yellow with a narrow brown band at the external edge and a dark round spot in the middle.

Taxonomy and Ecology of American Bollworm



<https://www.google.com/search?q=american+bollworm&tbm=isch&ved=2ahUKEwiTxO-q9v7tAhUJmhoKHUwTC7cQ2-cCegQIABAA#imgsrc=00XDS5sv1dC38M&imgdii=QDgYES2fs9LHZM>

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Taxonomy and Ecology of American Bollworm



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Taxonomy and Ecology of American Bollworm



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- Caterpillars are polyphagous
- Feed on foliage and on the bolls of cotton
- Reduce yield
- Show prominent hole
- Dirty feces accumulate on the boll surface
- It shifts from one boll to another and damages dozens of bolls during its life time.

Taxonomy and Ecology of American Bollworm



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- Avoid the cultivation of okra, moong and castor in and around the cotton crop
- Avoid growing of American cotton in the field
- Ichneumonid wasp, larval parasitoid of American bollworm should be promoted in the field
- Spray profenofos EC 800 ml/acre

Module# 169 Principles of Systematics

Taxonomy and Ecology of Pink Bollworm

Taxonomy and Ecology of Pink Bollworm

Phylum	Arthropoda
Class	Insecta
Order	Lepidoptera
Family	Noctuoidea
Genus	Pectinophora
Species	<i>P. gossypiella</i>

- The pink bollworms prefer areas where cotton and okra are being produced.
- They originated in the eastern Indian
- All over the worlds

Taxonomy and Ecology of Pink Bollworm



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- Adult pink bollworms are small and grayish-brown in color with folded wings and a slender body.
- Young larvae are small caterpillars with dark brown heads.
- Once the larvae have matured, they are about 12 mm in length with pink bands on their backs.

Taxonomy and Ecology of Pink Bollworm



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- Once laid, bollworm eggs take days to hatch.
- Freshly hatched pink bollworm larvae are white with brown heads, turning pink in the fourth larval stage.
- Larvae bore into cotton plants to feed on their seeds.

Taxonomy and Ecology of Pink Bollworm



- The larvae take twelve to fifteen days to develop, then they move to the soil to pupate.
- The brown pupa is immobile for its first seven to eight days.

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Taxonomy and Ecology of Pink Bollworm



- Common signs of an infestation include shedding of flower buds, deformation of flowers, reduction of lint development and destruction of the seeds in lint.

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Taxonomy and Ecology of Pink Bollworm



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- Bollworms' greatest harm is in the damage they do to cotton bolls.
- As the larva of the pink bollworm burrows into the boll, it stains the lint, rendering it commercially unusable.
- If the humidity is high, it only takes one or two larvae to completely destroy a boll.

Module# 170 Taxonomy and Ecology of Jassids

Phylum	Arthropoda
Class	Insecta
Order	Hemiptera
Family	Cicadellidae

- Major sucking pests of cotton.
- Eggs yellowish white
- Nymphs and adults are greenish yellow with a black spot on tip of each forewing.
- Jump on disturbing

Taxonomy and Ecology of Jassids



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Taxonomy and Ecology of Jassids



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Taxonomy and Ecology of Jassids



<https://www.slideshare.net/EhtishamAliHussain/cotton-jassid>

- Nymphs and adults both suck sap.
- Leaves first show yellow and then reddish spots.
- Attacked leaves turn downwards, dry and fall
- Plants become weak and their fruit fall

Taxonomy and Ecology of Jassids



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Control

- Clean cultivation and destruction of alternate host plant
- Selected varieties of cotton should be grown
- Green lace wing is a good predator of cotton jassid
- Spray of acetamiprid 125ml/acre
- Spiders

Module# 171 Taxonomy and Ecology of Thrips

Phylum	Arthropoda
Class	Insecta
Order	Thysanoptera
Family	Thripidae

- Tiny sucking insects
- Their identification to species by standard morphological characters is often challenging.
- There is also considerable variability leading to many species being misidentified. Molecular sequence based approaches have increasingly been applied to their identification

Taxonomy and Ecology of Thrips

Phylum	Arthropoda
Class	Insecta
Order	Thysanoptera
Family	Thripidae

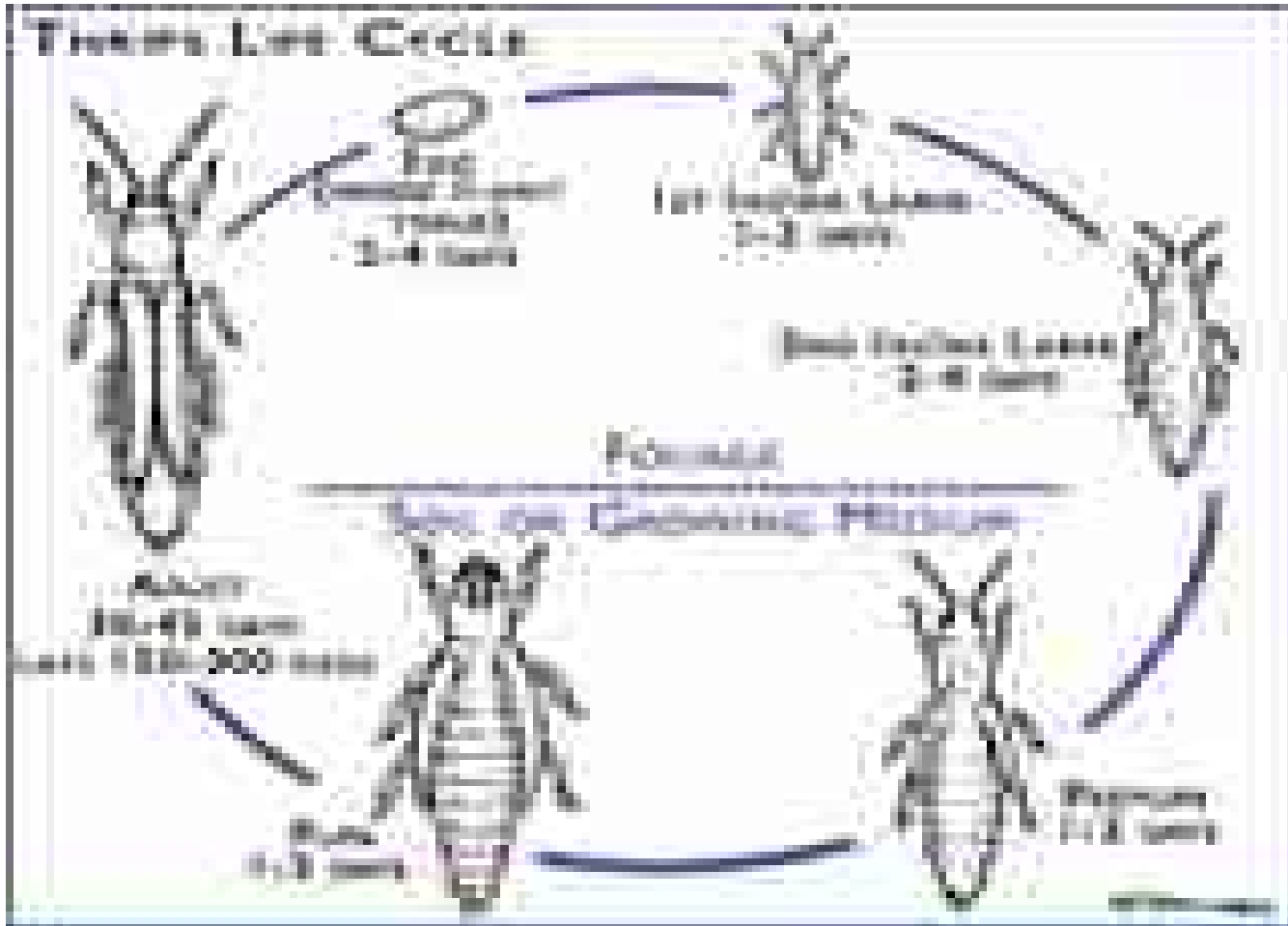
- Fringed wings
- Also transmit tomato spotted wilt virus to many plants
- Feed on wide range of plants world wide
- They prefer tender parts of the plant, such as buds, flowers and new leaves.
- Besides feeding on plant tissues, the common blossom thrips feeds on pollen grains and on the eggs of mites.

Taxonomy and Ecology of Thrips

Phylum	Arthropoda
Class	Insecta
Order	Thysanoptera
Family	Thripidae

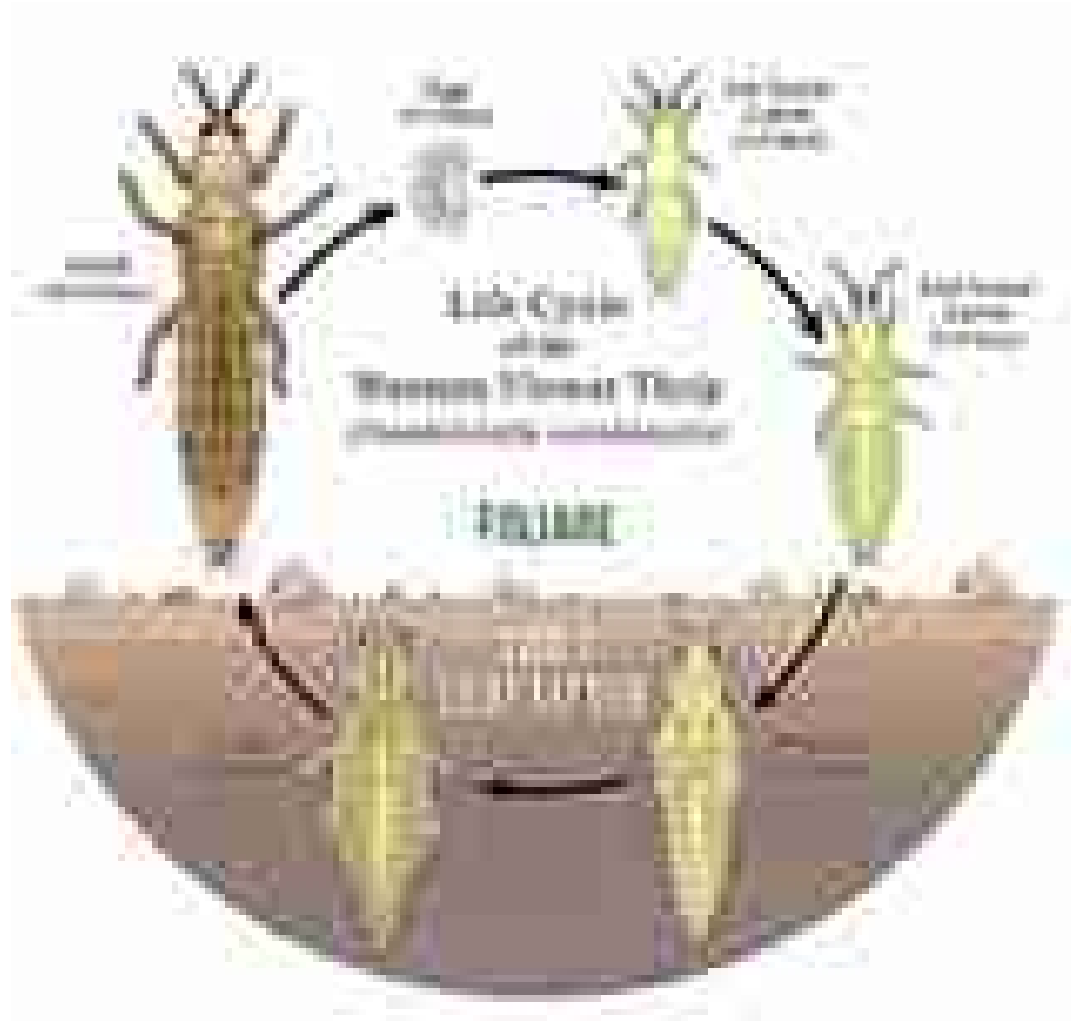
- When the larva supplements its diet in this way, its development time and mortality is reduced,
- Adult females that consume mite eggs increase their fecundity and longevity.

Taxonomy and Ecology of Thrips



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Taxonomy and Ecology of Thrips



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Taxonomy and Ecology of Thrips



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Damage

- In the right conditions, such as in greenhouses, many species can **exponentially increase in population size** and form large swarms because of a **lack of natural predators** coupled with their ability **to reproduce asexually**

Taxonomy and Ecology of Thrips



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Damage

- Sucks plant cells from many garden flowers, plants and fruits
- Damage includes streaks and small white patches
- Major infestation leads to stunted growth and damaged fruit and flowers

Taxonomy and Ecology of Thrips



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Control

- Try using yellow or blue sticky traps
- Spray dormant oil on fruit trees
- Shake branches of plants to remove the thrips
- Spray of insecticidal soap kills them
- Reflective mulches can be used

Module# 172 Taxonomy and Ecology of Rice Leaf Folder

- Very active
- Major pest of rice

Phylum	Arthropoda
Class	Insecta
Order	Lepidoptera
Family	Crambidae

Taxonomy and Ecology of Rice Leaf Folder



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- Bright yellow or straw in color
- Two wavy lines in forewing and one in hindwing
- Eggs are laid singly or in groups in rows beneath the leaf surface
- Eggs are scaly white in color
- Incubation period is 4-8 days

Taxonomy and Ecology of Rice Leaf Folder



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Taxonomy and Ecology of Rice Leaf Folder



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Taxonomy and Ecology of Rice Leaf Folder



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Damage

- Larval stage is damaging
- All stages of plants are damaged by this pest
- Newly hatched caterpillar cut leaf edges and folds the leaf
- Infested leaves appear white
- Attacked plant dries up
- Yield loss vary from 10-50%

Taxonomy and Ecology of Rice Leaf Folder



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Control

- Reform tillage and cultivation system
- Light trap or lure can be used.
- Utilize natural enemies (beetles and *Trichogramma* spp.) as biological control
- Application of chlorpyrifos EC 1000ml/acre

Module# 173 Taxonomy and Ecology of Citrus Leaf Miner

Phylum	Arthropoda
Class	Insecta
Order	Lepidoptera
Family	Gracillariidae

- Origin-Asia
- Distribution-worldwide
- Leaf miner: when the larvae being very small, live in between the two epidermal layers of leaves and feed on the food material inside.
- Examples: Citrus leaf miner, the cashew and mango leaf miner, and the buprestid leaf miner etc.

Taxonomy and Ecology of Citrus Leaf Miner

Life cycle stages



- Eggs whitish in color usually laid towards the petiole of leaf
- Larvae are translucent, light green in color and very difficult to detect.
- The pupa is yellowish-brown and darkens with age
- Adults females have a black and yellow color with a conspicuous yellow dorsal spot.

<https://www.agric.wa.gov.au/citrus/citrus-leafminer>

Taxonomy and Ecology of Citrus Leaf Miner



https://www.pestnet.org/fact_sheets/citrus_leafminer_240.htm

https://ucanr.edu/blogs/UCIPMurbanpests/blogfiles/58278_original.jpg

Damage

- Leaf mining results in
- Leaf deformation
- Leaf chlorosis
- Necrosis
- Leaf fall

Taxonomy and Ecology of Citrus Leaf Miner



<http://ggc.gardencenternews.com/citrus-leafminer/>

Control

- Monitoring:

Pheromone traps can be used

- Biological control:

General predators and parasitoids

- Chemicals:

- ☐ Abamectin

- ☐ Imidacloprid

- ☐ Spinosad

Module# 174 Principles of Systematics

Taxonomy and Ecology of Citrus Psylla (*Diaphorina citri*)

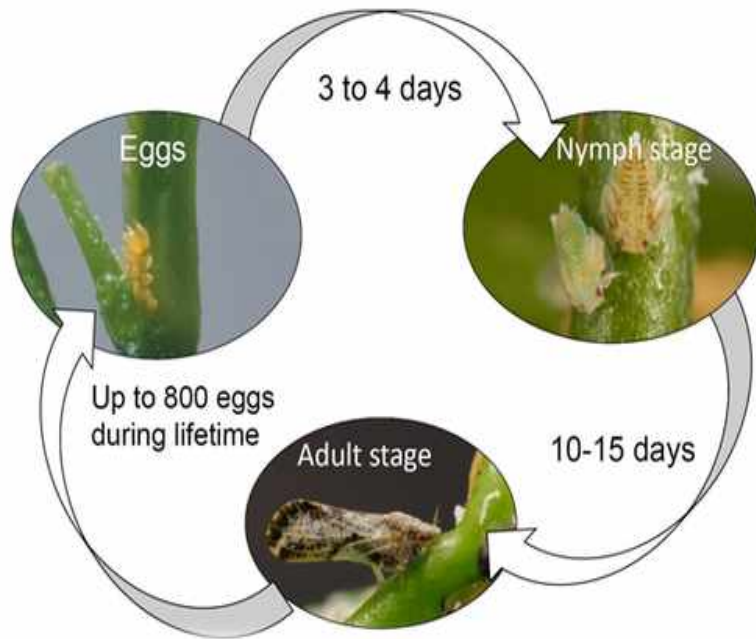
Taxonomy and Ecology of Citrus Psylla

Phylum	Arthropoda
Class	Insecta
Order	Hemiptera
Family	Liviidae

- Newly laid eggs are pale brown but the turn yellow and finally orange before hatching
- Nymph is generally yellowish-orange
- Adults are mottled brown
- Body is covered with whitish waxy secretion, making it appear dusty
- Greening disease or Huanglongbing

Taxonomy and Ecology of Citrus Psylla

Life cycle



<https://www.agristudyinfo.com/citrus-psylla/>

Taxonomy and Ecology of Citrus Psylla



<http://entnemdept.ufl.edu/creatures/citrus/acpsyllid.htm>

Damage

- Vectors of causative agent of Citrus greening disease or **Huanglongbing**
- Psyllid nymphs produce a toxin that causes the plant tips to die back or become contorted, preventing the leaves from expanding normally.

Taxonomy and Ecology of Citrus Psylla



<https://agrihunt.com/articles/horticulture-industry/citrus-psylla-and-its-control/>

• Control:

Traditional control:

Infected plants and trees should be eradicated before spread of disease

• Chemical control:

Insecticides

Injection of trees with tetracycline and antibiotics

Taxonomy and Ecology of Citrus Psylla



<https://www.biocontrol.co.za/citrus-psyllid-control/>

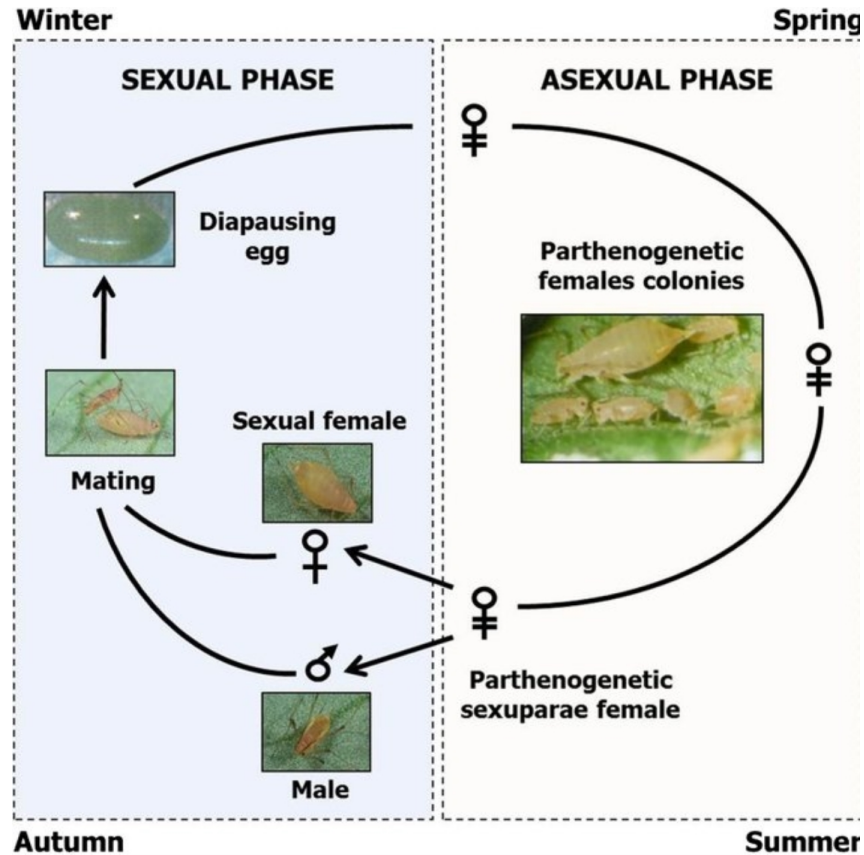
- Biological control:
 - Maggot Fly Larvae
 - Lady beetle
 - *Tamarixia radiata*
 - Lace wing
 - *Pterastichus radiatus*

Module# 175 Taxonomy and Ecology of Aphids

Phylum	Arthropoda
Class	Insecta
Order	Hemiptera
Superfamily	Aphidoidea

- Soft bodied-weak
- Compound and simple eyes
- Walking legs:skinny
- Head pointed downwards for feeding
- Most aphids have conicles (excrete pheromones)
- Also have cauda (flick honeydew)

Taxonomy and Ecology of Aphids



https://www.researchgate.net/figure/Pea-aphid-life-cycle-During-spring-and-summer-asexual-reproduction-phase-occurs-when_fig1_260211188

Taxonomy and Ecology of Aphids



<https://iapps2010.me/2018/08/29/plant-viruses-manipulate-the-feeding-behavior-of-aphids/>

Feeding habits

- Aphid feed from the phloem of plants which they trap into with the styletes of their proboscis. They gain access to the phloem vessels from 3 main parts of the plant, stems, leaves, and roots.

Taxonomy and Ecology of Aphids



<https://www.hipchickdigs.com/2012/07/battling-aphids/>

Damage

- Large populations of aphids can turn leaves yellow and stunt shoots; **aphids** can also produce large quantities of a sticky exudates known as honeydew, which often turns black with the growth of a sooty mold fungus.

Taxonomy and Ecology of Aphids



https://en.wikipedia.org/wiki/Aphid#/media/File:Wasp_&_aphid_May_2010-1.jpg

Control

Chemical control

- Using insecticides like carbamates, pyrethroids and organophosphates

Biological control

- Ladybug, Ladybug larvae, Lacewing, Parasitoids wasp, Mummies, Fungal Pathogen

Module# 176 Phenon, Taxon and Category

Phenon

A term used for the different forms or phenotypes that may occur within a single population.

It includes:

- Sexes
- Age stages
- Seasonal varieties
- Morphs

Phenon, Taxon and Category

Phenon

- The term *Penon* was first introduced by the **Camp and Gilly (1943)** to describe phenotypic ally homogeneous samples at the species level.
- It was later used by **Sneath and Sokal (1973)**

Phenon, Taxon and Category



Taxon

- Defined by simpson (1961) as
'a group of real organisms
recognized as a formal unit at
any level of hierarchical
classification'
- In other words
- A taxon is any rank

Phenon, Taxon and Category

Taxon

- In other words

A taxon is any rank that is considered sufficiently distinct by the taxonomists to be formally recognized and assigned to a definite category.

Two aspects:

1. A species is not a taxon but category

- Example: Robin (*Tundus migratorius*) is a taxon

Phenon, Taxon and Category

Taxon

Taxon must be formally recognized by the taxonomists **Examples:** Demes

Geographic isolates within a species become taxa only –subspecies. **Wiley (1981)** called Taxa as historical groups which are clearly individuals like and not classes.

1. **Higher taxa:** Thrushes, Birds, Vertebrates

2. **Lower taxa:** Bluebirds, Robins

Phenon, Taxon and Category

Category:

‘Rank or level in a hierarchical classification’ a class whose members are all the taxa

- A class whose members are all the taxa that are assigned a given rank

Phenon, Taxon and Category

Examples:

The **species category** is a class whose members are species taxa.

20 or more categories fall into 3 categories

1. The species category
2. Intraspecific categories
3. Higher categories

END

Module# 177 Silkworm

Phylum	Arthropoda
Class	Insecta
Order	Lepidoptera
Family	Bombycidae
Genus	Bombyx
Species	mori

- Silkworm, common name for the silk-producing larvae of any of several species of moths.
- Silkworms possess a pair of specially modified salivary glands called silk glands, or sericteries, which are used in the production of cocoons.

