Rulers of the Earth.

An Introduction to Entomology

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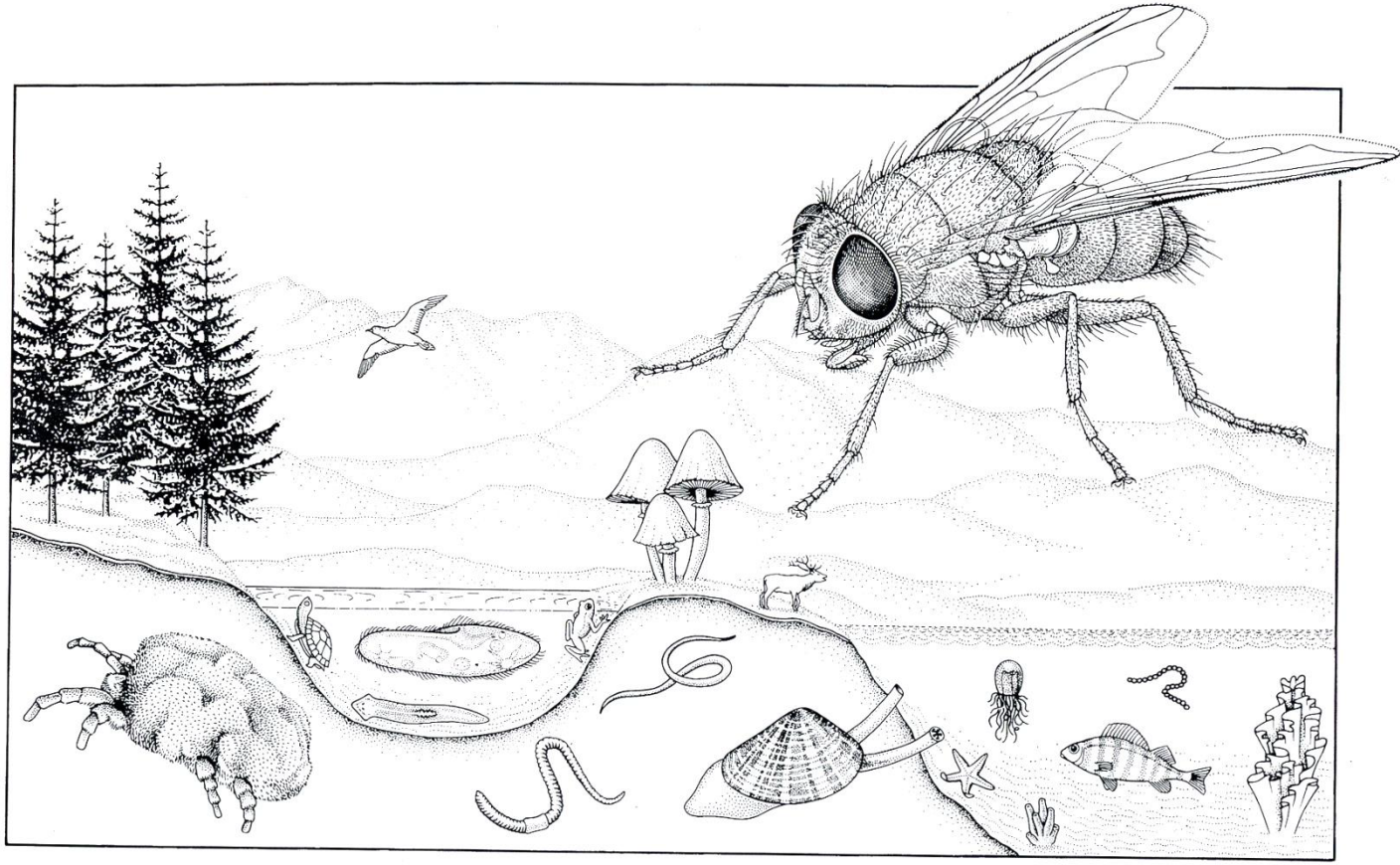
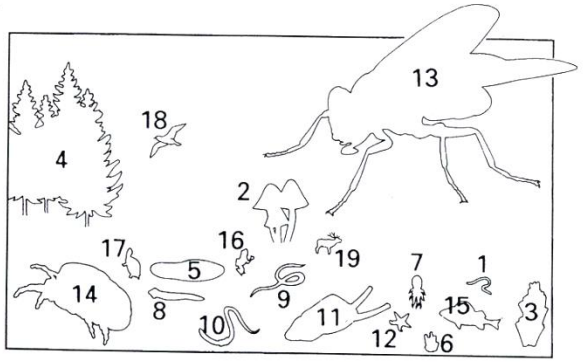
Insects are the most species-rich group of organisms on earth as indicated in this species-scape.