Silkworm

Phylum	Arthropoda
Class	Insecta
Order	Lepidoptera
Family	Bombycidae
Genus	Bombyx
Species	mori

- The silk glands secrete a clear, viscous fluid that is forced through openings, called spinnerets, on the mouthparts of the larva; the fluid hardens as it comes into contact with air.
- The diameter of the spinneret determines the thickness of the silk thread produced.

Silkworm

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Silkworm

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Order	Lepidoptera
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Genus	Bombyx
Species	mori

- The best-known silkworm is the larvae of the common, domesticated silkworm moth. This moth, native to China, was introduced into Europe and western Asia in the 6th century AD and into North America in the 18th century.

Silkworm

Phylum	Arthropoda
Class	Insecta
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Species	mori

- The best-known silkworm is the larvae of the common, domesticated silkworm moth. This moth, native to China, was introduced into Europe and western Asia in the 6th century AD and into North America in the 18th century.
- Silk is known as queen of textile due to sheen and luster

Silkworm

Phylum	Arthropoda
Class	Insecta
Order	Lepidoptera
Family	Bombycidae
Genus	Bombyx
Species	mori

- Silk is one of the most beautiful and precious fibers given to us by nature
- It is considered **bio-steel** because of its strength
- China is the largest producer of silk followed by India

Silkworm

Phylum	Arthropoda
Class	Insecta
Order	Lepidoptera
Family	Bombycidae
Genus	Bombyx
Species	mori

SERICULTURE IN PAKISTAN

- Despite the growing demand for natural silk, this industry could not flourish in Pakistan.
- This industry is facing numerous challenges such as lack of trained personnel, high mortality rate in local silk breed, and poor economic conditions of the farmers.

Silkworm

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SERICULTURE IN PAKISTAN

- Unfortunately, this industry has not been on the list of priorities of our Government.
- Provide livelihood for rural poor families but silk proteins also have wide range of applications in textile, food, cosmetics and pharmaceutical industry as well as in traditional medicines.
- Currently, Pakistan is importing about 70% raw silk to meet the demand of local market.

Silkworm



Feeding

- Mulberry silkworm feeds on mulberry plants of genus *Morus*
- *M. alba*
- *M. indica*
- *M. nigra*
- Deep rooted plants
- Grow well in loamy soil or red sandy loamy
- Plantation during early spring and late autumn

Silkworm



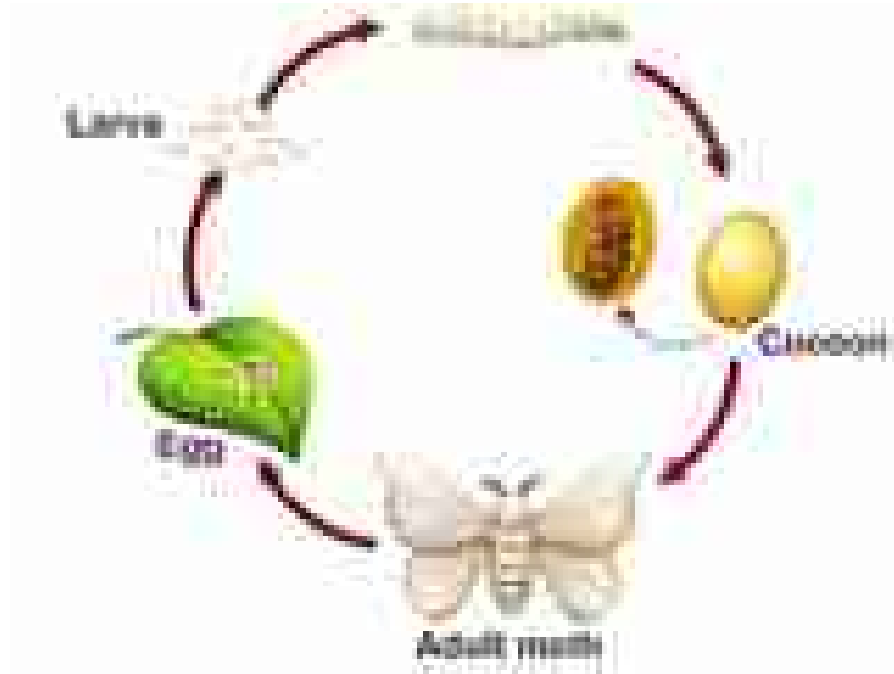
- Mulberry plants grow 15-37 degree temperature
- 600-2500mm rainfall
- 300-900m altitude above sea level

Module# 178 Life Cycle of Silkworm



https://www.google.com/search?q=life+cycle+of+bombyx+mori&tbm=isch&ved=2ahUKEwi97eq2wJDuhVX04UKHX1UDLoQ2-cCegQIABAA&oeq=life+cycle+of+bombyx&gs_lcp=CgNpbWcQARgAMgQIlxAnMgIADICCAyAggAMgYIABAFEB4yBggAEA UQHjIGCAAQCBAeMgQIABAYMgQIABAYMgQIABAYOgQIAB BDOgUIABCxA1D5B1igLWDjOmgAcAB4AIABrASIAf0WkgEJ Mi03LjluMC4xmAEAoAEBqgELZ3dzLXdpei1pbWfAAQE&scli ent=img&ei=KX_6X_20LdemlwT9qLHQcw&bih=600&biw=1360#imgrc=T2GFif2nGeMvrM

Life Cycle of Silkworm

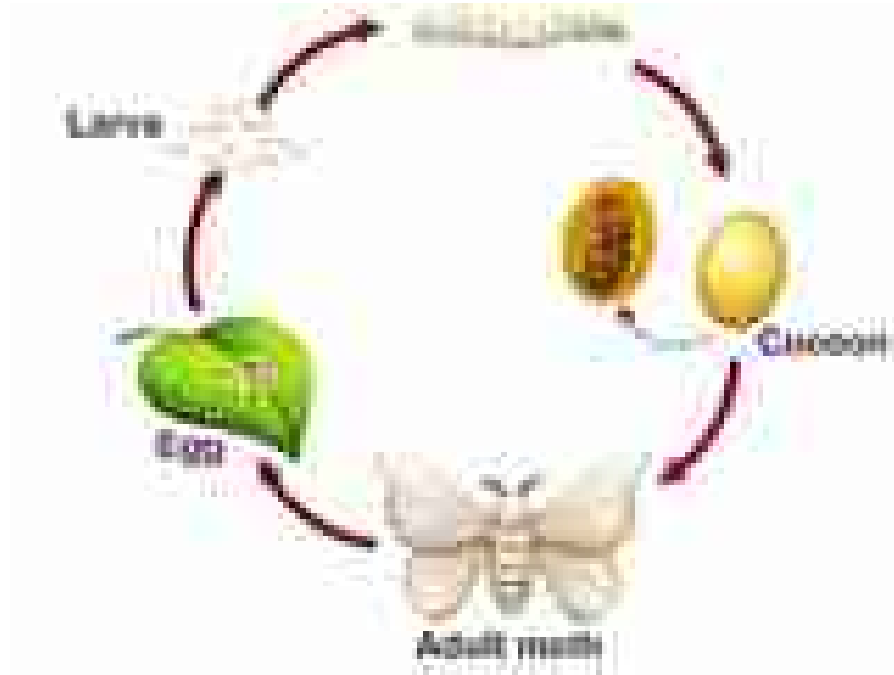


https://www.google.com/search?q=life+cycle+of+bombyx+mori&hl=en&sxsrf=ALeKk00DLnINrorKjhrTMlGD6alt7iic-g:1610252730004&source=lnms&tbn=isch&sa=X&ved=2ahUKEwiNquHvwpDuAhVOZcAKHcNPDD8Q_AUoAXoECBAQAw&biw=1360&bih=600#imgsrc=BluSQkTq1mUHIM

Copulation

- Following emergence from the cocoon, the females rest on the cocoon, spreading out her feeble wings and immediately begin to scent by exuding pheromone from her abdominal projection.
- The males being attracted by the pheromone find the female and start mating.

Life Cycle of Silkworm



https://www.google.com/search?q=life+cycle+of+bombyx+mori&hl=en&sxsrf=ALeKk00DLnINrorKjhrTMlGD6alt7iic-g:1610252730004&source=lnms&tbn=isch&sa=X&ved=2ahUKEwiNquHvwpDuAhVOZcAKHcNPDD8Q_AUoAXoECBAQAw&biw=1360&bih=600#imgrc=BluSQkTq1mUHIM

Eggs lying

- Thus they remain over for 12-24 hours when the females get inseminated by the male.
- After mating for 12-24 hours, the pair gets separated and the female starts laying eggs while the male moths die.
- Most females lay 150-300 eggs over the course of 1-2 days, some can lay as many as 1000 also.

Life Cycle of Silkworm



https://www.google.com/search?q=life+cycle+of+bombyx+mori&tbm=isch&ved=2ahUKEwi97eq2wJDuhVX04UKHX1UDLoQ2-cCegQIABAA&oq=life+cycle+of+bombyx&gs_lcp=CgNpbWcQARgAMgQIlxAnMgIIADICCAAyAggAMgYIABAFEB4yBggAEAUQHjIGCAAQCBAeMgQIABAYMgQIABAYMgQIABAYOgQIABBDOgUIABCxA1D5B1igLWDjOmgAcAB4AIABrASIAf0WkgEJMi03LjluMC4xmAEAoAEBqgELZ3dzLXdpei1pbWfAAQE&sclient=img&ei=KX_6X_20LdemlwT9qLHQcw&bih=600&biw=1360#imgsrc=xYs_vHjdFWKWiM

Life Cycle of Silkworm

Stages	Period (days)	Characters
Egg	9-12	Yellowish-white, semi round, 1 mg wt
I instar	3-4	Last instar larvae is greenish, cylindrical caterpillar, 3-3.5 inches long, bear 3 pairs of thoracic legs, 5 pairs of pre-legs, last pair of leg modified to claspers, 1 thoracic and 8 abdominal spiracles, each larvae feed on 90 gm of leaves during larval period (voracious feeder)
II instar	2-3	
III instar	3-4	
IV instar	5-6	
V instar	7-8	
Prepupa	4-7	Non-feeding stage, cocoon spinning within 2-3 days
Pupa	10-12	
Adult	2-3	Robust creamy white, 2-3 day, bipectinate antennae, non-feeder, poor fliers, each female lays 400-600 eggs, secrete alkaline secretions to dissolve cocoon fibers.

Life Cycle of Silkworm



- Fifth instar larvae makes quick round movements of its head
- Rate of 65 movements per minutes while spinning its cocoon.

Life Cycle of Silkworm

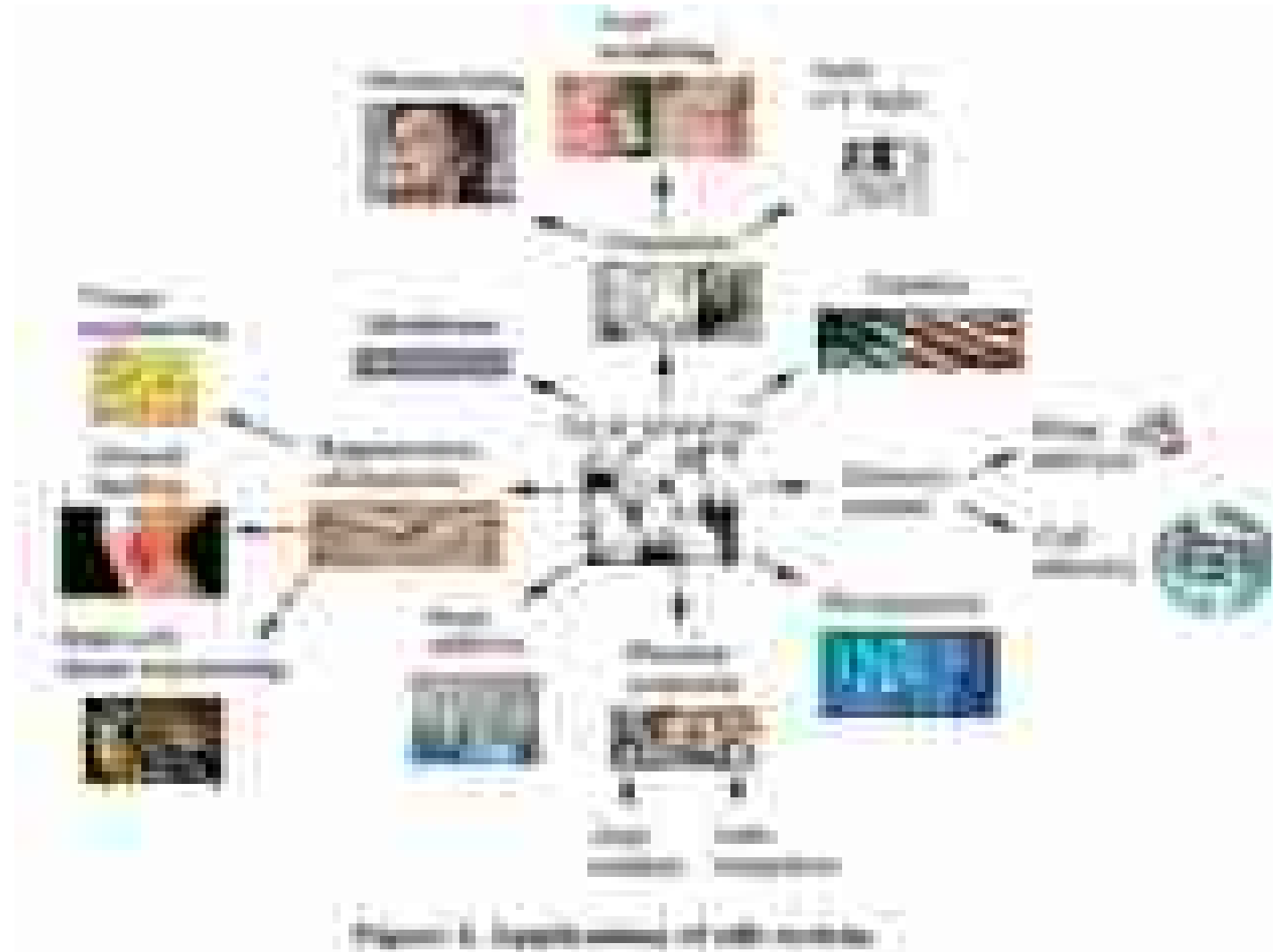


Module# 179 Composition of Silk

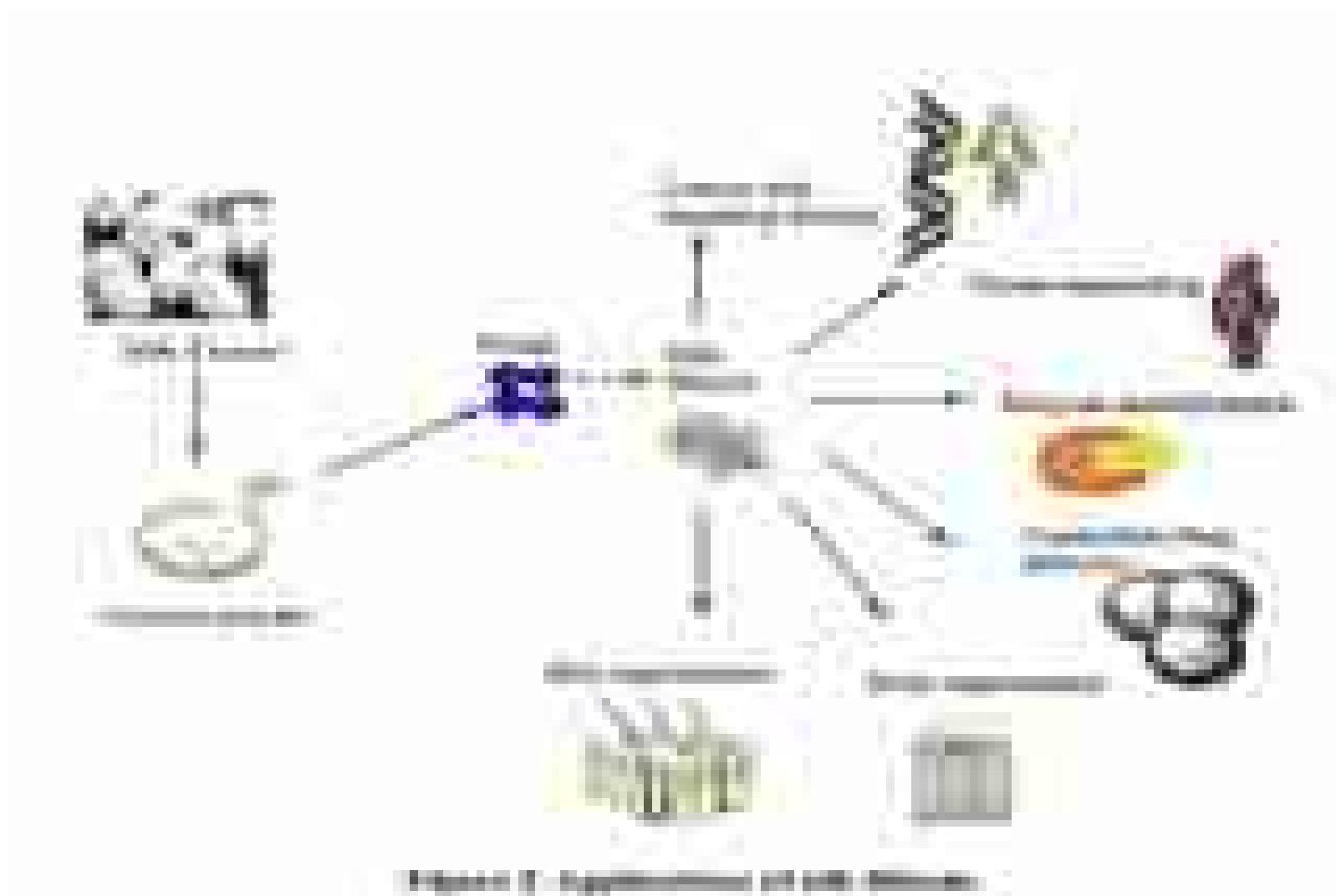
https://www.google.com/search?q=sericin+and+fibroin&hl=en&sxsrf=ALeKk01htdAQq6Kj9SKjy0Hp29TwqyER6g:1610254161949&source=lnms&tbn=isch&sa=X&ved=2ahUKEwj2msiayJDuAhUt4YUKHWICDGMQ_AUoAXoECBEQAw&biw=1360&bih=600#imgsrc=HBldrPESaxbasM&imgdii=ohYUlsISWHcmpM



Composition of Silk



Composition of Silk



Module# 180 Lac Insect

Kingdom	Animalia
Phylum	Arthropoda
Class	Insecta
Order	Hemiptera
Family	Kerriidae
Genus	Kerria
Species	<i>Kerria lacca</i>

- Lac insect live as parasite on sap of certain tress and shrubs and shows sexual dimorphism
- *Babul (Acacia arabica)*
- *Khair (Acacia catcchu)*
- Its life is completed in 6 months
- Two crops can be obtained

Lac Insect

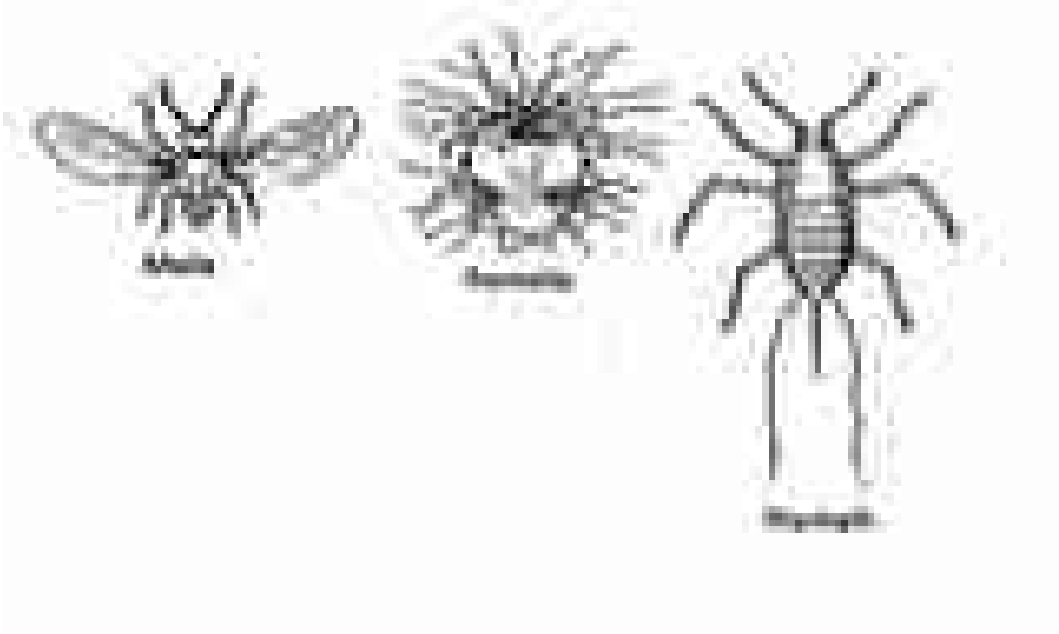
Sexual dimorphism



- The adult lac insect shows a marked phenomenon of sexual dimorphism. The male and female insect varies in:
- Shape
- Size and
- Presence or absence of certain body parts

Lac Insect

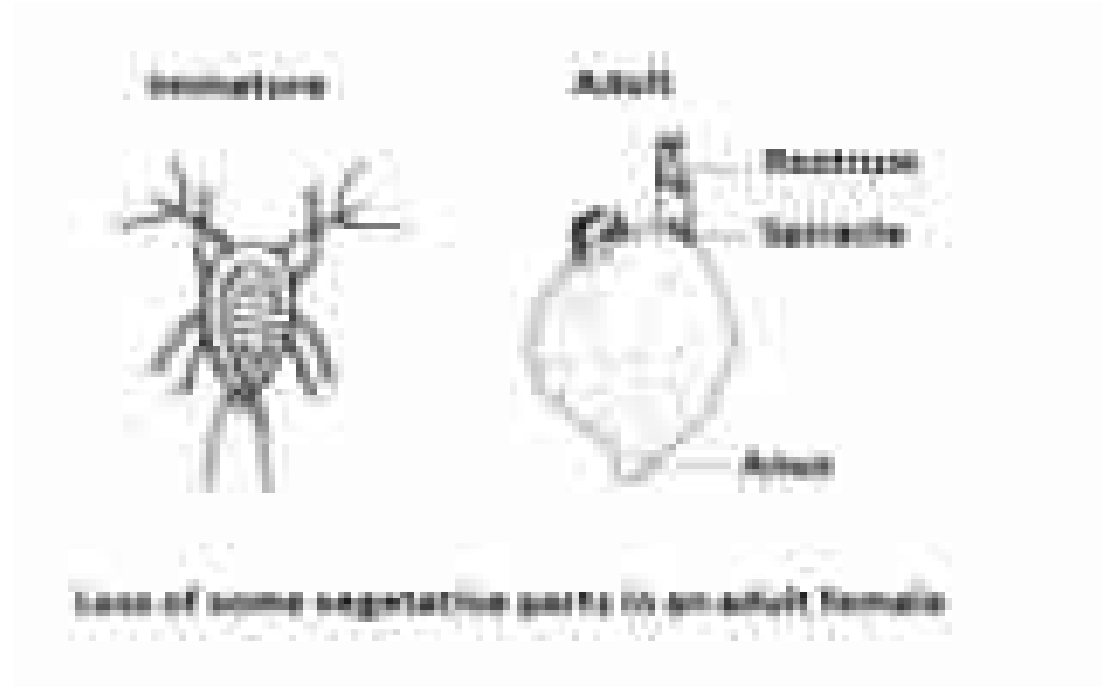
Sexual dimorphism



- The adult lac insect shows a marked phenomenon of sexual dimorphism. The male and female insect varies in:
- Shape
- Size and
- Presence or absence of certain body parts

Lac Insect

Female Lac Insect



- Small in size
- Head bear a single Antennae
- Single Proboscis
- Eyes are absent
- **Female produce bulk of Lac**

Lac Insect



Fertilization

- After attaining the maturity, males emerge out from their cells and walk over the lac incrustations.
- The male enters the female cell through anal tubular opening and inside female cell it fertilizes the female.