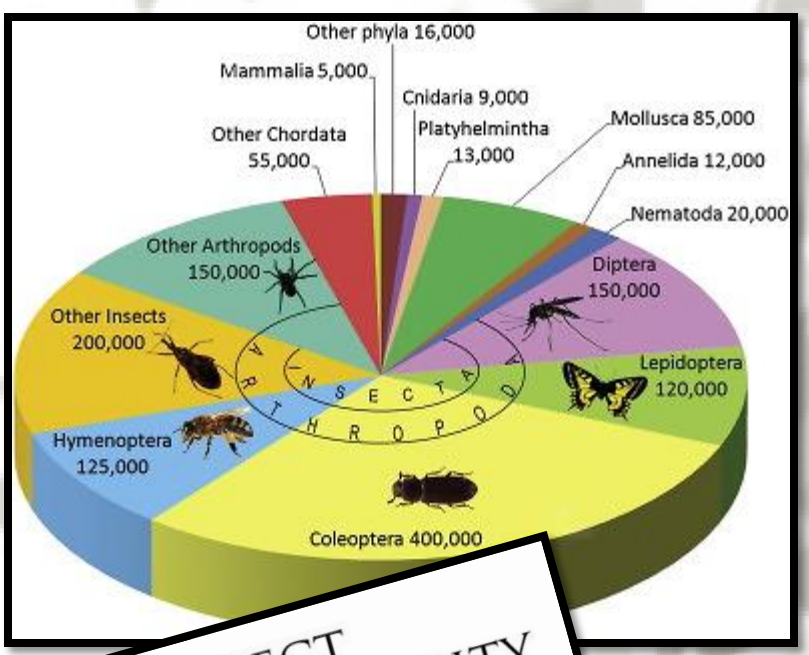
The size of the organism reflects the number of described species.

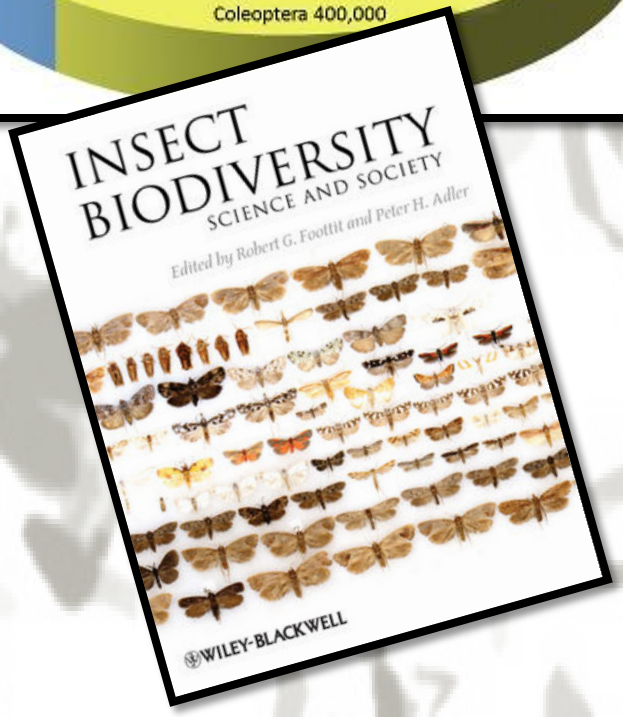




1 Monera (bacteria, blue-green algae)
2 Fungi
3 Algae
4 Plantae (multicellular plants)
5 Protozoa
6 Porifera (sponges)
7 Cnidaria (jellyfish, corals, etc.)
8 Platyhelminthes (flatworms)
9 Nematoda (roundworms)
10 Annelida (earthworms, leeches, etc.)
11 Mollusca (snails, bivalves, octopus, etc.)
12 Echinodermata (starfish, sea urchins, etc.)
13 Insecta
14 Non-insect Arthropoda
15 Pisces (fish)
16 Amphibia (frogs, salamanders, etc.)
17 Reptilia (snakes, lizards, turtles)
18 Aves (birds)
19 Mammalia (mammals)