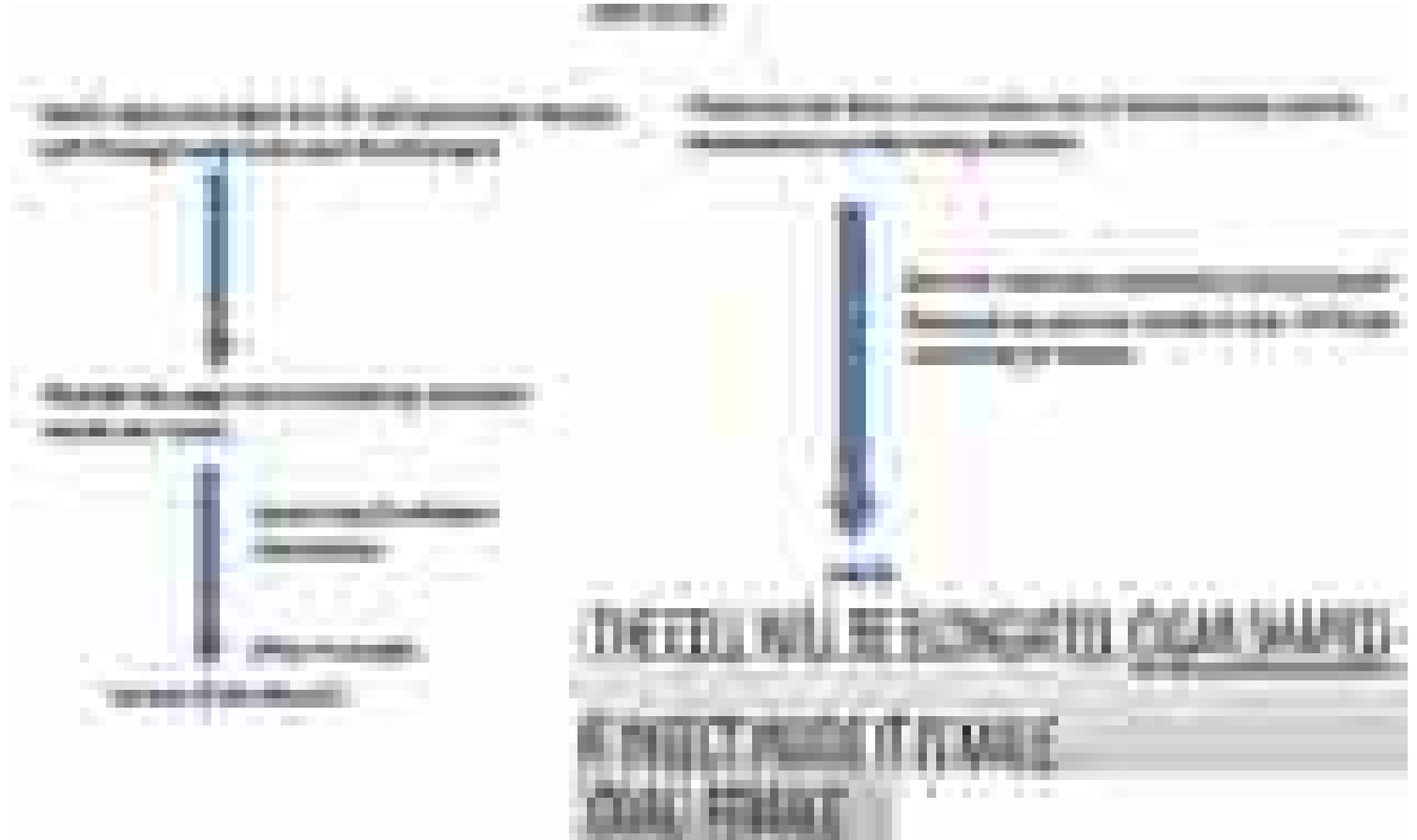
Lac Insect

Fertilization

- After copulation, the male dies. One male is capable of fertilizing several females.
- Females develop very rapidly after fertilization.
- They take more sap from plants and exude more resin and wax.

Lac Insect

https://www.google.com/search?q=life+cycle+of+lac+insect&tbm=isch&ved=2ahUKEwjExJ_b2JDuAhVBrhoKHbRgcZIQ2-cCegQIABAA&oq=life+cycle+of+lac+insect&gs_lcp=CgNpbWcQAzIECAAQZlCCAAyBggAEAUQHjIGCAAQBRAeMgQIABAYMgQIABAYMgQIABAYOgQIlxAnOgUIABCxAzoHCAAQsQMqqzoGCAAQCBAeOgQIABAeULnFQVik_0Fg2YJCaABwAHgAgAGDBogB516SAQsyLTluNy4zLjYuNpgBAKABAaoBC2d3cy13aXotaW1nwAEB&sclient=img&ei=oJ6X8T0IcHcarTBpZAJ&bih=600&biw=1360#imgsrc=qaJmF6tx4IGHIM



Module# 181 Lac Insect



Swarming

- These larvae begin to wander in search of suitable centre to fix them.
- **This mass movement of larvae** from female cell to the new off-shoots of host plant, is termed as “swarming”.

Lac Insect



Lac Secretion

1. Glands present in the abdomen of the lac insects.
2. Secrete immediately after the larval settlement on the new and tender shoots
3. This secretion appears first as a shining layer which soon gets hardened after coming in contact with air.
4. This makes a coating around the insect and the twig on which it is residing.

Lac Insect



Lac Incrustation

https://www.google.com/search?q=lac+incrustations&tbm=isch&ved=2ahUKEwiY7ITv3JDuAhVQ-YUKHValBOIQ2-cCegQIABAA&oq=lac+incrustations&gs_lcp=CgNpbWcQAzoECCMQJzoECAAQQzoCCABQqccXWlv0F2Dq9hdoAHAAeACAAe4EiAGmK5IBCTItOC4yLjQuMpgBAKABAaoBC2d3cy13aXotaW1nwAEB&scli=ent=img&ei=-5z6X9iCMdYlwTWkJKQDg&bih=600&biw=1360#imgsrc=5Ko97ssJN9okIM

Lac Secretion

5. As the secretion continues the coating around one insect meet and fuses completely with the coating of another insect.
6. *In this way a continuous or semi-continuous incrustation of lac is formed on the tender shoots.*

Lac Insect



Lac Incrustation

https://www.google.com/search?q=lac+incrustations&tbm=isch&ved=2ahUKEwiY7ITv3JDuAhVQ-YUKHValBOIQ2-cCegQIABAA&oq=lac+incrustations&gs_lcp=CgNpbWcQAzoECCMQJzoECAAQQzoCCABQqccXWlv0F2Dq9hdoAHAAeACAAe4EiAGmK5IBCTItOC4yLjQuMpgBAKABAaoBC2d3cy13aXotaW1nwAEB&scli=ent=img&ei=-5z6X9iCMdYlwTWkJKQDg&bih=600&biw=1360#imgsrc=5Ko97ssJN9okIM

Lac Secretion

1. Proper care of host plant
2. Regular pruning of host plant
3. Propagation of insect
(Inoculation or infection)
4. Control of insect pests
5. Collection and processing of lac

Lac Insect



Inoculation

- The method by which the lac insects are introduced to the new lac host plant is known as inoculation.
- This may be of two types, namely “Natural infection” and “Artificial infection”.
- When infection from one plant to other occurs by natural movements of insect, it is called natural infection.

Lac Insect



Inoculation

- This may be due to overcrowding of insect population and non-availability of tender shoots on a particular tree.

Module# 182 Lac Insect

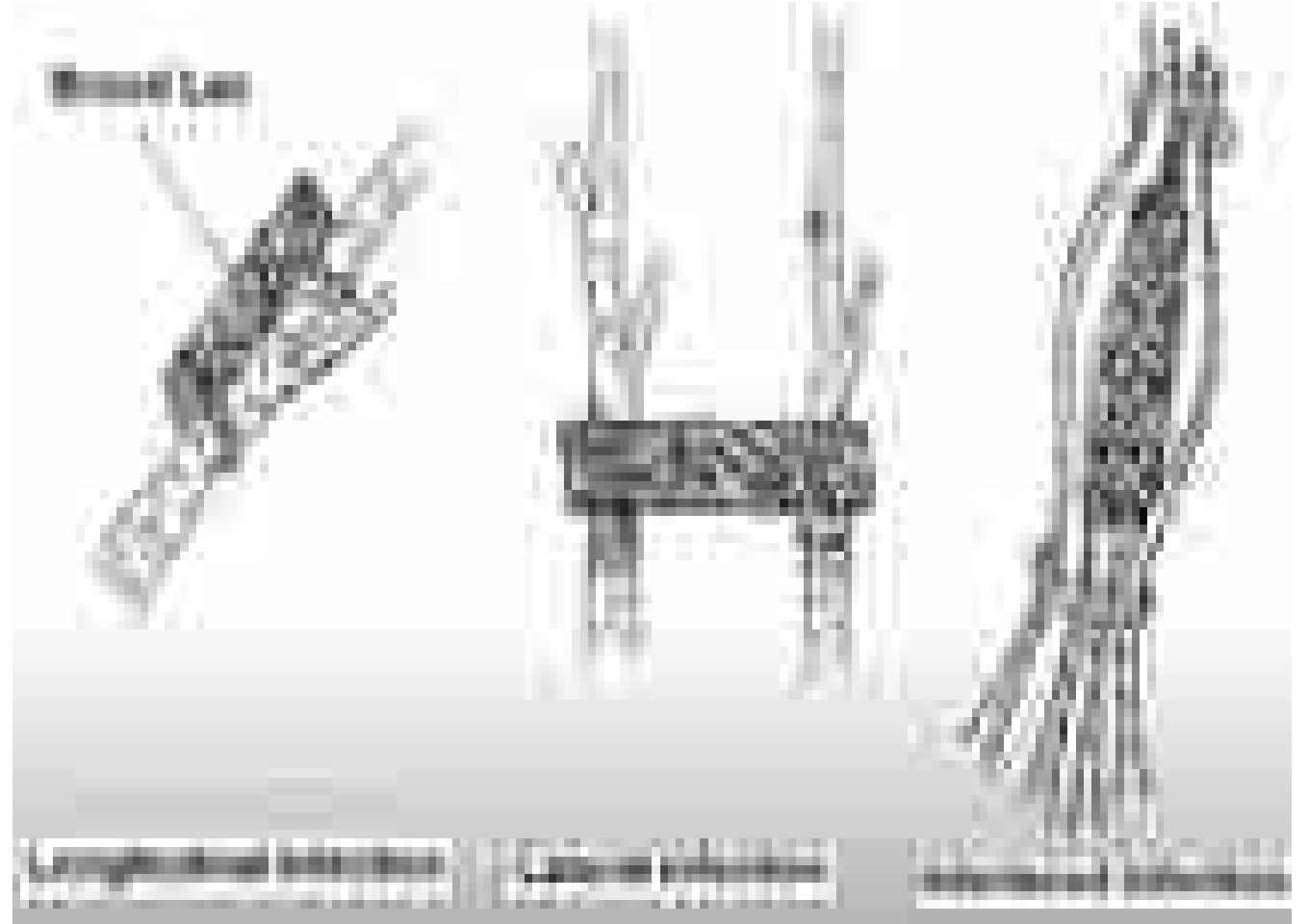


Artificial Infection

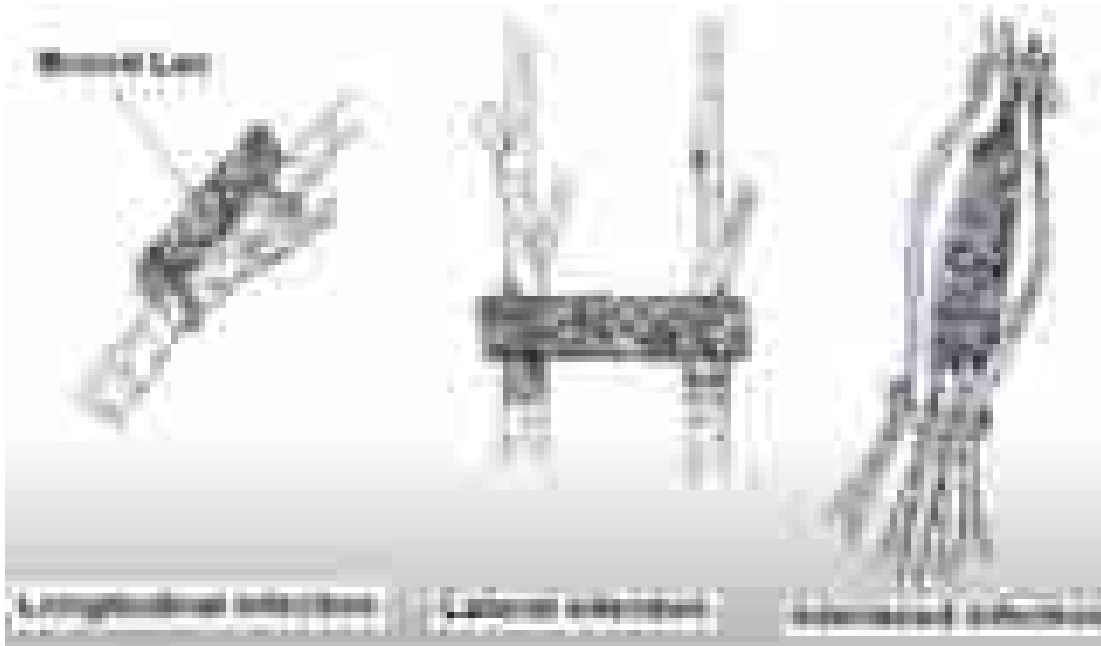
- Prior to about two weeks of hatching, lac bearing sticks are cut to the size of six inches. **They are called “Brood lac”.**
- Brood lacs are then kept for about two weeks in some cool place.
- When the larvae start emerging from this brood lac, they are supposed to be ready for inoculation

Lac Insect

https://www.google.com/search?q=lac+artificial+infection&tbm=isch&ved=2ahUKEwiniZKr3pDuAhVKiRoKHY8wCAAQ2-cCegQIABAA&oq=lac+artificial+infection&gs_lcp=CgNpbWcQA1CZsy1YweAtYMniLWgAcAB4AIABAlgBAJIBAJgBAKABAaoBC2d3cy13aXotaW1nwAEB&sclient=img&ei=hp76X6euEcqSao_hIA&bih=600&biw=1360



Lac Insect

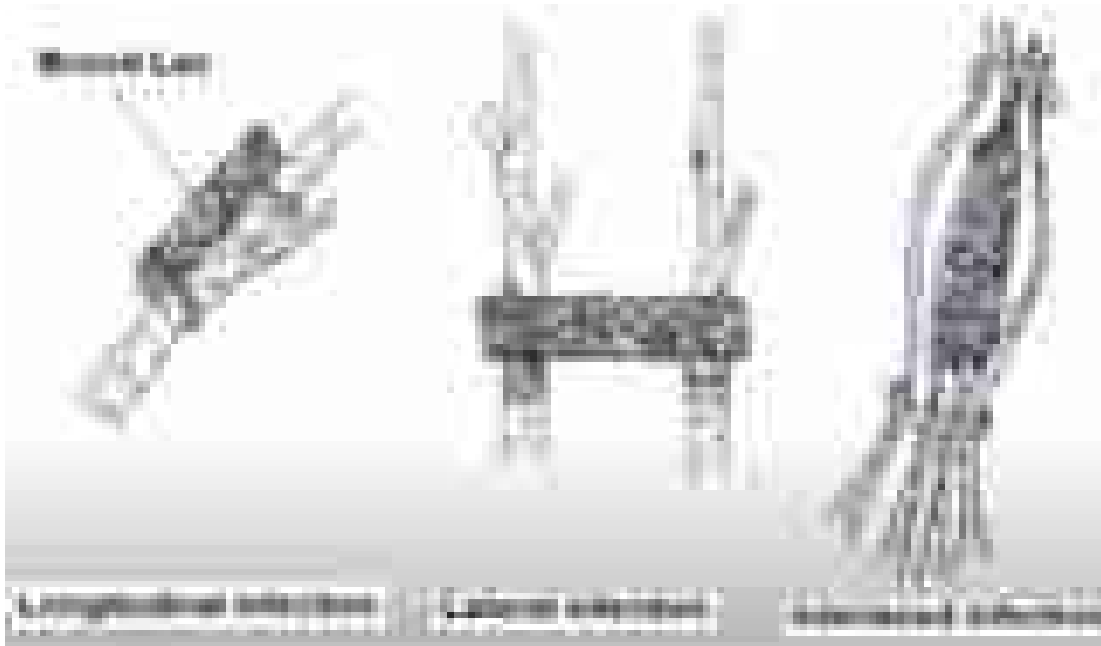


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Extraction of Lac

- Lac cut from the host plant is called as “stick lac”.
- Lac can be scraped from the twigs before or after the emergence of larvae.
- Ari lac (if used before emergence of larvae)
- Phunki lac (if used after swarming of larvae)
- Swarming

Lac Insect

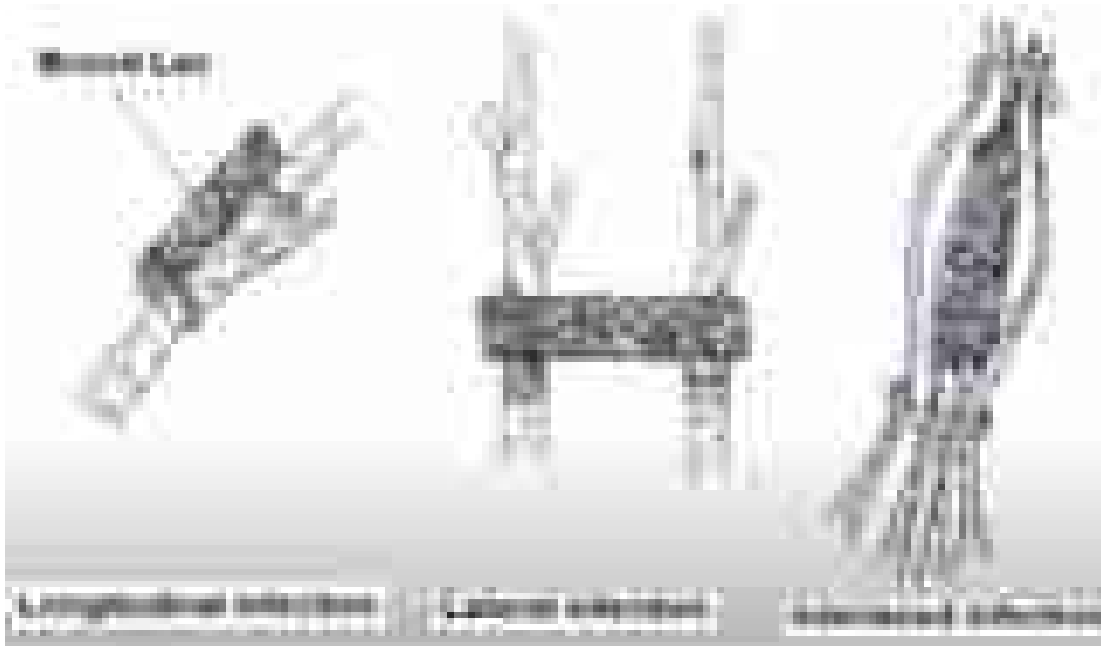


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Scraping of Lac

- The scraping of lac from twig is done by knife, **after which they should not be exposed to sun.** The scraped lac is grinded in hard stone mills.
- The unnecessary materials are sorted out.

Lac Insect



https://www.google.com/search?q=lac+artificial+infection&tbm=isch&ved=2ahUKEwiniZKr3pDuAhVKiRoKHY8wCAAQ2-cCegQIABAA&oq=lac+artificial+infection&gs_lcp=CgNpbWcQA1CZsy1YweAtYMniLWgAcAB4AIABAIgBAJIBAJgBAKABAaoBC2d3cy13aXotaW1nwAEB&sclen=t=img&ei=hp76X6euEcqSao_hIA&bih=600&biw=1360

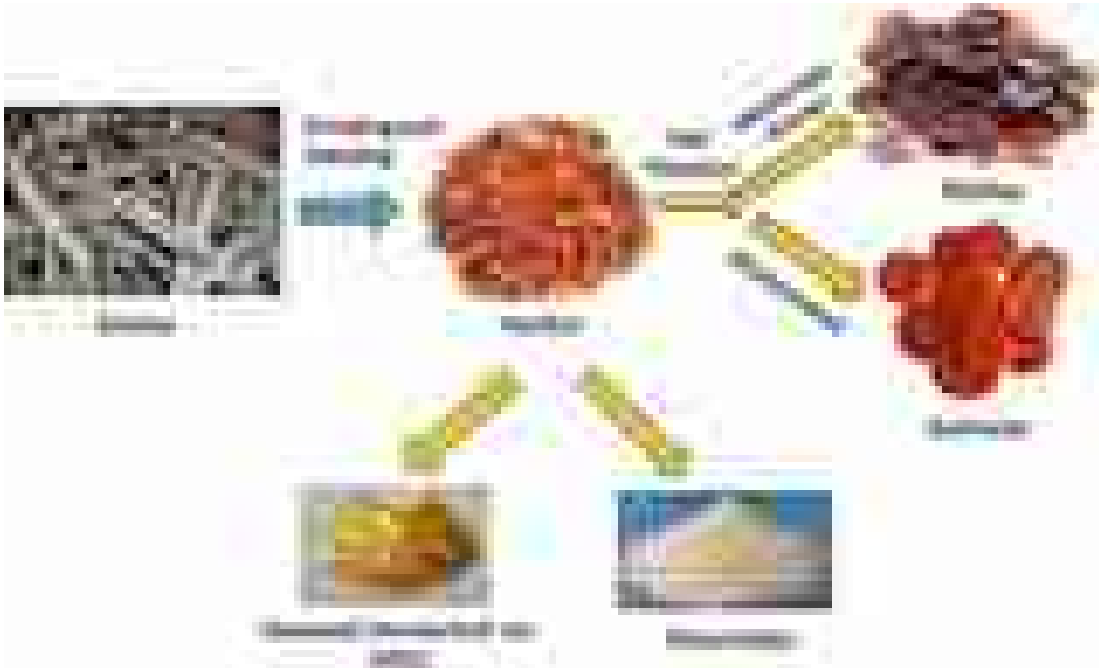
Scraping of Lac

- In order to remove the finer particles of dirt and colour, this lac is washed repeatedly with cold water.
- Now at this stage it is called as **“Seed lac”** and is exposed to sun for drying.

Lac Insect

Scraping of Lac

- **Bleach lac** is a refined product obtained by chemical process.
- **Shell lac** is dissolved in Sodium carbonate solution and bleaching the solution with Sodium hypochlorite. precipitation of the resin with sulphuric acid.
- Deteriorate quickly and should be used within 2-3 months.



https://www.google.com/search?q=lac+artificial+infection&tbm=isch&ved=2ahUKEwiniZKr3pDuAhVKiRoKHY8wCAAQ2-cCegQIABAA&oq=lac+artificial+infection&gs_lcp=CgNpbWcQA1CZsy1YweAtYMniLWgAcAB4AIABAlgBAJIBAJgBAKABAaoBC2d3cy13aXotaW1nwAEB&sclien t=img&ei=hp76X6euEcqSao_hIA&bih=600&biw=1360

Module# 183 Principles of Systematic

Sub species

In 19th century, term subspecies replaced the term variety

Ant specialists use term not only for geographic races but also for sibling species and individual variants.

‘An aggregate of phenotypic ally similar populations of a species inhabitation a geographic subdivision of the orange of that species and differing taxonomically from other populations of that species.’

Temporal sub species identified on the basis of paleontology

Principles of Systematic

Sub species

Difficulties in application of sub species

Wilson and brown (1953) and Inger (1961) pointed out four aspects:

1. The tendency of different characters to show independence trends
2. The independence occurrence of similar or phenotypic ally indistinguishable populations
3. The occurrence of micrographic races within subspecies
4. The arbitrariness of the degree of distinction-local population

Principles of Systematic

Sibling species

‘Reproductively isolated species without morphological difference are called sibling species’

- **Sibling species** are very similar in appearance, behaviour and other characteristics but they are reproductively isolated.
- **In other words**, sibling species are pairs or groups of genetically closely related species which are often morphologically indistinguishable, but are reproductively isolated, meaning that while they may interbreed, the offspring cannot reproduce.

Module# 184 Principles of Systematics

Polytypic species

Species that contain two or more subspecies are called polytypic species. Species that are not subdivided into subspecies are called monotypic species.

The term *formenkreis* and *rassenkreis* were formally applied to polytypic species

Principles of Systematics

Importance of recognition of Polytypic species

- Discovery of the fact that previously morphospecies were not reproductively isolate
- and did not qualify as a separate species hence...sub species
- Polytypic species **provide simplicity** of classification of birds snail, mammals and butterflies

EXAMPLES: 1900 monotypic species of birds-----9040 polytypic species

Principles of Systematics

Difficulties of Polytypic species

1. Differentiation between allopatric and allochronic populations at subspecies level
2. Closely related species replace each other geographically
3. Species are on the borderline between sub species and species (Species under the process of evolution (Incipient species))

Principles of Systematics

Occurrence of Polytypic species in animal kingdom

- In animals 40-80% are polytypic
- *Formenkries* and *rassenkries* are the order terms for polytypic species

Module# 185 Phenetics Vs Cladistics

- In the field of taxonomy there are two methods of constructing phylogenetic trees i.e. Phenetics and Cladistics
- **Phnetics** **methods** construct trees (phenogram) by considering the current states of characters without considering the evolutionary history that brought the species to their current phenotype.

Phenetics Vs Cladistics

- However, **cladistics** **method** depend on the assumptions about ancestral relationships as well as current state.
- Which character states are deeply conserved characters
- Which character states are not deeply conserved characters
- Conserved character state are used for phylogenetics reconstruction

Phenetics Vs Cladistics

- In **cladistics approach** trees are drawn based on conserved characters
- **Phenetic approach** trees are drawn based on some measurements of morphological traits.
- **Molecular phylogenies** are inferred from molecular data (DNA sequence, Protein sequence)
- Phenetics or cladistics or mixture of both

Phenetics Vs Cladistics

- **Traditional taxonomy** is based on phenetics.
- Phenetics is based on overall similarity to group organisms into hierarchical levels called *Taxonomic groups*.
- **Faster and convenient but not accurate.**
- **Cladistics** use certain shared features to group the organisms by common ancestor **(better method of determining ancestry)**

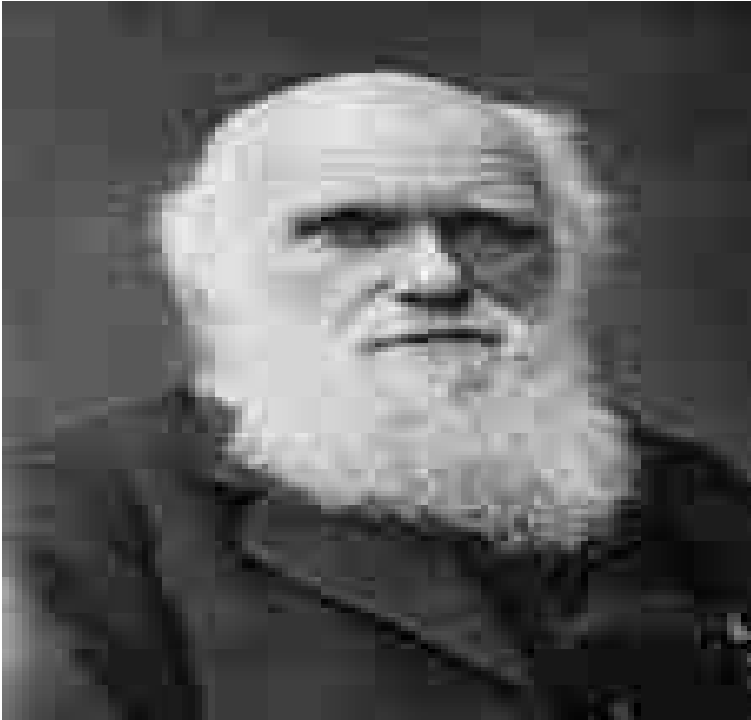
Phenetics Vs Cladistics



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- **Linnaeus was a Phenetists**
- Although he did not believe in evolution by descent but his pattern of classification provide a framework for thinking about evolution from common ancestor.
- For him **“relatedness”** meant propinquity in creators' design.
- Phenetic clustering

Phenetics Vs Cladistics



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- **Darwin was a Cladist**
- According to him natural system based on descent with modification.
- The characters that show true affinity have been inherited from a common parent.
- All true classification is genealogical
- Phenetic classification is artificial
- Cladistic classification is natural

(Darwin, origin of species, 1859)

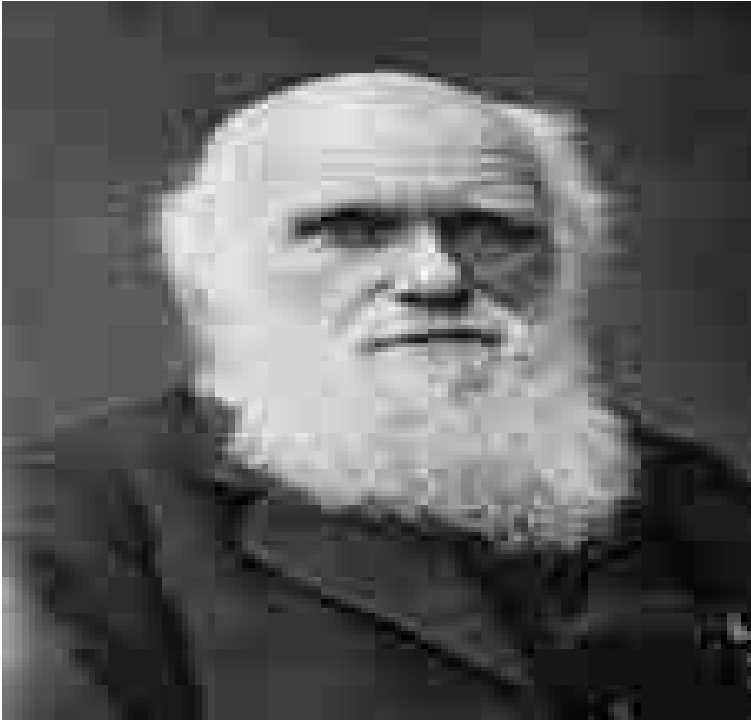
Phenetics Vs Cladistics

- **Phenetics**
- Computer algorithms based on the phenetic model rely on **distance method** to build tree from sequence data.
- Phenetic approach lead to faster algorithms and have nice statistical properties for molecular data.
- Error rate is less
- But final tree is not highly reliable

Phenetics Vs Cladistics

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Phenetics Vs Cladistics

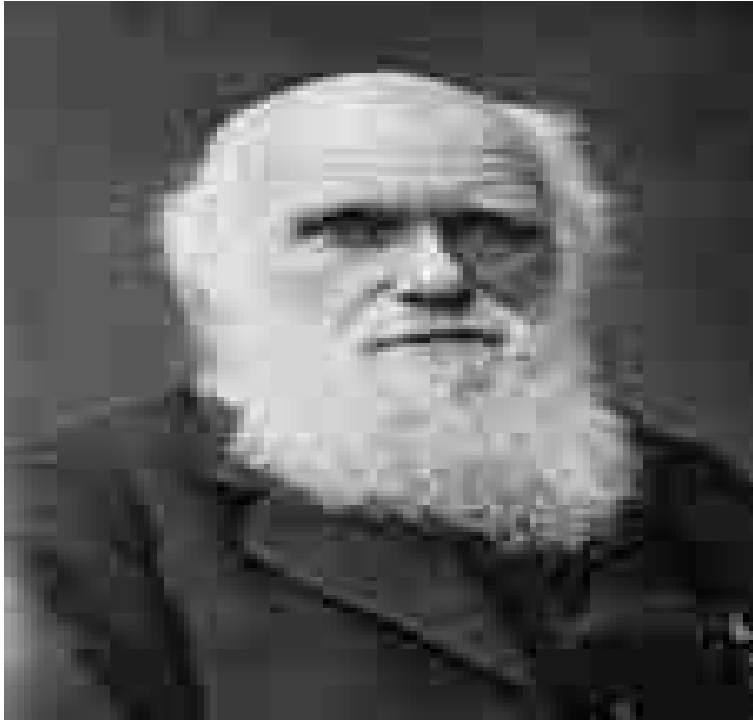


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Cladistic

- Evolutionary relationships are documented by creating a branching structure **(phylogenetic tree)**
- It illustrates the relationships among sequences
- Cladistic method construct a tree (cladogram) by considering **various possible pathways** of evolution and chose from among the best.

Phenetics Vs Cladistics



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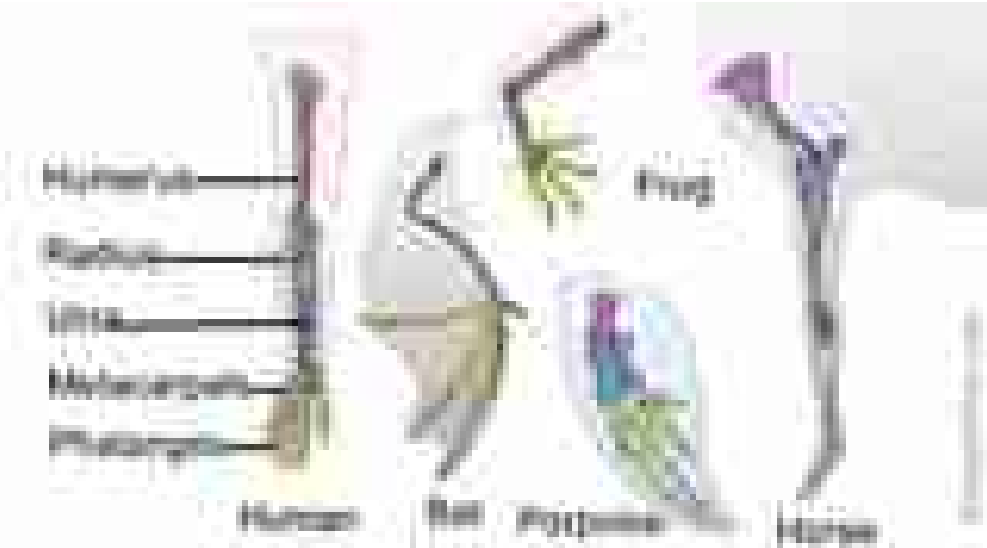
Cladistic

- Evolutionary relationships are documented by creating a branching structure (**Cladogram**)
- **Phylogram** is a tree with branching that are proportional to the evolutionary distances.
- It is more informative

Module# 186 Homology

What are homologous structure

- A body part with a same structure between some groups due to inheritance from same ancestor.
- Not necessarily performing same function



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Homology

Importance of homologous structure

- To provide a path of evolutionary paths
- Diverges between species and sub-species



<https://www.slideshare.net/ClarissaNitihardjo/homologous-structure-evolution>

Homology

Common examples

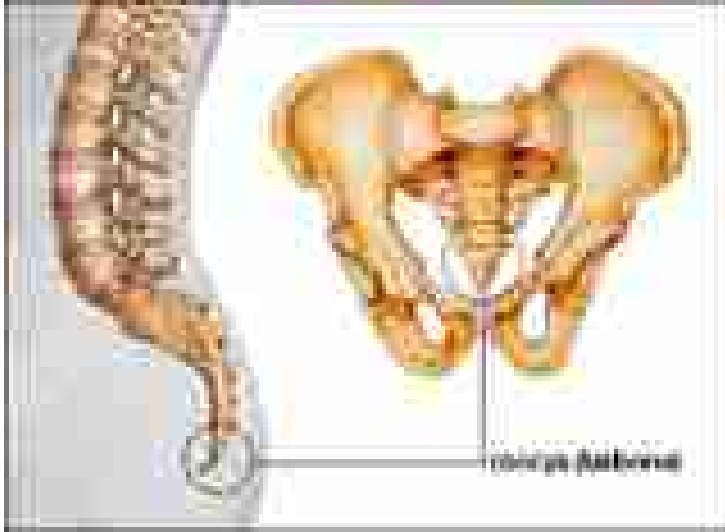
- Common **example** of **homologous structures** is the forelimbs of vertebrates, where the wings of bats and birds, the arms of primates, the front flippers of whales and the forelegs of four-legged vertebrates like dogs and crocodiles are all derived from the same ancestral tetrapod **structure**.



<https://www.slideshare.net/ClarissaNitihardjo/homologous-structure-evolution>

Homology

Tail bone

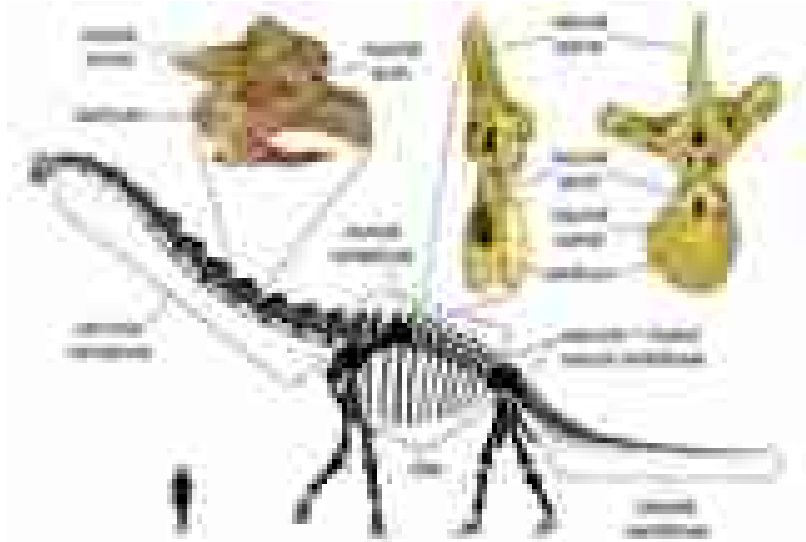


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- The tail bone in human is a homologous structure to the beginning of many animals' tails, such as monkeys. It is known as a **“vestigial structure”** because it is the last vestige of what was once a tail. **This structure serves as evidence of having a common ancestor,** one that would have had a tail.

Homology

Neck bone

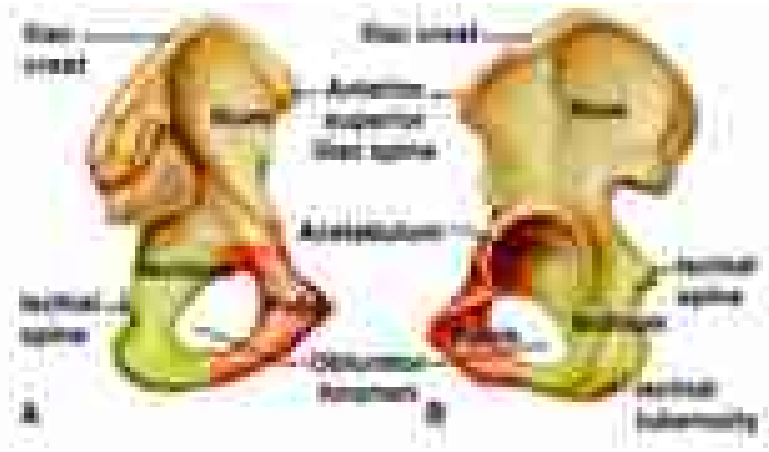


- In spite of its height, the giraffe has the very same number of neck bones (seven) as a giant whale and a tiny human being.

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Homology

Pelvis bones

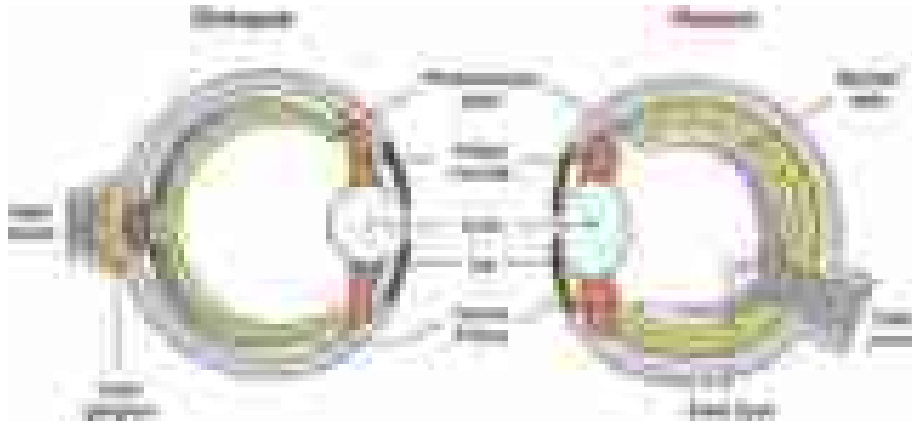


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- Human beings, dogs, and cats all have similar pelvises, which are homologous structures to a vestigial pair of bones in snakes. These bones in snakes are the last remains of a pelvis, with no legs to attach.

Homology

Eyes structure



- Human eyes are homologous to the eye bulbs which blind creatures who live in caves – **like cave fish**-- have on their heads.

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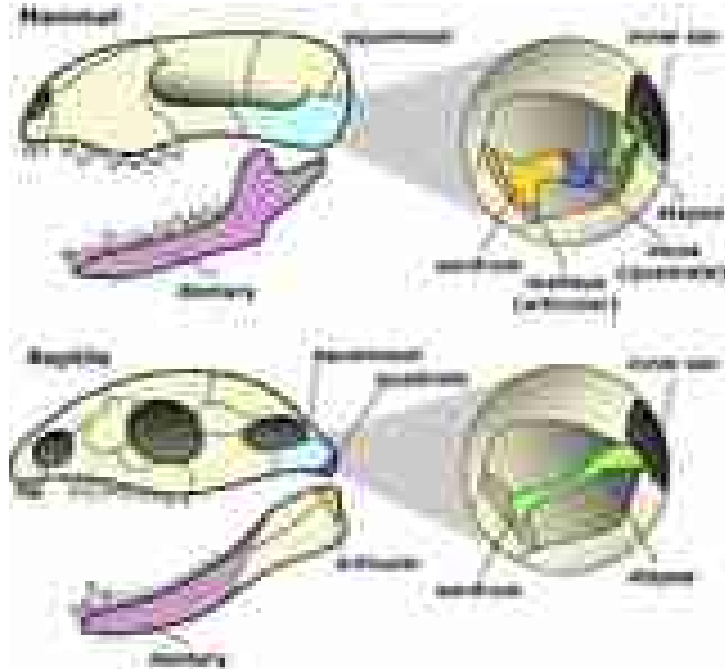
Homology

Plasma membrane

- All organisms contain homologous plasma membranes with what is called a phospholipid bilayer.

Homology

Auditory bones



- An auditory bone that exists inside the ears of mammals is a homologous structure to a reptile's jawbone, including dinosaurs.

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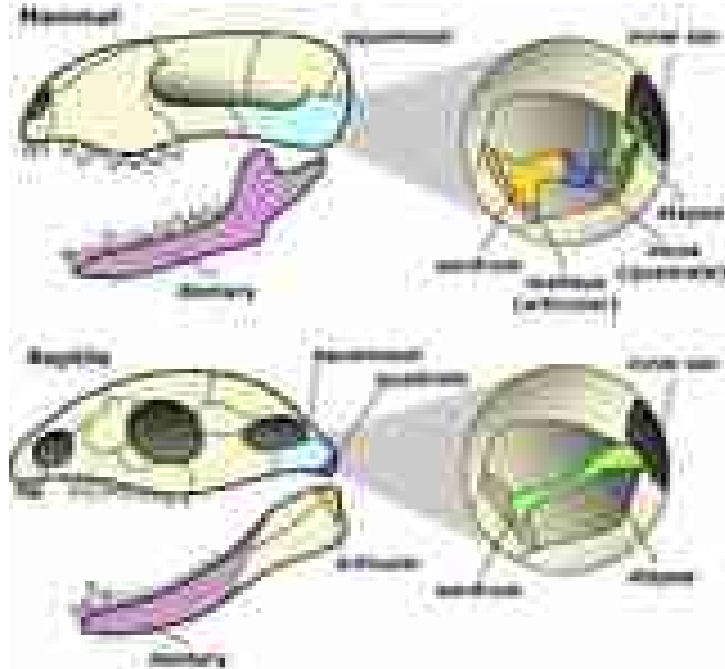
Homology

Stinger of wasps and bees and ovipositor of insects

- Wasps and bees have stingers that they can use when they feel they are in danger. This is a homologous structure to the ovipositor of other organisms like insects and certain fish; the feature allows these organisms to lay eggs.

END

Module# 187 ANALOGY



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- The structure which are different in different species but perform similar function.
- Have similar appearance
- Not evolved together
- Do not share common ancestor
- Linnaeus started classification on the basis of morphological similarities.
- Wrong classification
- All similar looking organism do not have same origin

ANALOGY



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- Analogous structures evolves due to convergent evolution
- When different organism adapt to same environment
-
- Wings of insect and birds
- Fins of fish and penguin
- Limbs of human, horse and dolphin

ANALOGY



- For similarity we should not only depends on general appearance
- Analogous structure act as evidence that theory of natural selection persists and adaptations accumulates over time

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ANALOGY



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- An example is the convergence of the **streamlined form** in the bodies of squid, shark, seal, penguin, and ichthyosaur, animals of diverse ancestry.
- **Physiological processes and behaviour patterns** may also exhibit analogous convergence.

ANALOGY



- Egg-guarding behaviour in the cobra, the stickleback, the octopus, and the spider is thought to have evolved independently among those animals, which are quite distant in their biological relationships.

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Module# 188 Natural Enemies

- Predators
- Parasitoids
- Pathogens

Natural Enemies

EXAMPLES



Dragon fly (odonota)



Lady beetles (Coccinellidae)



Greenlacewings(Chrysopidae)



wasps (vaspidae)



Soldier beetles (Cantharidae)



hover flies (Syrphidae)



Stink bugs (Pentatomidae)



spider



BIRD

- Predators kills and consume other organisms (prey)
- Usually prey is smaller in size
- Weak
- Lion is a predators
- Spiders are predators
- Lady beetles are predators

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Natural Enemies

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Natural Enemies



- A **parasitoid** is an organism that has young that develop on or within another organism (the host), eventually killing it.
- **Parasitoids** have characteristics of both predators and parasites.
- **Parasitoids** are usually smaller than their selected host

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Natural Enemies

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Natural Enemies

- Pathogen is an infectious agent that feed on host body and cause damage to its host.
- Bacteria
- Viruses
- Protozoon

END

Module# 189 Mimicry

- Mimicry refer to similarities between species.
- Mimicry is a form of symbiosis where species may mimic colours, patterns or even behaviours for one of the two reasons:
 - A. Either to be able to get closer to unsuspecting prey
 - B. To gain protection by attaining similarity with predators or poisonous species.

Mimicry

- Mostly in mimetic relationship advantage is one side.

Types of Mimicry

- Batesian mimicry
- Mullerian mimicry
- Wasmannian mimicry
- Peckhamian mimicry
- Self-mimicry



<https://www.slideshare.net/m5g7j8/mimicry-70192874>

Mimicry

- Batesian mimicry is a type of mimicry in which palatable animal mimics the bad-tasting or noxious prey so that predator may not distinguish b/e them.
- After several attempts of distasteful encounters predators learn to avoid such appearance.
- It is called Batesian mimicry in honor of English naturalist Henry W. Bates who published an explanation of this mimicry in 1862.