At least half (50%-80%) of the animal species currently occupying the earth are insects (approximately 1.5 million different animal species)





With so many species we need a way to efficiently communicate the identity of a species but also to gather knowledge on nature history. These goals fall under the science of systematics

Systematics

- **Taxonomy**
  - Field of biology concerned with the theory, practice, and rules of classifying living and extinct organisms and viruses
- **Phylogentics**
  - Study of biological diversity and the evolutionary relationships among organisms, both extinct and modern

Taxonomic groups are now based on hypotheses regarding evolutionary relationships derived from systematics

Taxonomy

- A field of science that encompasses the description, identification, nomenclature, and classification of organisms
- Hierarchical system involving successive levels
- Each group called a taxon

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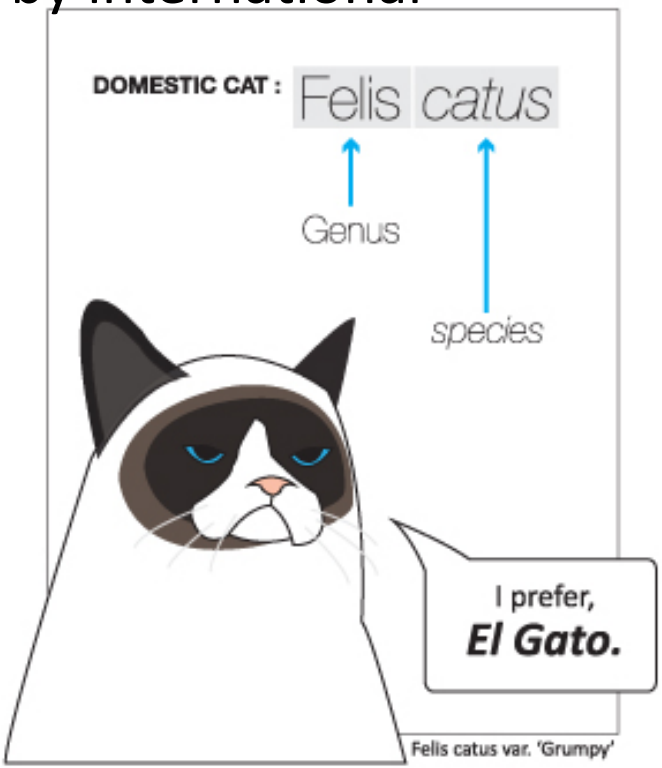
Taxonomic group	Gray wolf found in	Number of species
Domain	Eukarya	~4–10 million
Kingdom	Animalia	~2 million
Phylum	Chordata	~50,000
Class	Mammalia	~5,000
Order	Carnivora	~270
Family	Canidae	34
Genus	*Canis*	7
Species	*lupus*	1

Binomial nomenclature

- Genus name and species epithet
- Genus name always capitalized
- Species epithet never capitalized
- Both names either *italicized* or <u>underlined</u>
- Rules for naming established and regulated by international associations **ICZNC**
  - Give description
  - Location
  - Honorifics



Melanerpes erythrocephalus

Marmota flaviventris

Agaporomorphus colberti

Agra katewinsletae

Agathidium vaderi

Pheidole harrisonfordi

Avahi cleesei

Buteo jamaicensis

Horntail wasps have tails longer than their bodies!

Anyone could be excused for feeling a little wary at the sight of the lengthy black tail on this colorful yellow and orange wasp.

And this was just one of several wasps with scary looking tails zipping around dipping their tails into a very old hackberry tree at Back Bay National Wildlife Refuge.

Even their name, horntail wasp, sounds formidable.

But not.

The female wasp's graceful, or menacing tail, depending on your perspective, appears to be a stinger, but it is really an organ, called an ovipositor, designed for laying eggs in wood bark.