Mimicry

Example

- Viceroy butterfly (palatable)
(Mimic)
- Monarch (unpalatable/bad-taste)
(Model)

END

Module# 190 Mimicry

Batesian Mimicry

- Eastern coral snake (poisonous)
- Scarlet King snake (non-poisonous)
- Condition for successful Batesian Mimicry
- Number of mimics should be lower than number of models
- Mimicry breakdown

Mimicry

Mullerian Mimicry

- Mullerian mimicry is the form of protective mimicry in which two or more distasteful or harmful species especially insects, closely resemble each other and therefore avoided equally by all their natural predators (Muller (1821-1897)/German born Brazilian Zoologist)
- **Larger the group greater will be the benefit.**

Mimicry



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Mimicry



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Module# 191 Mimicry



Wasmannian Mimicry

- Wasmannian mimicry is a mimicry in which the mimics resembles its host in order to live within the same nest or structure.
- Several jumping spiders closely resemble ants.
- This works well in order to get "lost in the crowd" and thus avoid predators.

<https://www.slideshare.net/m5g7j8/mimicry-70192874>

Mimicry

Wasmannian Mimicry

- Some beetles mimic ants in order to be provided with food, shelter and protection.



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Mimicry



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Peckhamian Mimicry

- Peckhamian mimicry is also known as Aggressive mimicry.
- In this type of mimicry predator mimics its prey in order to catch it.
- Bolas spiders are type of aggressive mimics.
- They produce chemicals that mimics the sex pheromones of particular moth species.

Mimicry



- When male moths approach what they perceive to be a females in order to mate with her, they are caught by bolus spiders

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Module# 192 Species Concepts

Nominalistic Species Concept

- According to this concept "Nature produces individuals and nothing more"
- It is also known as Linneaus species concept.
- Proponents of this concept (Buffon, Bessey, Lamarck etc.) believe that only individuals exist but they do not believe in existence of species.

Species Concepts

Nominalistic Species Concept

- Species are man's own creations
- No actual existence in nature.
- Mental concept nothing more.
- Such mental concept of man has no value.
- This concept was popular in France in 18th Century.

Species Concepts

Criticism

- Simpson (1961), Rollins (1965) and Mayr (1969) stated that no biologist can agree with the idea that species do not exist as it is established fact.
- Species are product of evolution.

Species Concepts

Biological Species Concept

- “A species is a group of interbreeding natural population that is reproductively isolated from other such species”
- A species has three properties:
- Reproductive community
- Ecological Unit
- Genetic Unit

Species Concepts

Criticism

- Not application on asexually reproducing individuals
- Not applicable on sibling/cryptic species
- Fossil record
- Incomplete speciation

END

Module# 193 Species Concepts

- **Morphological concept:** The organisms are supposed to share a "specific morphological system", or SMPS.
- species are reproductive populations, and in that respect they are equivalent to biological species.
- However, there are two important differences.
- First, a population, in principle at least, might vary geographically in how states are transmitted.
- Second, a single lineage might involve a different SMPS.

<https://www.slideshare.net/MrTAiMOR/species-concept-150698533>

Species Concepts

- Cohesion species concept emphasizes the point that something inherent hold the species together.
- It has been suggested that something other than sex might play this role.

Species Concepts

- **Morphological species concept**
- It is based on the morphological variations.
- Variations/different species/sub-species/sibling species

Module# 194 Worm Blooded vs Cold Blooded animals

Worm Blooded animals

- They maintain their body temperature
- **Examples:** Birds, Mammals

Cold Blooded animals

- Do not maintain their body temperature
- **Examples:** Amphibians, Fishes

Problems: Some cold blooded fishes, Lizards maintain body temperature and some worm blooded animals such as birds do not

END

Module# 195 Ecotherms, Endotherms & Heterotherm

Ectotherms

- Produce metabolic heat at low level and quickly exchange with environment.
- Absorb heat from surroundings to maintain body temperature
- **Examples:** Mostly invertebrates, Amphibians, Fishes etc

Endotherm

- Generate own body heat for temperature regulate
- **Examples:** Birds, some

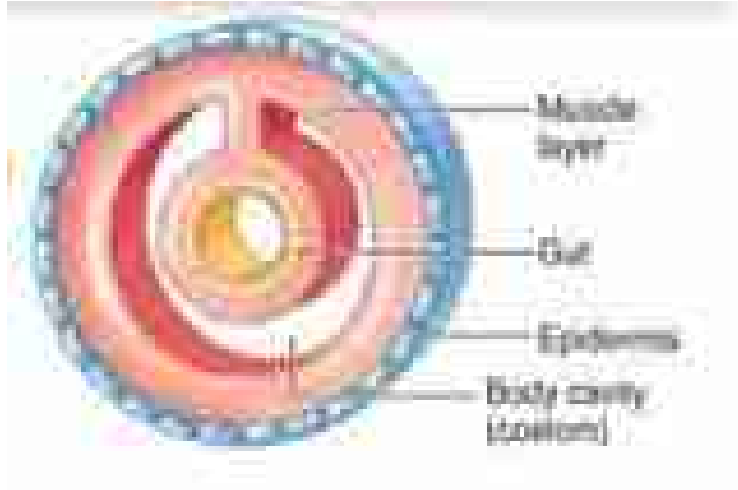
Ecotherms, Endotherms & Heterotherm

Heterotherms

- Capable of producing endothermic heat but generally do not use this to regulate their body temperature within a narrow range
- **Examples:** Bats, humming birds etc.

END

Module# 150 Coelomates, Acoelomates & Pseudocoelomates

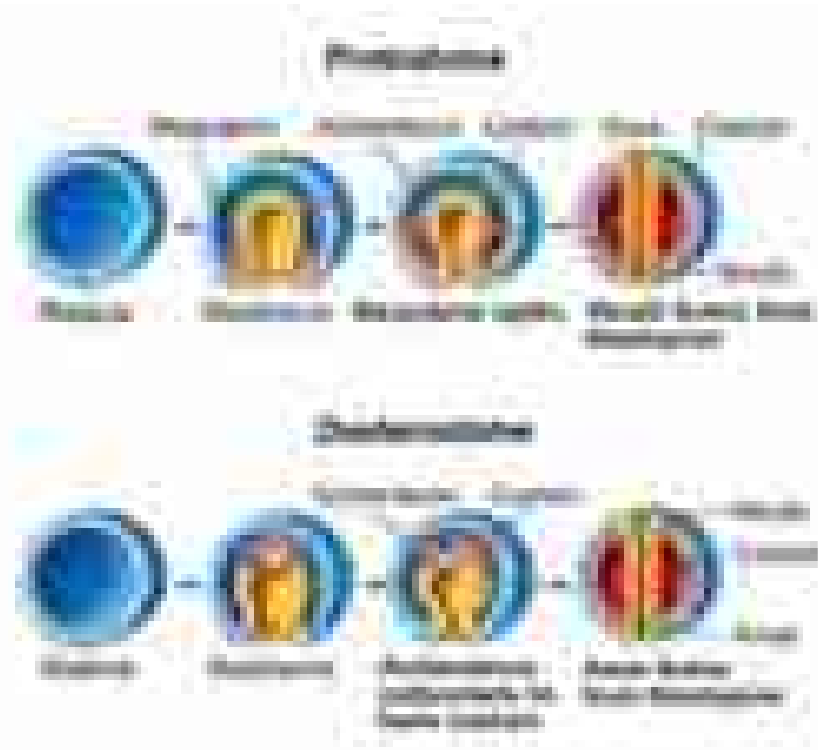


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Coelom

- Body cavity between body wall and alimentary canal
- Schizocoel/enterocoel
- **Acoelomates:**
Coelenterates,
Platyhelminthes
- **Coelomates:**
Annelids, Echinoderms, etc. Mollusk, Arthropod, Vertebrates
- **Pseudocoelomates:**
Nematodes

Module# 197 Protostomes Vs Deuterostomes

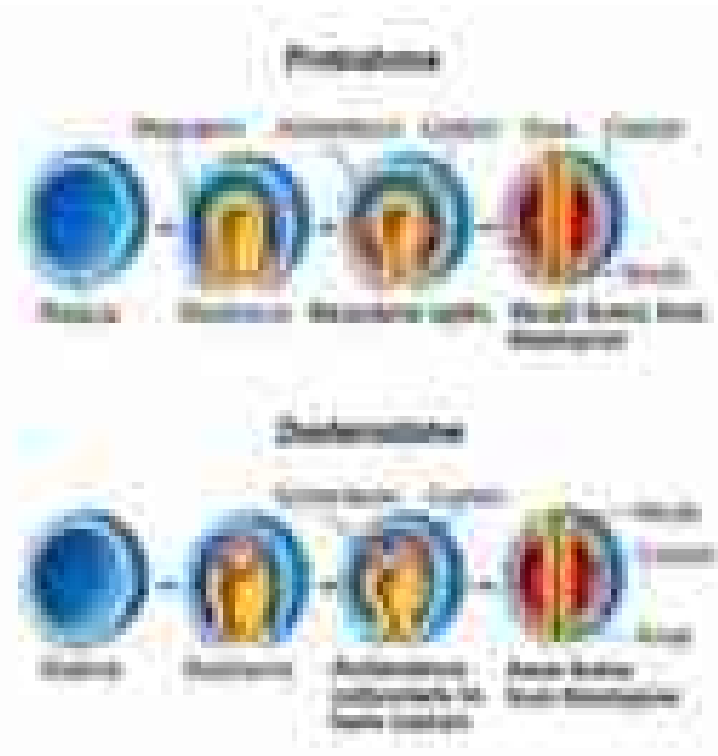


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Protostomes

- Any member of the lower invertebrate phyla in which the mouth appears before the anus during development, cleavage is spiral and determinate and the coelom forms as a splitting of the mesoderm.
- Examples: Leeches, Insects, Spiders, Crustaceans, Centipedes and millipedes, Earthworms, Squid, Octopus, Snail and slugs, Bivalve

Protostomes Vs Deuterostomes

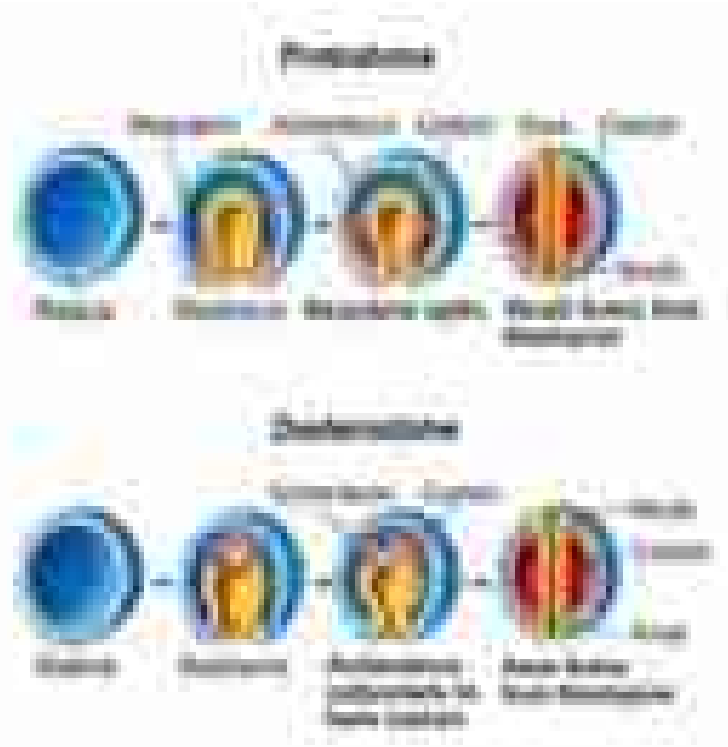


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Deuterostomes

- In deuterostomes, the first cavity formed by the blastopore ends up as the organism's anus, while the mouth is formed secondarily on the opposite side.
- The animals whose embryonic development undergoes radial cleavage.

Protostomes Vs Deuterostomes



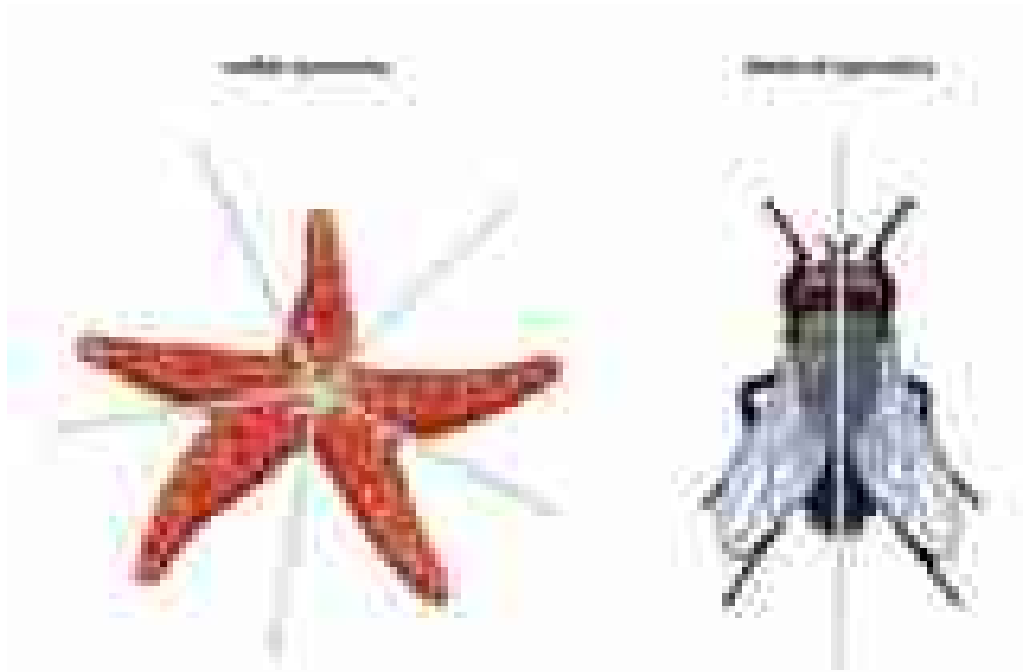
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Examples of Deuterostomes

- Echinodermata
- Chordates include marine and terrestrial animals (mammals, reptiles, amphibians, frog, turtle, lizard, bat, tetrapods, Sloth, and jawless fish).
- Cephalochordata
- Vertebrata

Module# 198 Radial Symmetry Vs Bilateral Symmetry

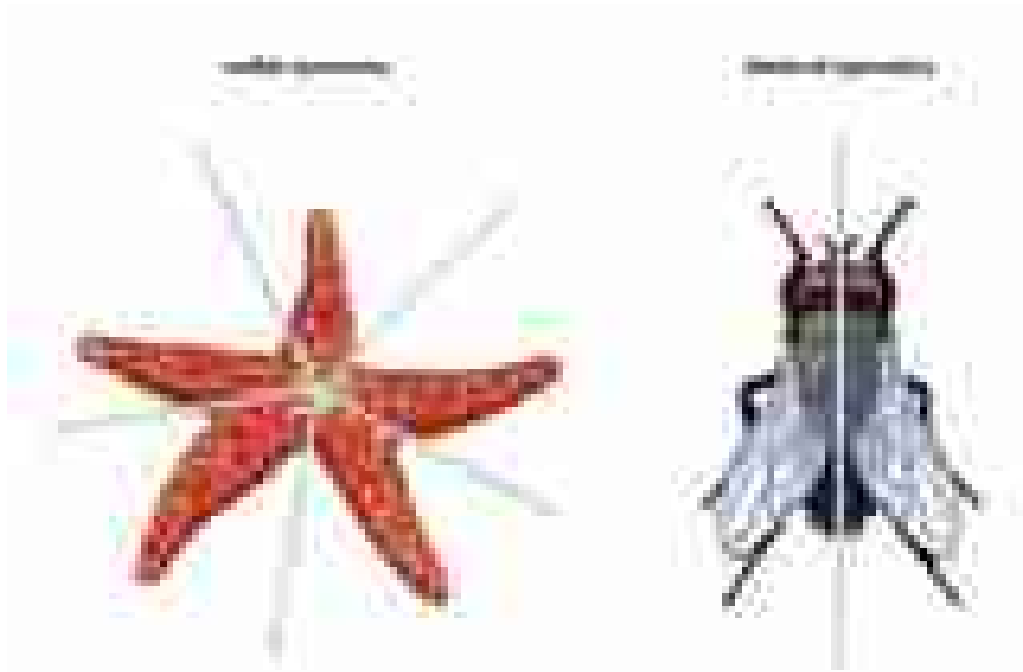
- The key difference between radial and bilateral symmetry is that radial symmetry generates identical body halves around the central axis whereas bilateral symmetry generates only two sides as left and right.



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Radial Symmetry Vs Bilateral Symmetry

- Examples of radial symmetry includes starfish, hydra
- Examples of bilateral symmetry includes insects, vertebrates
- Activity
- Development



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Radial Symmetry Vs Bilateral Symmetry

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Module# 199 Chordates, Invertebrates Vs vertebrates

Chordates

- Five characteristic features of chordates present during some time of their life cycles are a **notochord**, a dorsal hollow tubular **nerve cord**, **pharyngeal slits**, endostyle/thyroid gland, and a **post-anal tail**.

Chordates, Invertebrates Vs vertebrates

Invertebrates

- Invertebrates are animals with no vertebral column or backbone.
- Invertebrates comprise approximately 97% of the animal kingdom.
- Most of them are soft-bodied and do not develop rigid internal skeletons.
- Many invertebrates do, however, possess hard exoskeletons to protect their bodies from their

Chordates, Invertebrates Vs vertebrates

Invertebrates

- Some common examples of invertebrates are snails, sponges, earthworms, squids, sea-stars, centipedes, butterflies, spiders, and jellyfish.

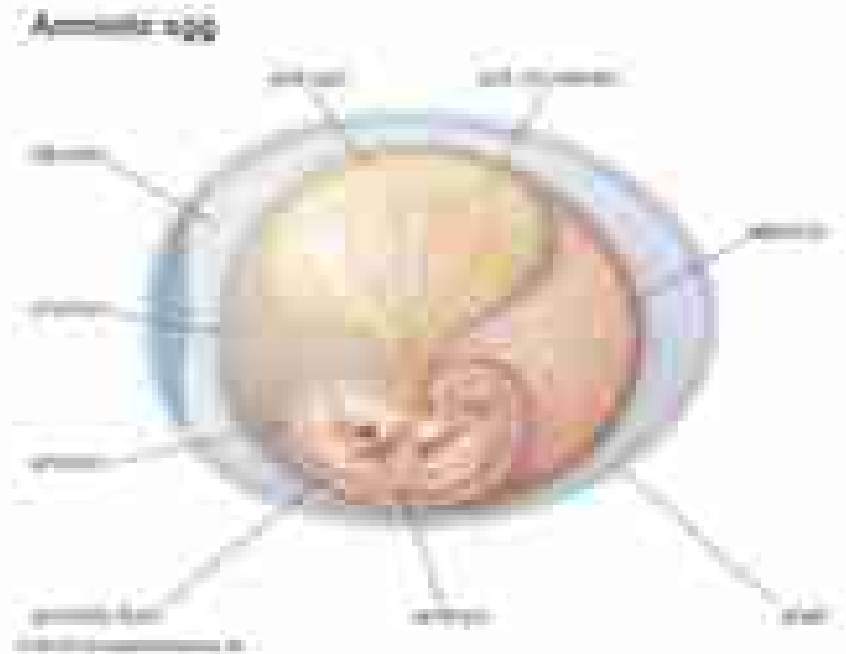
Chordates, Invertebrates Vs vertebrates

vertebrates

- Fish
- Amphibian
- Reptiles
- Birds
- Mammals

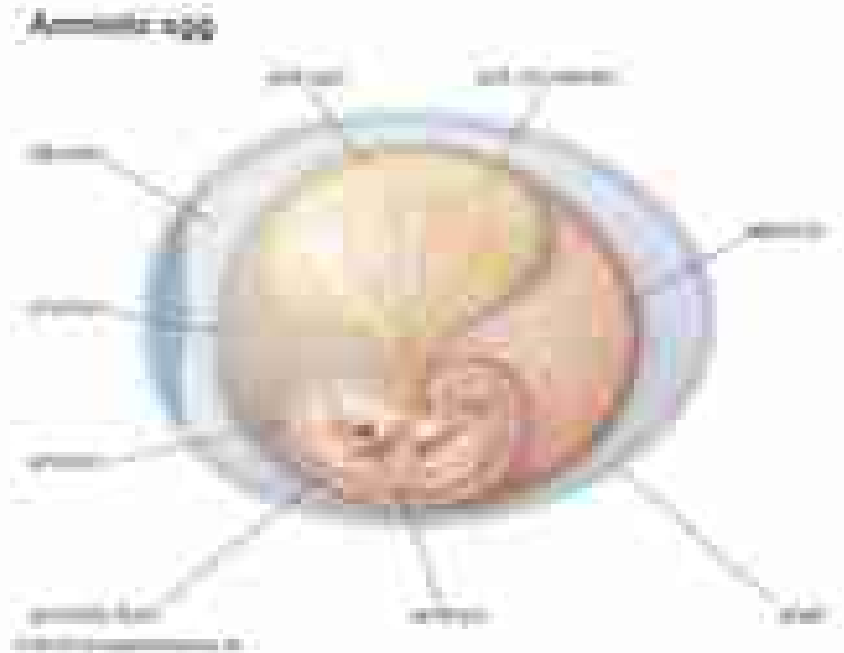
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Module# 200 Amniotes Vs Anamniotes



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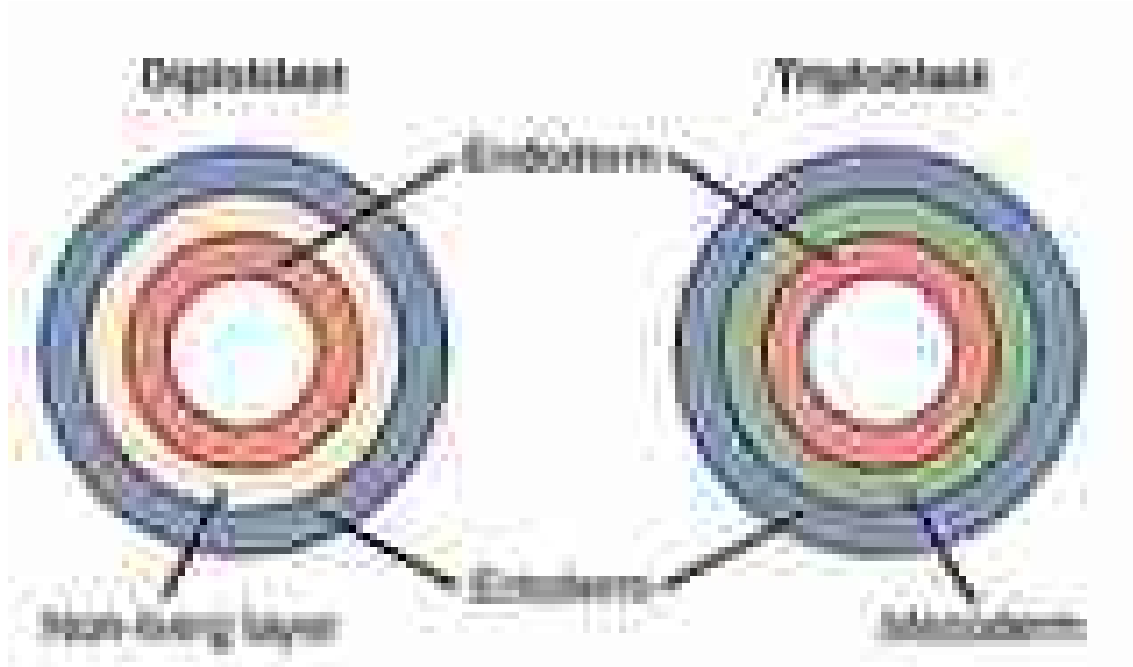
Amniotes Vs Anamniotes



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- The **anamniotes** are an informal group comprising the fishes and the amphibians, the so-called "lower vertebrates", which lay their eggs in water.
- They are distinguished from the **amniotes**, the "higher vertebrates" (reptiles, birds and mammals), which lay their eggs on land or retain the fertilized egg within the mother.

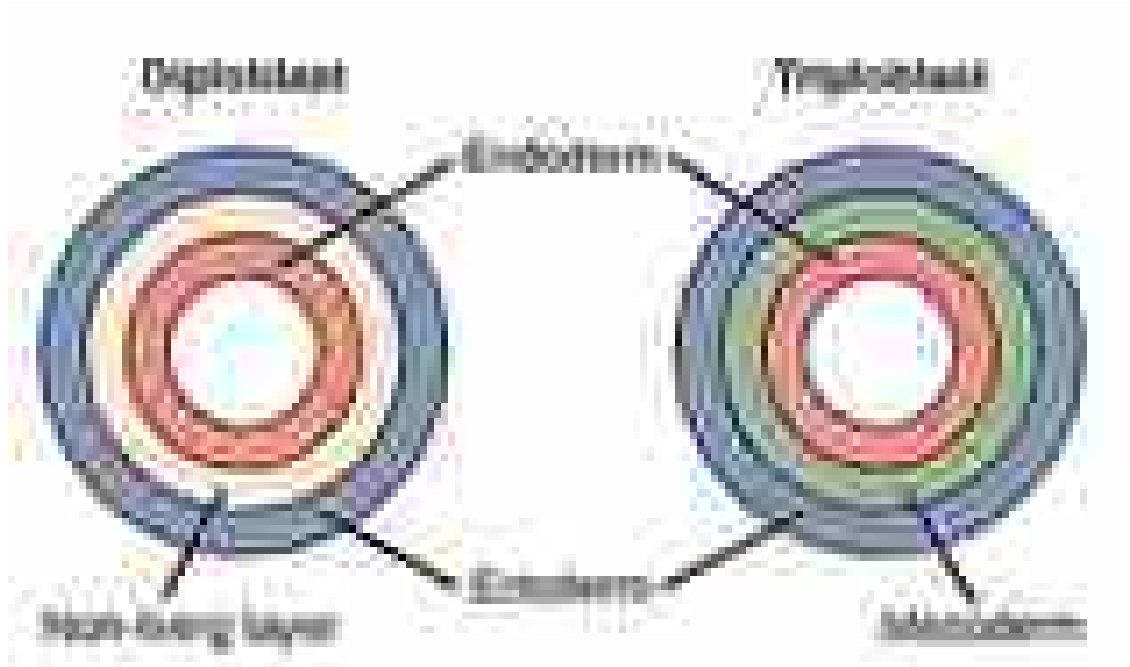
Module# 201 Diploblastic Vs Triploblastic



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- Diploblastic organisms have only two primary germ layers in their blastula: endoderm and ectoderm.
- They lack the middle layer or the mesoderm.
- The inner layer, which is the endoderm, gives rise to tissues associated with gut and associated glands.
- In contrast, the outer layer, ectoderm, gives rise to covering tissues like epidermis.

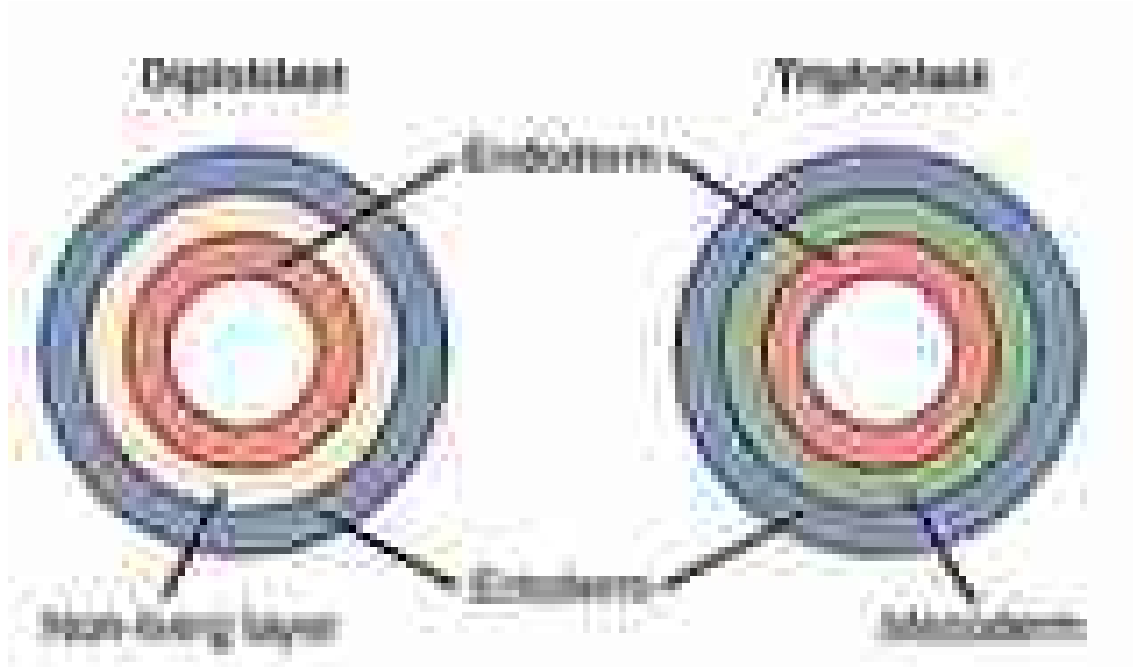
Diploblastic Vs Triploblastic



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- Animals in phyla Cnidaria and Ctenophore belong to this group.
- Cnidarians include jellyfish, corals, sea pens, sea anemones, etc. and ctenophores include comb jellies.
- These simple, primitive metazoans basically lack body cavities and true organs.

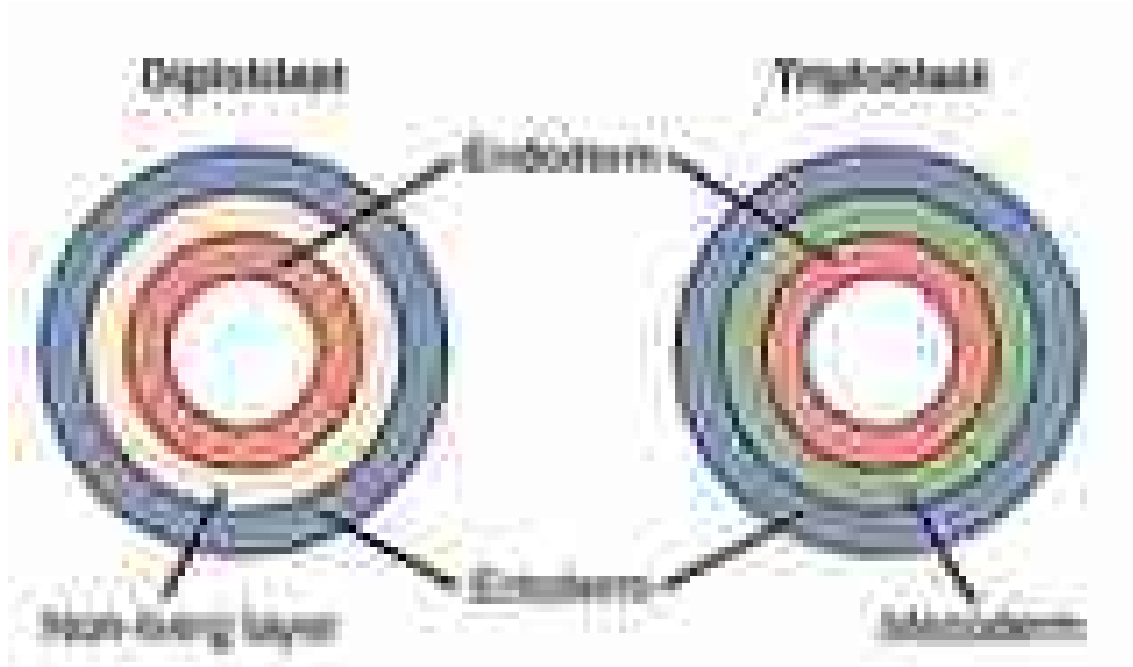
Diploblastic Vs Triploblastic



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- Most metazoans develop three primary germ layers in their blastula; hence, they are referred to as triploblastic animals.
- The three primary germ layers are ectoderm, mesoderm, and endoderm.
- Ectoderm basically gives rise to the epidermis and may also give rise to sensory organs and parts of the nervous system.

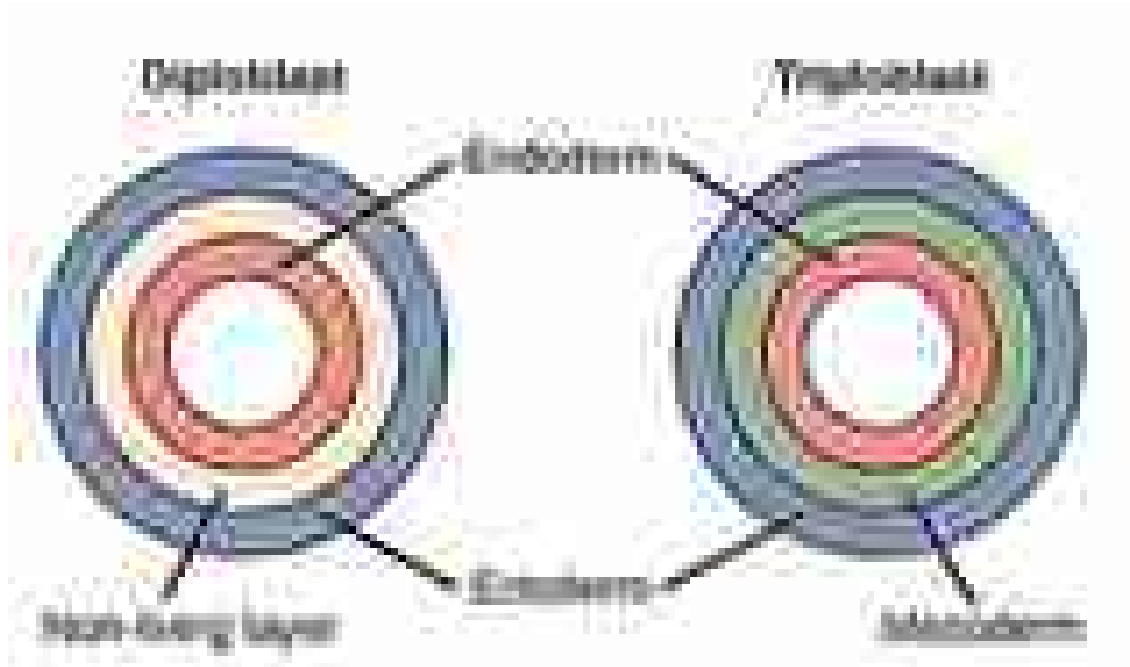
Diploblastic Vs Triploblastic



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- Mesoderm mainly forms muscles, connective tissues, blood vessels, epithelial lining of interior cavities, certain excretory organs, and skeletal elements. Endoderm gives rise to parts of gastrointestinal tracts, respiratory tract, parts of endocrine glands and organs, and auditory system.

Diploblastic Vs Triploblastic



- Examples include arthropod, Echinoderms, Mollusks, vertebrate etc.

<https://www.differencebetween.com/difference-between-diploblastic-and-vs-triploblastic/>

Module# 202 Classification of Animals on the Basis of Nutrition

- **Herbivores**– **Animals** that only eat plant. ... Rabbits, Goat, sheep, grasshoppers etc
- **Carnivores** – **Animals** eat only other **animals**. ... dog, lion
- **Omnivores**– **Animals** that eat both plants and **animals**. ... Man, fox, Rats, crows
- **Detrivores or Scavengers**– **Animals** that eat the remains of died **animal**

Classification of Animals on the Basis of Nutrition



- **Herbivores**– Two important groups of herbivores are rodents (rat & squirrel) and ungulates.
- Rodents is the largest group of mammals.
- Ungulates are hoofed grassing animals such as horses, cattle and sheep.

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Classification of Animals on the Basis of Nutrition



- Premolar and Molars have large grinding surfaces.
- Canines are missing
- In grassing and browsing herbivores i.e., deer and sheep, there are no upper incisors.

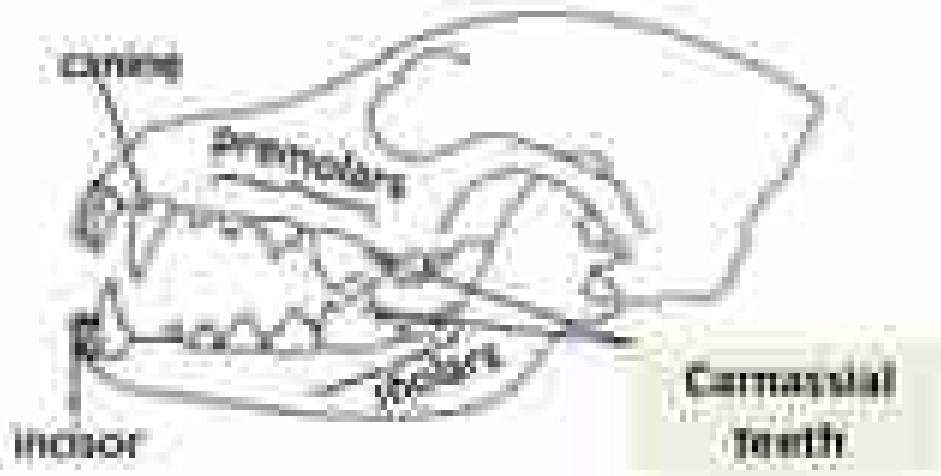
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Module# 203 Principles of Systematics

Classification of Animals on the Basis of Nutrition

Classification of Animals on the Basis of Nutrition

Dog - a carnivore



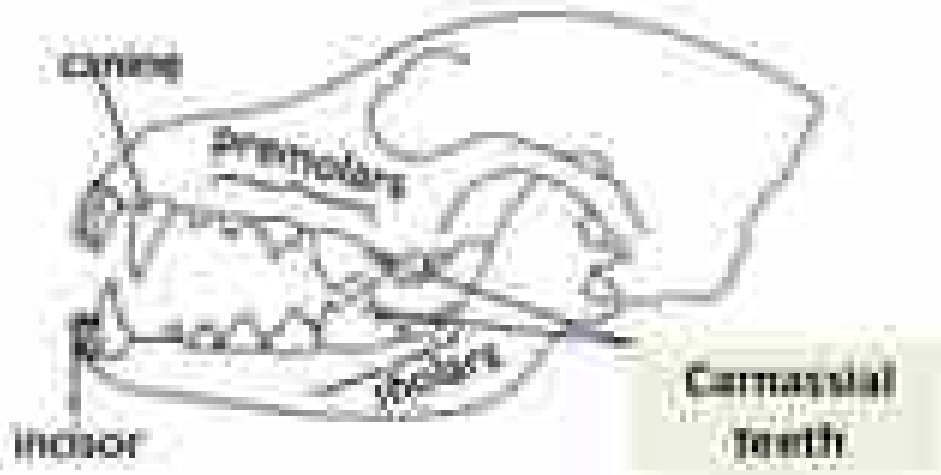
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Carnivores

- The animals which feed on other animals are called carnivores.
- Have large canine teeth for catching and tearing the prey.
- Incisors, premolars and molars are all adapted for cutting flesh, cracking bones and reducing the chunks to sizes suitable for swallowing.

Classification of Animals on the Basis of Nutrition

Dog - a carnivore



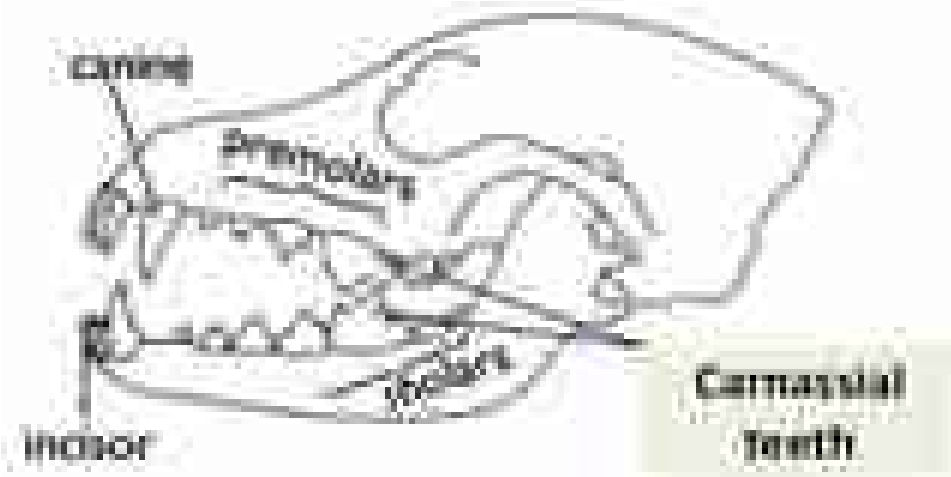
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Predator

- Predator is an animal, which captures and readily kills live animals for its food.
- The animal which is eaten by predator is called prey.
- Prey-predator interaction helps in maintaining ecosystem stable.
- A species in the area without its natural predator leads to disastrous results.

Classification of Animals on the Basis of Nutrition

Dog - a carnivore



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Omnivores

- Animals which eat both plants and animals.
- They are teethes structurally and functionally intermediate between the extremes of specialization attained by the teethes of herbivores and carnivores.
- Man, Cow,

Classification of Animals on the Basis of Nutrition



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Detritivores

- **Detritivores** (also known as detritivores, detritus feeders, or detritus eaters) are heterotrophs that obtain nutrients by consuming detritus (decomposing plant and animal parts as well as faeces).
- There are many kinds of invertebrates, vertebrates and plants that carry out coprophagy.

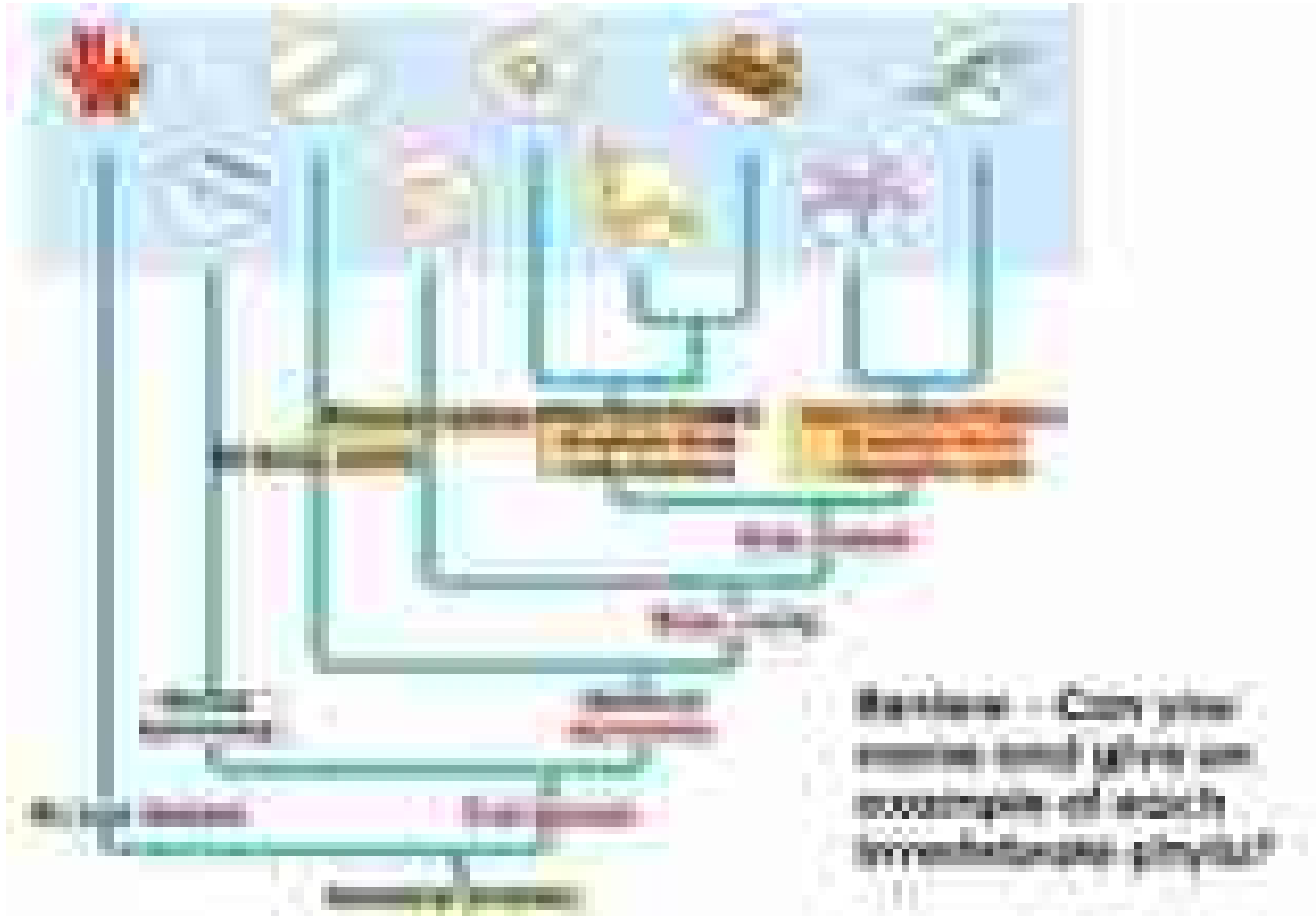
Classification of Animals on the Basis of Nutrition



- Detritivores are often invertebrate insects such as mites, beetles, butterflies and flies; mollusks such as slugs and snails; or soil-dwelling earthworms, millipedes and woodlice.

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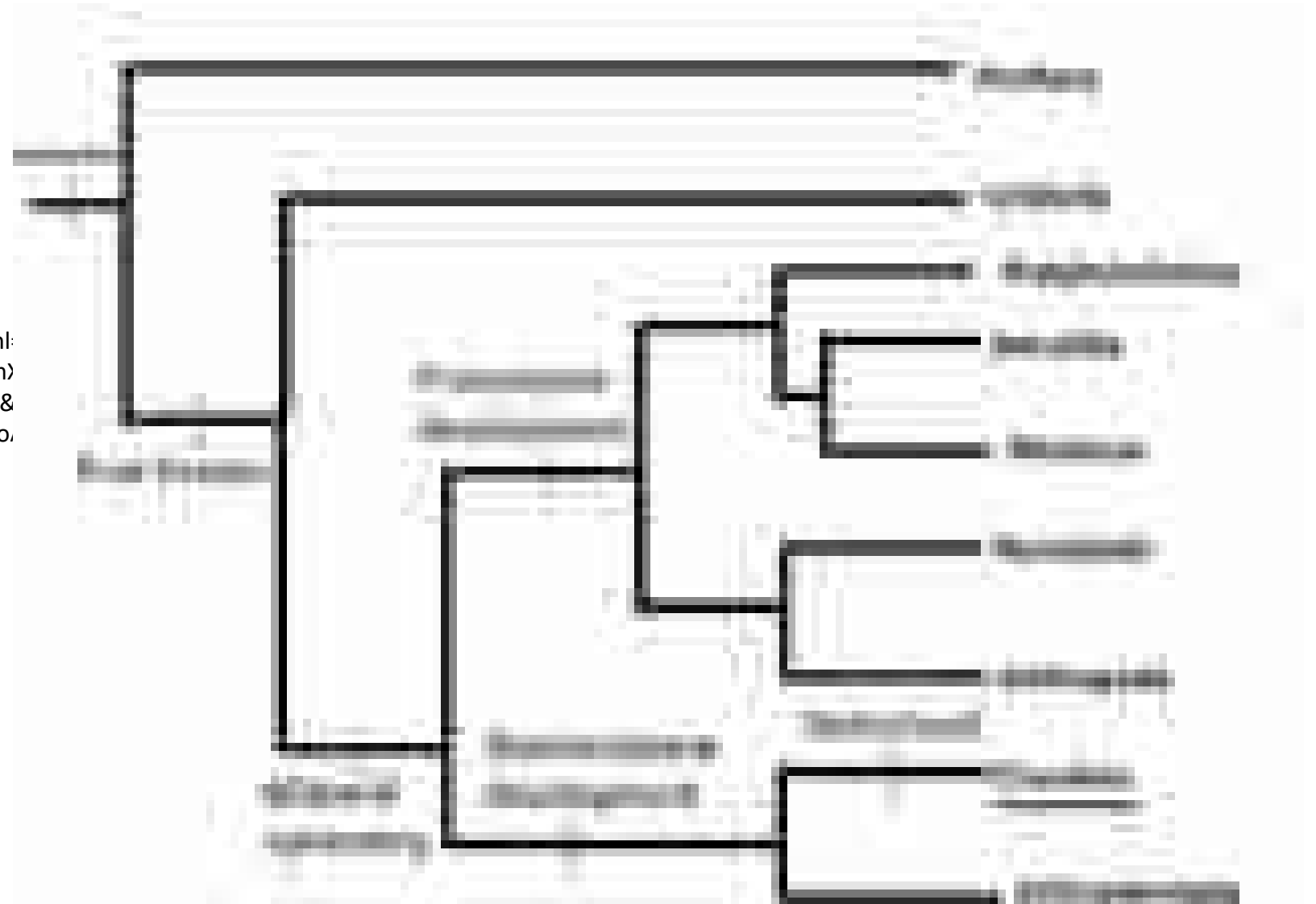
Module# 204 Invertebrates



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Invertebrates

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Module# 205 Phylum Porifera



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- Poriferans are commonly referred to as sponges. An early branching event in the history of animals separated the sponges from other metazoans.
- Fossil sponges are among the oldest known animal fossils, dating from the Late Precambrian.