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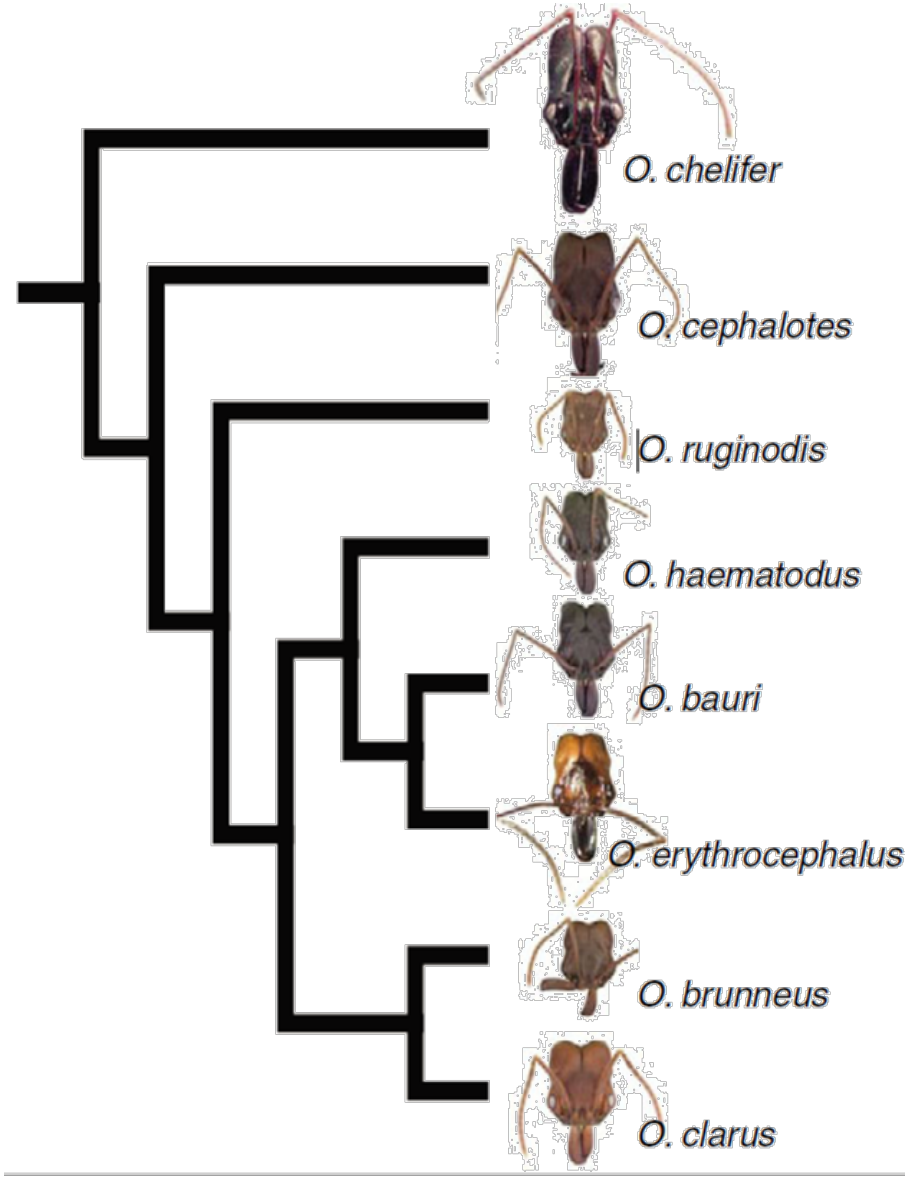
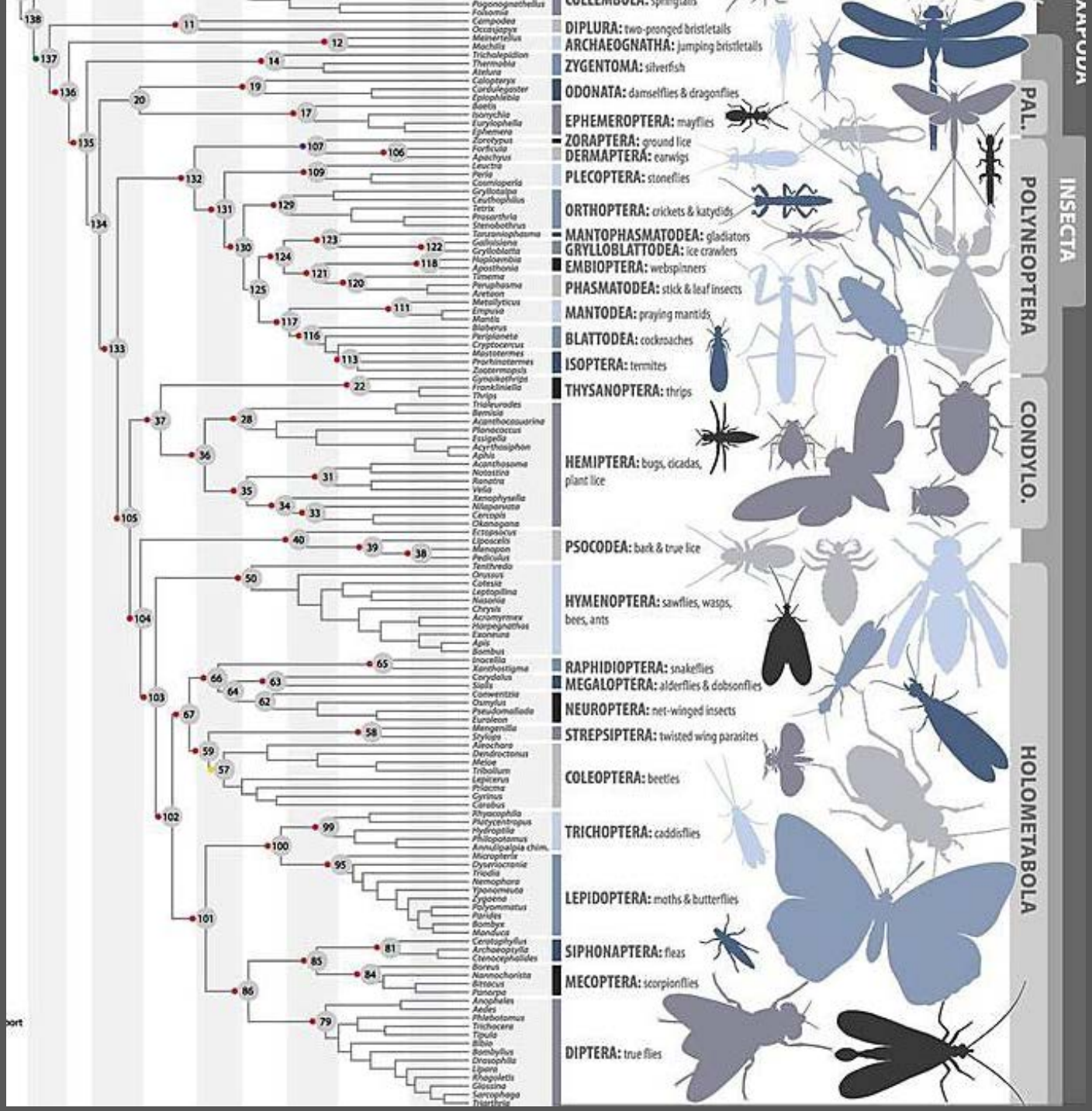
Phylogenetics-Cladistics