Phylum Porifera



- The approximately 5,000 living sponge species are classified in the phylum Porifera, which is composed of three distinct groups, the **Hexactinellida** (glass sponges), the **Demospongia**, and the **Calcariea** (calcareous sponges).

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Phylum Porifera



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- Sponges are characterized by the possession of a feeding system unique among animals. Poriferans don't have mouths; instead, they have tiny pores in their outer walls through which water is drawn.
- Cells in the sponge walls filter food from the water as the water is pumped through the body and out other larger openings.

Phylum Porifera



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- The cells of Poriferans are loosely organized.
- They are mostly found in marine water.
- Only a few are found in freshwater.
- They are either radially symmetrical or asymmetrical.
- Their body is usually cylindrical.
- The scleroblast secretes spicules while spongin fibres are secreted by spongioblasts.

Phylum Porifera



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- They have no organs in their body.
- They depict cellular grade of organization.
- The body comprises numerous pores known as Ostia and osculum.
- The central cavity is called spongocoel or atrium which opens to the outside through the osculum.

Phylum Porifera



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- They reproduce asexually by budding and fragmentation.
- The nutrition is holozoic.
- They have the power to regenerate the lost parts.
- The exchange of respiratory gases and nitrogenous wastes occurs by the process of diffusion.

Module# 206 Phylum Coelentrata



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- Coelentrata also known as Cnidaria.
- This name of cnidaria is due to single cavity Coelenteron.
- Cnidarian have tissue but don't have organ or organ system. That's why they possess tissue level of organization.
- They are Radially symmetry and Diploblastic.
- Radial Symmetry
- Diploblastic
- No separate body cavity.

Phylum Coelentrata



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- They have incomplete digestive system. It has a single aperture mouth but don't have anus.
- They respire through body surface by diffusion.
- They excrete through body surface by diffusion.
- Segmentations are absent in them.
- Tentacles are present in them which act as appendages.
- They are mostly marine, aquatic animals and free-living animals.

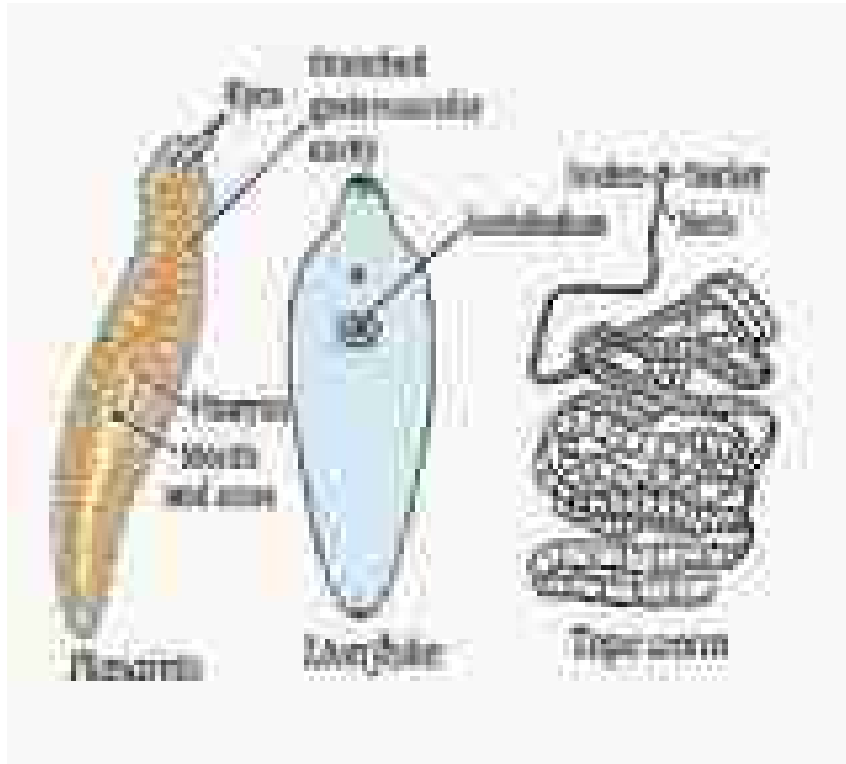
Phylum Coelentrata



- They reproduce both sexually and asexually.
- Ex :- Sea-pan, Sea-fan, Brain coral etc.

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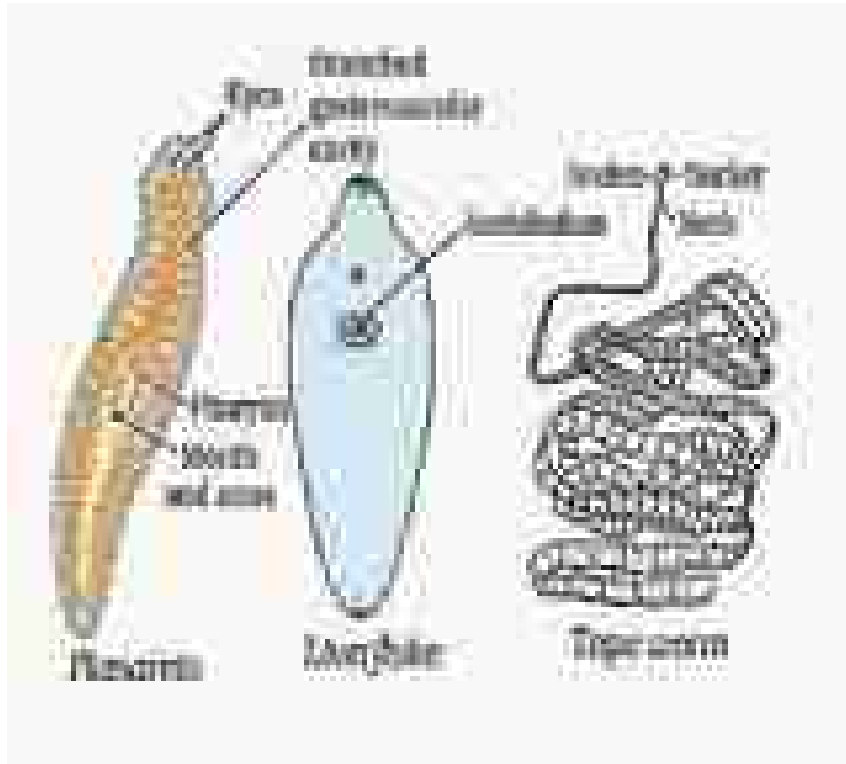
Module# 207 Phylum Platyhelminthes



- Platys: flat; helminthes: worms)
- Kingdom: Animalia
- Habitat: mostly parasitic, few are free living in sea water or fresh water
- Grade of organization: Organ-system grade of organization
- Symmetry: Bilateral symmetry and Body is dorso-ventrally flattened

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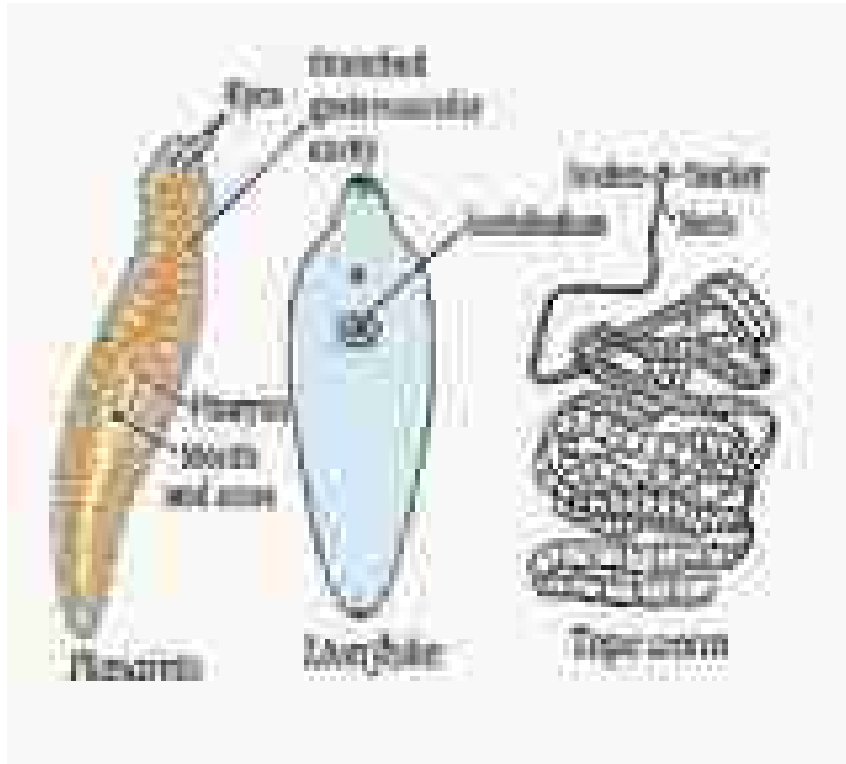
Phylum Platyhelminthes



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- Germ layer: Triploblastic.
- Ectoderm is very specialized with distinct epidermis
- Coelom: Absent (acoelomate).
- Digestive system: incomplete or absent
- No mouth (oral opening directly into pharynx).
- No true stomach structure (pharynx opens into a complex “intestinal” structure).

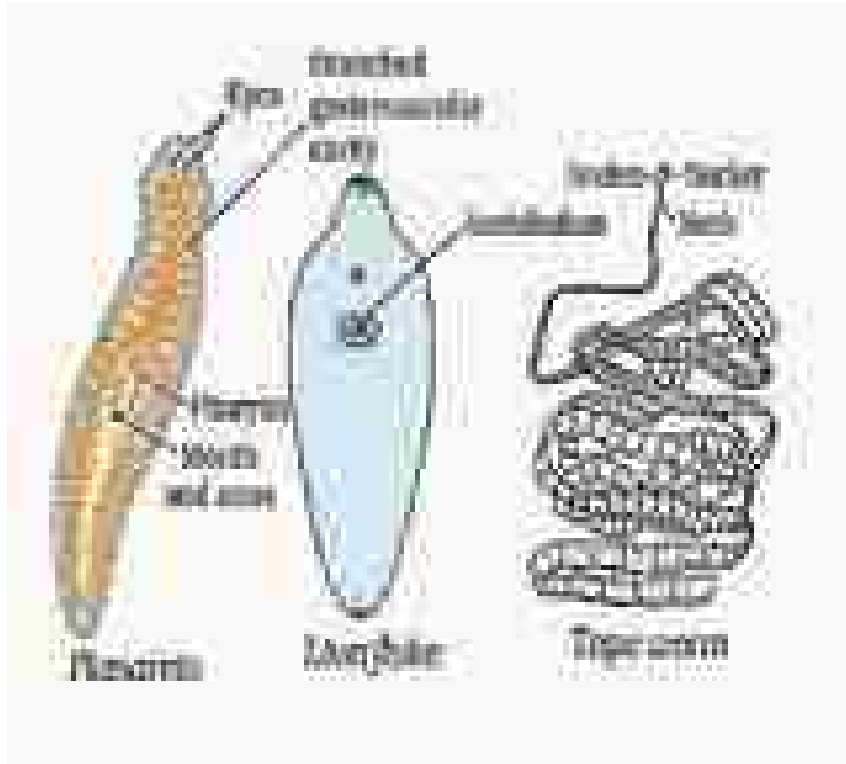
Phylum Platyhelminthes



- In tapeworms, Direct absorption of soluble nutrients by cells and tissues.
- Excretory system: Protonephridia with Flame cell
- Respiration: by simple diffusion of gases through body surface
- Circulatory system: Absent

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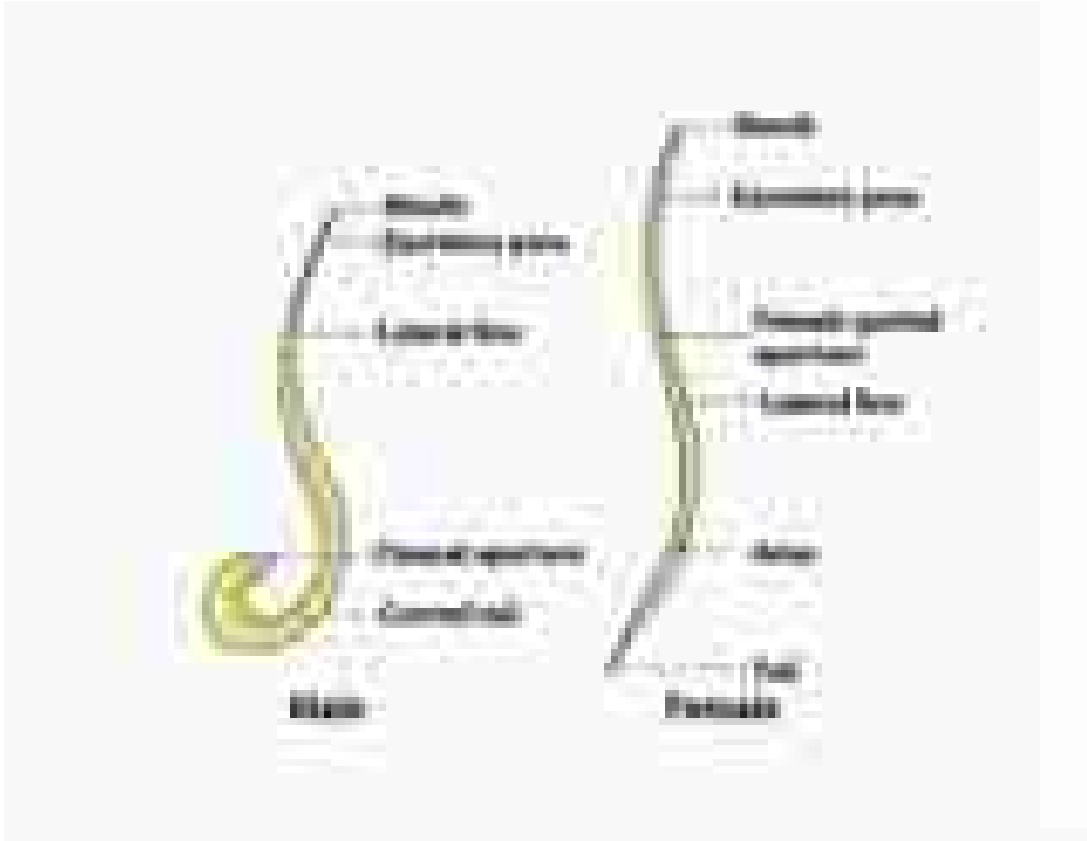
Phylum Platyhelminthes



- Reproduction
- Sexual: by gamatic fusion in hermaphrodite species
- Asexual : by regeneration and fission
- Fertilization: internal.
- Life cycle is complex involving one or more hosts.
- Examples: Tapeworms, Planaria

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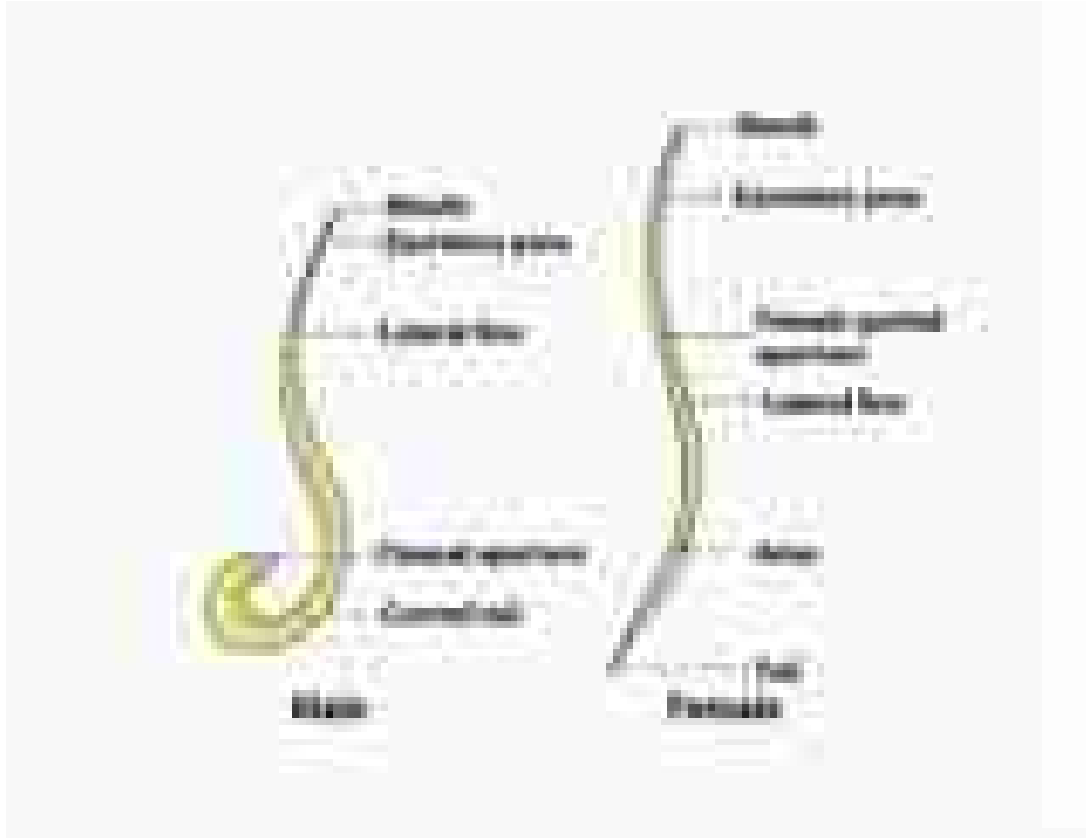
Module# 208 Phylum Nematodes



- Their body is bilaterally symmetrical and triploblastic.
- They are cylindrical in shape.
- They exhibit tissue level organization.
- Their body has a cavity or pseudocoelom.
- The alimentary canal is distinct, with the mouth and the anus.
- They are sexually dimorphic.

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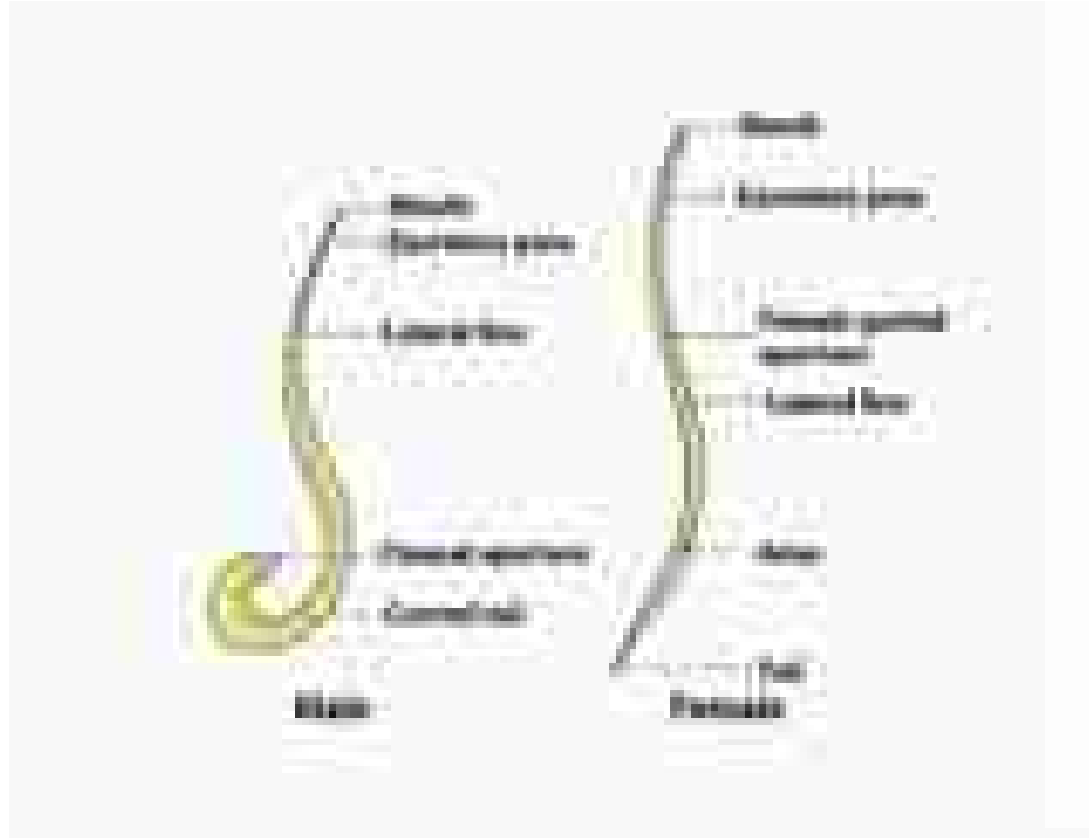
Phylum Nematodes



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- They are devoid of the circulatory system and respiratory system.
- They are free-living or parasitic.
- Parasitic nematodes cause diseases in the host.
- Fertilization is internal and reproduction is sexual.
- Their cuticle moults periodically.
- The epidermis is syncytical and contains dorsal or ventral nerve cords.

Phylum Nematodes



- The body-wall muscles are longitudinal.
- They possess amoeboid sperm cells.
- They consist of chemosensory organs called aphids situated on the lips.

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Module# 209 Phylum Annelida



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- Their body is bilaterally symmetrical
- They have a long and segmented body.
- **Annelids** are bilaterally symmetrical.
- They are triploblastic.
- Also, they exhibit organ system grade of organisation, showing organ differentiation

Phylum Annelida



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- The body is covered with a thin cuticle.
- They are coelomate.
- Annelids live in moist environments, moist soil, freshwater and marine water.
- They have parapodia and chitinous setae, used for locomotion.
- Their body appears red due to the presence of haemoglobin.

Phylum Annelida



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- Excretory and nervous systems are present.
- The digestive system is complete and developed.
- Respiration happens through the general body surface.
- These invertebrates have a true closed circulatory system.
- Sexes may be separate or united, wherein they are called hermaphrodites.