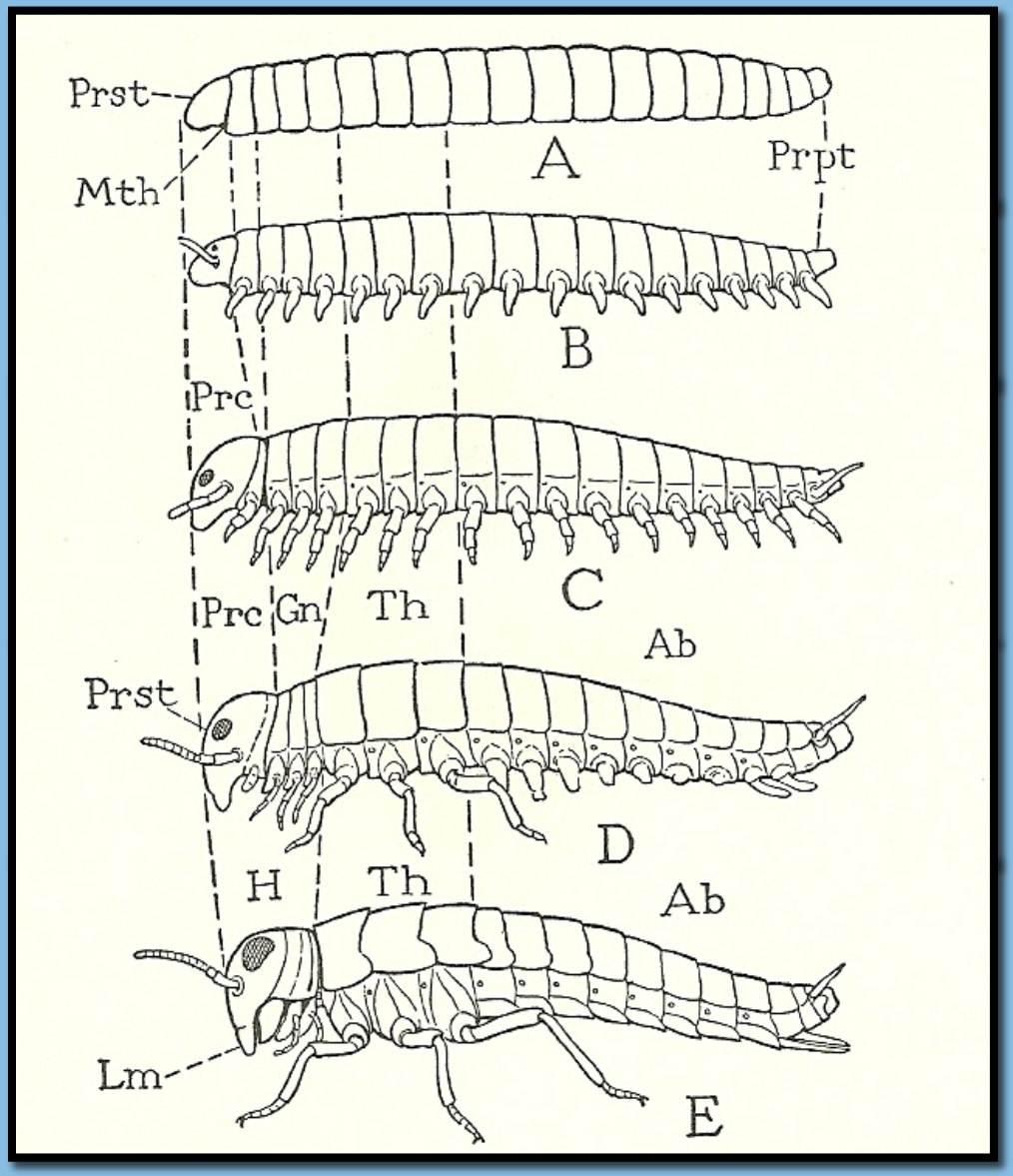
- An approach to biological classification in which organisms are grouped together based on whether or not they have one or more shared unique characteristics that come from the group's last common ancestor
- And are not present in more distant ancestors.
- Therefore, members of the same group are thought to share a common history and are considered to be more closely related

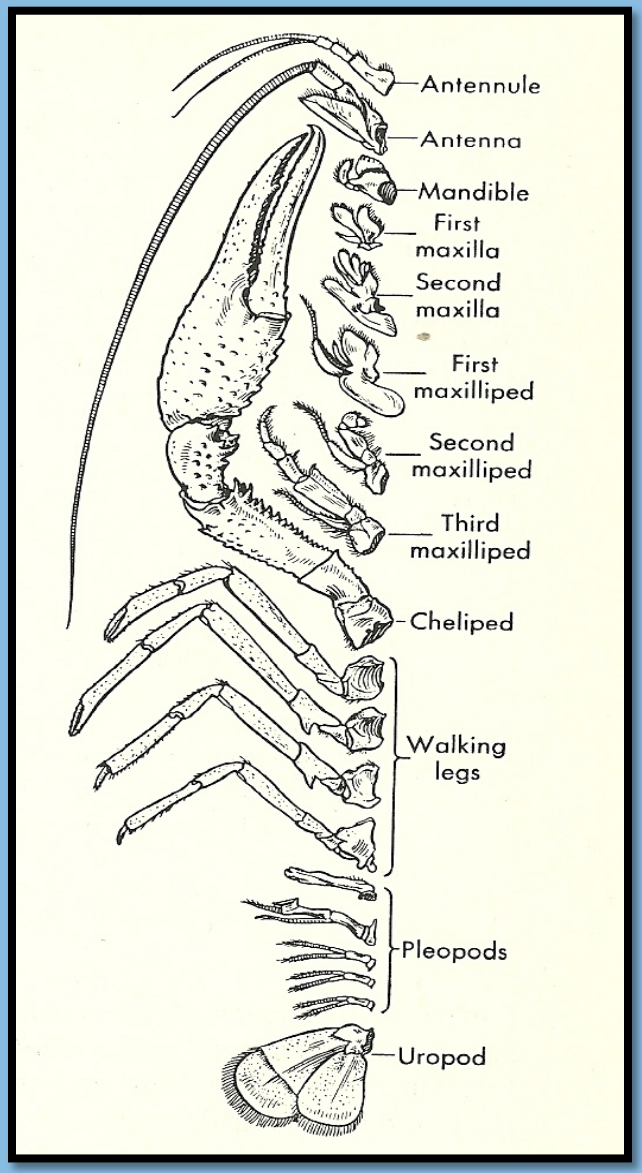


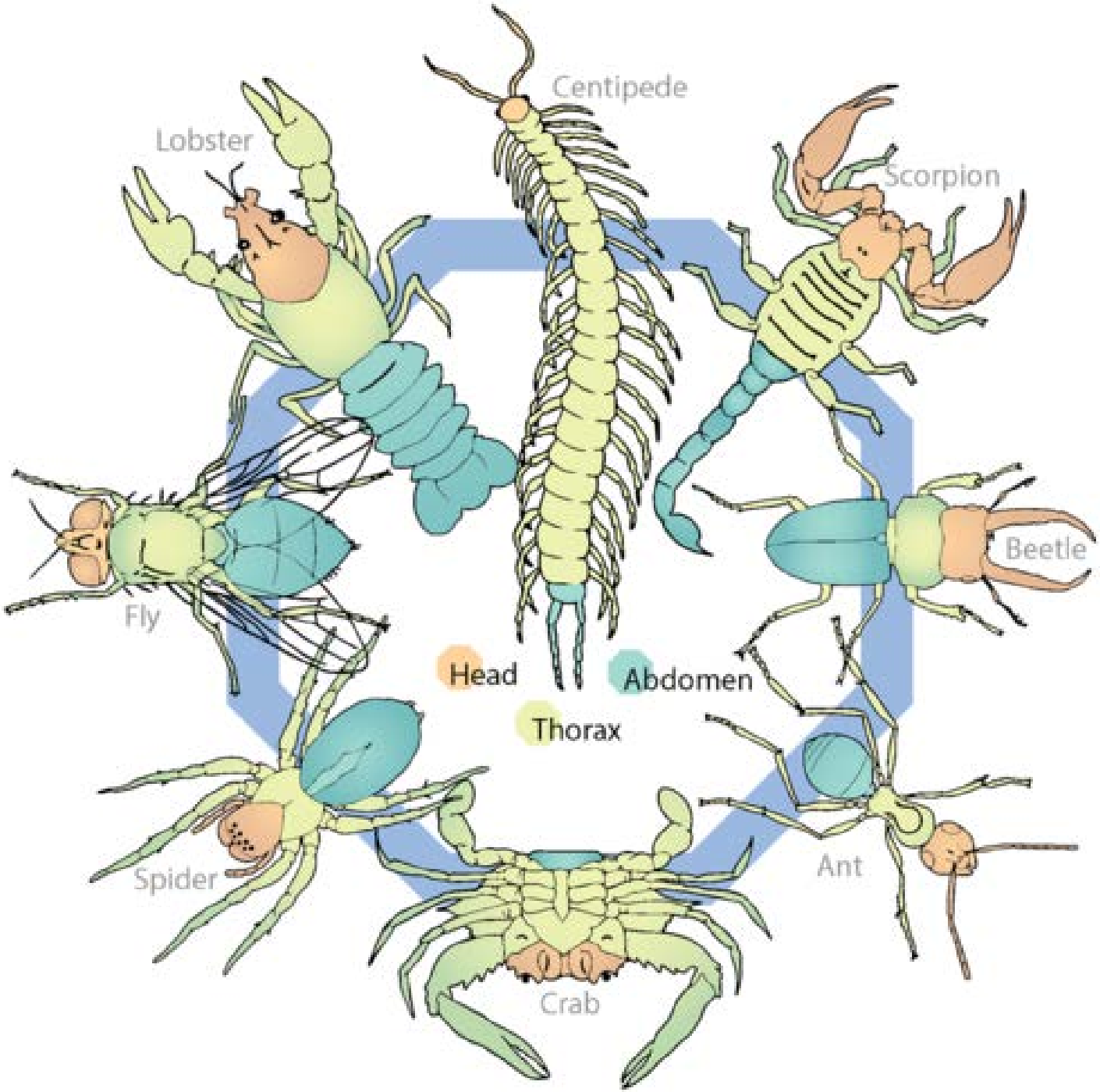

HEXAPODA
COLLEMBOLA: springtails
DIPLURA: two-pronged bristletails
ARCHAEOGNATHA: jumping bristletails
ZYGENTOMA: silverfish
ODONATA: damselflies & dragonflies
EPHEMEROPTERA: mayflies
ZORAPTERA: ground lice
DERMAPTERA: earwigs
PLECOPTERA: stoneflies
ORTHOPTERA: crickets & katydids
MANTOPHASMATODEA: gladiators
GRYLLOBLATTODEA: ice crawlers
EMBIOPTERA: webspinners
PHASMATODEA: stick & leaf insects
MANTODEA: praying mantids
BLATTODEA: cockroaches
ISOPTERA: termites
THYSANOPTERA: thrips
HEMIPTERA: bugs, cicadas, plant lice
PSOCODEA: bark & true lice
HYMENOPTERA: sawflies, wasps, bees, ants
RAPHIDIOPTERA: snakeflies
MEGALOPTERA: alderflies & dobsonflies
NEUROPTERA: net-winged insects
STREPSIPTERA: twisted wing parasites
COLEOPTERA: beetles
TRICHOPTERA: caddisflies
LEPIDOPTERA: moths & butterflies
SIPHONAPTERA: fleas
MECOPTERA: scorpionflies
DIPTERA: true flies
PAL.
POLYNEOPTERA
INSECTA
CONDYLO.
HOLOMETABOLA

Arthropod Phylogeny

Arthropod Phylogeny






Centipede
Lobster
Scorpion
Beetle
Fly
Head
Abdomen
Thorax
Spider
Ant
Crab

Xiphosura (horseshoe crabs)

Appearance:

- Hard, rounded, brownish-green exoskeleton
- Spike-like tail