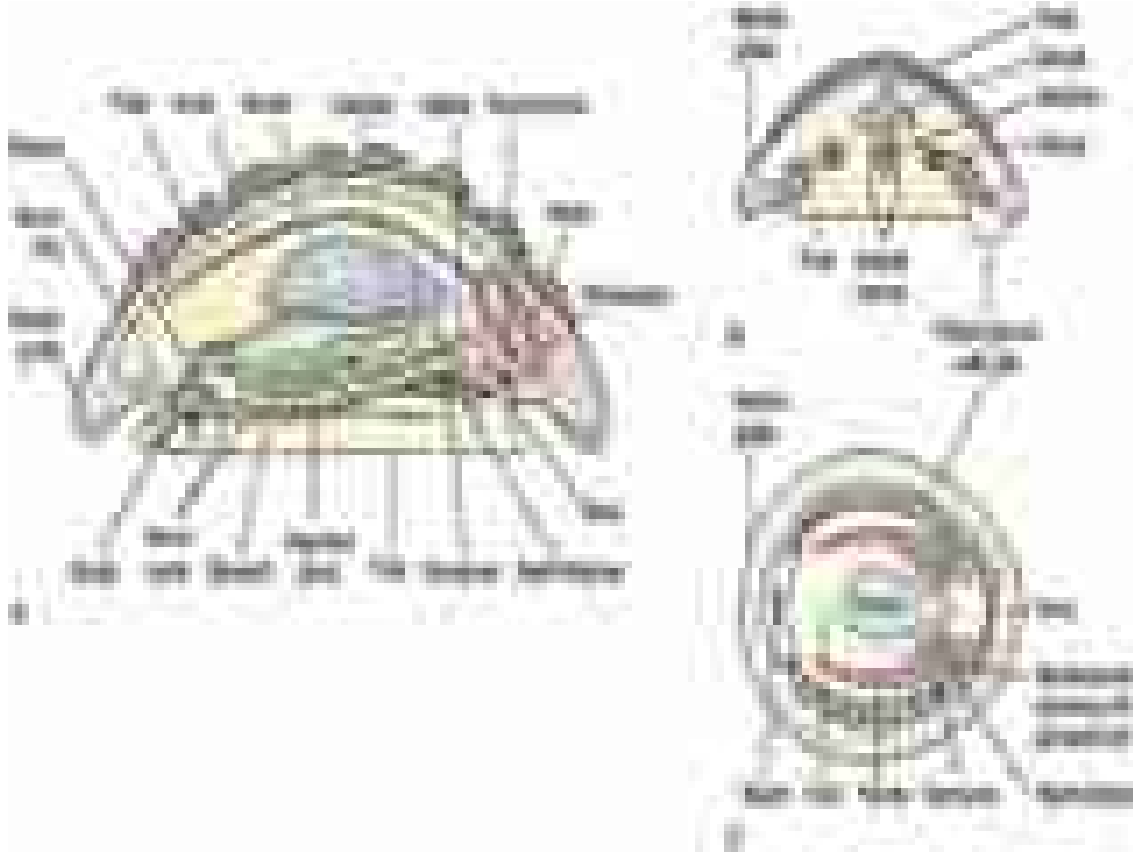
Phylum Annelida



- Fertilization can be internal or external.
- Examples of Annelids
- Earthworm
- Leeches
- Polychaetes

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Module# 210 Phylum Mollusca



<https://vignette.wikia.nocookie.net/animal-classification-project/images/8/89/Phylum-mollusca-32-728.jpg/revision/latest?cb=20170426210044>

Phylum Mollusca

- They are mostly marine.
- They have segmented body with distinct head, muscular foot and visceral hump.
- They show bilateral symmetry.
- The shell may be external, internal or absent. It is secreted by mantle and made up of calcium carbonate.

Phylum Mollusca

Phylum Mollusca

- Coelom is greatly reduced. It is restricted to pericardial cavity and to small spaces within kidneys and gonads.
- They have complete digestive tract.
- They have open blood vascular system.
- Blood is blue due to copper containing blue respiratory pigment called haemocyanin.

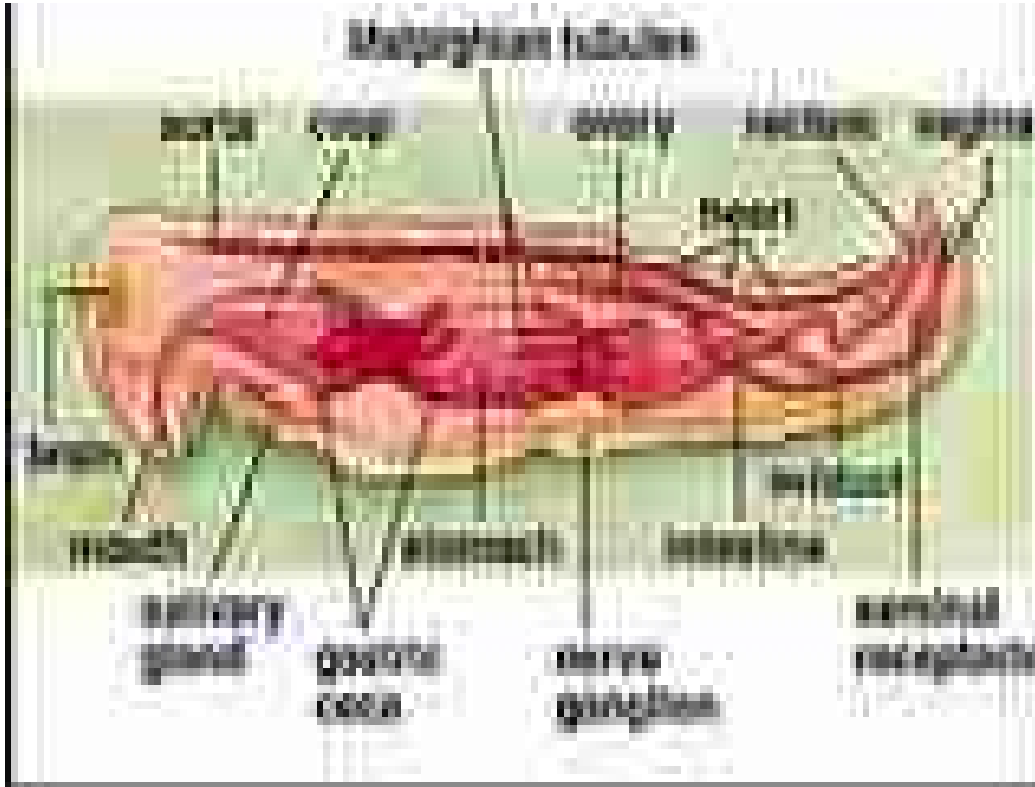
Phylum Mollusca

Phylum Mollusca

- Respirator organs are gills.
- Excretory organs are one or two pairs of sac-like kidneys.
- Osphradium is present in some molluscs for testing physical and chemical nature of water.
- The sexes are separated but some are hermaphrodite.
- Nervous system consists of cerebral, visceral, pleural and pedal ganglia.

END

Module# 211 Phylum Arthropoda



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Phylum Arthropoda

- Arthropods occur in all types of habitats i.e., marine, fresh water and terrestrial.
- There is an increasing tendency of cephalisation in arthropods.
- Their body is metamerically segment; composed of a linear series of segments or somites.

Phylum Arthropoda

Phylum Arthropoda

- Externally endoskeleton is divided into hardened segmental scutites. Internally the nervous system, muscular system and heart chambers are segmentally repeated.
- Metamerism is heteronomous.
- Appendages are joined. They act as lever systems providing mechanical advantages for locomotion.

Phylum Arthropoda

Phylum Arthropoda

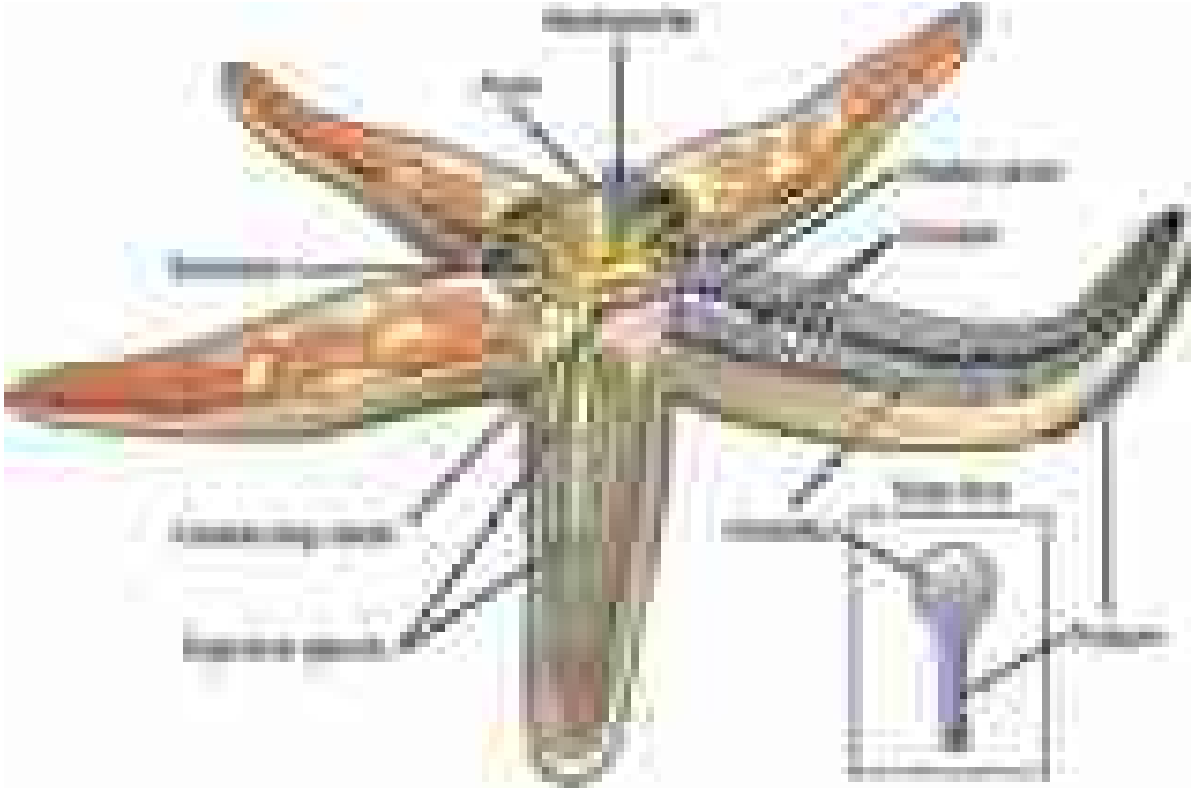
- Muscles of arthropods are striated
- Nervous system consists of nerve ring and a ganglionated double ventral nerve cord.
- Sense organs include compound eye, simple eyes, antennae, statocyst's etc.

Phylum Arthropoda

Phylum Arthropoda

- Most arthropods are unisexual. Fertilization may be external or internal in aquatic arthropods but internal in all the terrestrial forms.
- Eggs are centrolecithal (yolk in center).
- Cleavage is meroblastic and superficial.

END



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Phylum Echinodermata

- They are exclusively marine and are among the most common and widely distributed marine animals.
- Symmetry usually radial, nearly always pentamerous.
- Body shape globular, star-like, spherical, discoidal, or elongated.
- Water -vascular system of coelomic origin, including podia or tube feet for locomotion and usually with a madreporite.

Phylum Echinodermata

Phylum Echinodermata

- Sexes are usually dioecious with few exceptions.
- Gonads large and single or multiple; fertilization external, while few echinoderms are viviparous.
- Regeneration of lost parts, a peculiarity.

Phylum Echinodermata

Phylum Echinodermata

- A nervous system without a brain and with a circumoral ring and radial nerve.
- The excretory system is wanting.
- Respiratory organs include branchiae, tube-feet, respiratory tree, and bursae.
- Development is intermediate including characteristic larvae which undergo metamorphosis into the radially symmetrical adults.

END

Module# 213 Prokaryotes Vs Eukaryotes



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- **Prokaryotes** are organisms made up of cells that lack a cell nucleus or any membrane-encased organelles.
- **Eukaryotes** are organisms made up of cells that possess a membrane-bound nucleus that holds genetic material as well as membrane-bound organelles.

Prokaryotes Vs Eukaryotes

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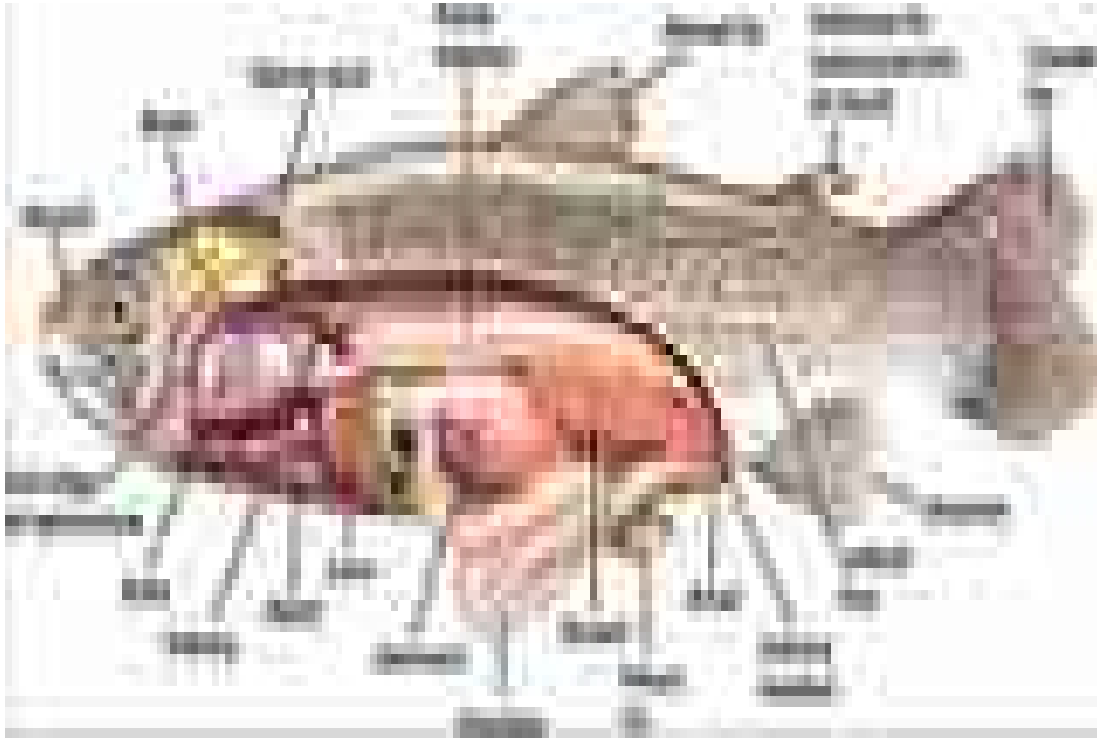


Prokaryotes Vs Eukaryotes

<https://www.technologynetworks.com/cell-science/articles/prokaryotes-vs-eukaryotes-what-are-the-key-differences-336095>

Key Differences Between Prokaryotes and Eukaryotes		
Feature	Prokaryotes	Eukaryotes
Cell Type	Single-celled organisms	Single-celled or multi-celled organisms
Cell Wall	Present in most	Absent in animals, present in plants and fungi
Nucleus	Absent	Present
Organelles	Absent	Present (mitochondria, Golgi, etc.)
Reproduction	Asexual (binary fission)	Asexual or sexual
Genome	Circular DNA	Linear DNA
Size	Small (1-5 µm)	Large (10-100 µm)
Examples	Bacteria, Archaea	Animals, Plants, Fungi

Module# 214 Class Pisces

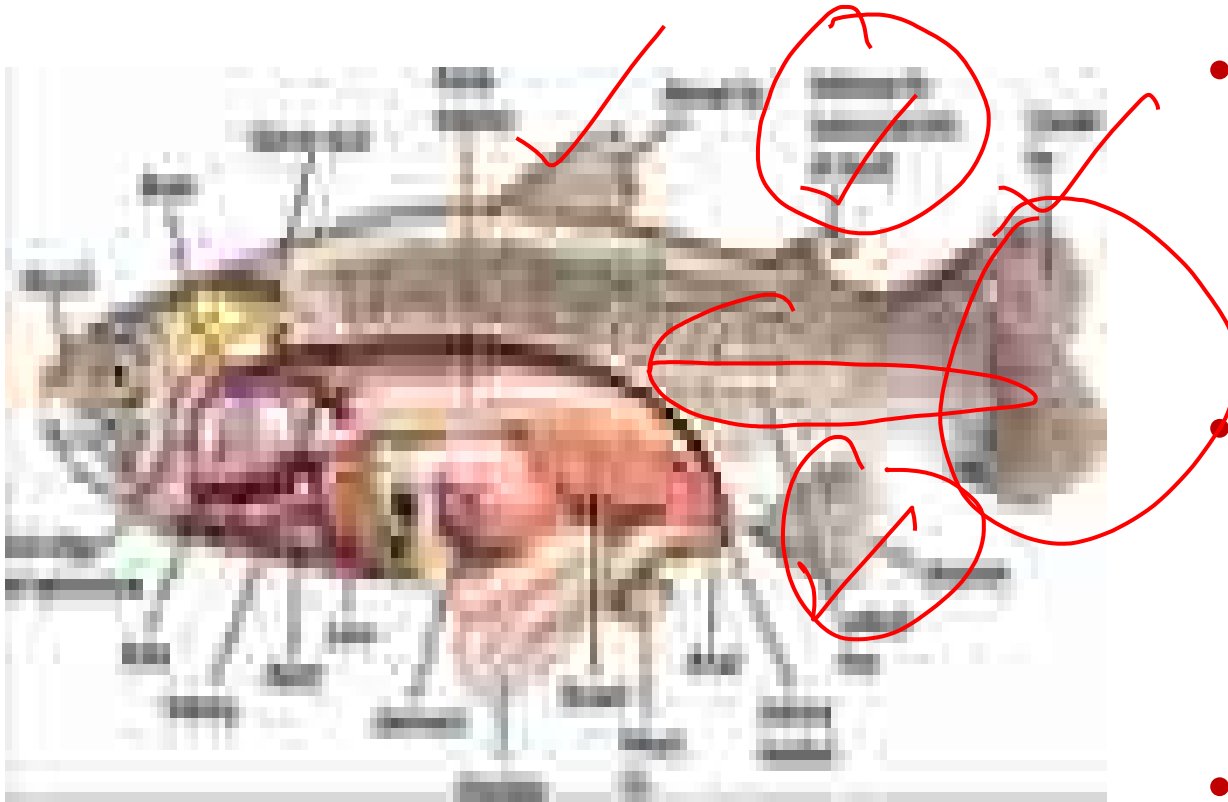


http://ourmarinespecies.com/wp-content/uploads/2018/12/fish_anatomy_9.jpg

Class Pisces

- They are found in fresh, marine, and brackish water.
- The body is usually streamlined. Some have a spindle-shaped or elongated body as well.
- Their body is distributed into a head, trunk and tail.
- They swim with the help of their tail.

Class Pisces



http://ourmarinespecies.com/wp-content/uploads/2018/12/fish_anatomy_9.jpg

- Paired and unpaired fins represent the appendages. These help the fish to balance while swimming.
- The lateral line system functions as a sensory organ to sense the disturbances in the nearby environment.
- The body is covered with thick-seated scales, which helps by providing protection to the internal organelles.

Class Pisces

- The gills help in respiration.
- Closed type blood circulation is observed.
- The internal skeleton is bony or cartilaginous.
- These are cold-blooded organisms.
- Swim bladder
- They may be herbivores or carnivores, oviparous or ovoviviparous.

Class Pisces

- The sexes are separate.
- Fertilization may be external or internal.
- They lack extra-embryonic membranes.
- The digestive system is well-developed.
- The nervous system comprises of the brain and ten pairs of the cranial nerves.
- Types

END

Module# 215 Class Amphibians

- They are the first cold blooded vertebrates from evolution point of view which came to the land.
- They occur in fresh water and moist land.
- Body is divisible into head and trunk. Tail may be present in some amphibians.
- The skin is smooth or rough having glands which keep it moist.

Class Amphibians

- They are usually without scales, but if present they are hidden beneath the skin (e. g. caecilians).
- Paired fins are absent. Unpaired fins may be present. Two pairs of limbs are used for locomotion except caecilians.
- The gills are present at least in the larval stage; some adult forms also carry external gills in addition to lungs (e.g., Proteus).

Class Amphibians

- Skull is dicondylic, i.e., with two occipital condyles for articulation with vertebral column.
- The respiratory organs are lungs, buccopharyngeal cavity, skin and gills.
- The heart is three chambered, having two auricles and one ventricle.
- Kidneys are mesonephric.

Class Amphibians

- Alimentary canal, urinary and reproductive tracts open into a common chamber called cloaca which opens outside through cloacal aperture.
- Ear consists of internal and middle ear. Tympanum (outer membrane) covers the middle ear. The eyes have eyelids. Nictitating membrane is well developed.

Class Amphibians

- Ten pairs of cranial nerves are present.
- Lateral line system is found during their development.
- Fertilization is external.

END

Module# 216 Class Reptilia

- Reptiles are the creeping and burrowing cold blooded vertebrates bearing epidermal scales.
- They are ectothermic (cold-blooded) and are found mostly in the warmer parts of the world.
- Skin is dry, rough and without glands, bearing epidermal scales or scutes.
- Snakes and lizards shed their scales as skin cast.

Class Reptilia

- They do not respire by means of gills. Respiration always takes place through lungs.
- Skull is monocondylic, i.e., with single occipital condyle.
- Except in snakes, there are two pairs of pentadactyl limbs, each with 5 digits bearing claws—tetrapodus pentadactyl type.

Class Reptilia

- Heart consists of two auricles and a partially divided ventricle. In crocodilians, heart is four chambered (two auricles and two ventricles).
- Twelve pairs of cranial nerves are present.
- Each ear consists of three parts; external, middle and internal.
Snakes do not possess ears.
- The lateral line system is altogether absent.

Class Reptilia

- Tortoises feed almost entirely on vegetation.
- Some turtles are flesh eaters.
- All other reptiles are
carnivorous/insectivorous.
- A typical cloaca is present.
- They are mostly oviparous.

END

Module# 217 Class Aves

- Birds are bipedal feathered and warm blooded (homoiothermous) animals.
- The hind-limbs are adapted for perching, walking or swimming, etc., and usually bear four, sometimes three and rarely two toes.
- Except uropygium gland (preen gland or oil gland), at the base of the tail, no skin gland is present. Ostrich and parrot lack oil gland.

Class Aves

- The upper and lower jaws are modified into beak, which lacks teeth.
- Legs are modified for walking, hopping, grasping, perching, wading and swimming. Legs bear horny epidermal scales.
- The alimentary canal has additional chambers, the crop and gizzard.

Class Aves

- The crop stores and softens the food; however, the gizzard helps in crushing and churning the food.
- Gall bladder is absent in some seed-eating birds (graminivorous) such as pigeons.
- Respiration is by lungs. The lungs are spongy and inelastic. Air sacs are connected to lungs for supplement respiration.

Class Aves

- Voice is produced by a special organ, the syrinx.
- The heart is four-chambered.
Sinus venosus is absent.
- Renal portal system is very much reduced. Red blood corpuscles are nucleated, oval and biconvex.
- The kidneys are metanephric.
- Birds have 12 pairs of cranial nerves.

Class Aves

Class Aves

- Female has usually well developed single left ovary and oviduct. If right ovary and oviduct are present, they are vestigial (nonfunctional).
- Many birds show sexual dimorphism.
- All birds are oviparous.
- They show courtship, nest building, parental care, migration and territorial behaviour.

END

Module# 218 Class Mammalia

Class Mammalia

- These animals are warm blooded, hairy and have mammary or milk producing glands, (mammary glands).
- They are homoiothermous.
- Oil glands (sebaceous glands) and sweat glands (sudoriferous glands) are present in the skin.
- Teeth are of different types (heterodont) and are embedded in the sockets of jaws (the codont).

Class Mammalia

- Except a few, mammals possess seven cervical (neck) vertebrae.
- The skull is dicondylic i.e., with two occipital condyles.
- Respiration is by lungs.
- They possess a muscular diaphragm dividing trunk into thorax and abdomen.
- The coelom is divided into four cavities.

Class Mammalia

- A pericardial cavity lodging the heart, two pleural cavities each containing the lung and an abdominal cavity having the rest of viscera.
- The heart is four chambered.
Sinus venosus is absent.
- The red blood corpuscles are
without nucleus.
- Renal portal system is absent.

Class Mammalia

- The brain has large cerebrum and cerebellum. Optic lobes are divided into four lobes called corpora quadrigemina.
- Corpus callosum connects the two cerebral hemispheres internally.
- 12 pairs of cranial nerves are present.

Class Mammalia

- Each ear consists of three parts: external, middle and internal.
Pinna is a part of external ear.
Middle ear has 3 bony ear ossicles.
- Except egg laying mammals they are viviparous.
- They are dominant animals and are capable to learn because of their better developed brain.
- Types

END