- Widely spaced eyes that look like bumps on the top of the shell
- Five pairs of jointed legs
- Gills have folds of membranes that look like leaves of a book
- Grows to 2 feet long

Habitat:

- Juveniles are found in shallow, protected waters
- Adults live in deeper waters

Range:

- Found year-round in the middle and lower Chesapeake Bay, as far north as the Chester River

Arachnida, (Spiders and allies)

Appearance:

- No antennae
- Two body regions: cephalothorax and abdomen
- Feeding appendages are chelicerae Most are carnivorous
- They hold the prey with chelicerae -- enzyme-rich salivary juices over the victim
- Digestion is mostly external
- Most are terrestrial
- 57,000 known species

Myriapods

Appearance:

- Myriapods have a single pair of antennae
- relatively simple bodies with a series of short segments, each with one or two pairs of legs.

Ecology:

- Millipedes are detritivores; centipedes are predatory carnivores.
- fertilization is internal- spermatophore; females lay eggs.

Crustacea

Appearance:

- Branched appendages 2 pairs of antennae
- gills on legs
- Mandibles, maxillae and maxillipeds
- Swimmerets
- Cuticle covering head extends over cephalothorax
- Nauplius larvae very different from adult

Ecology:

Primarily aquatic

Hexapoda Insecta (Insects)

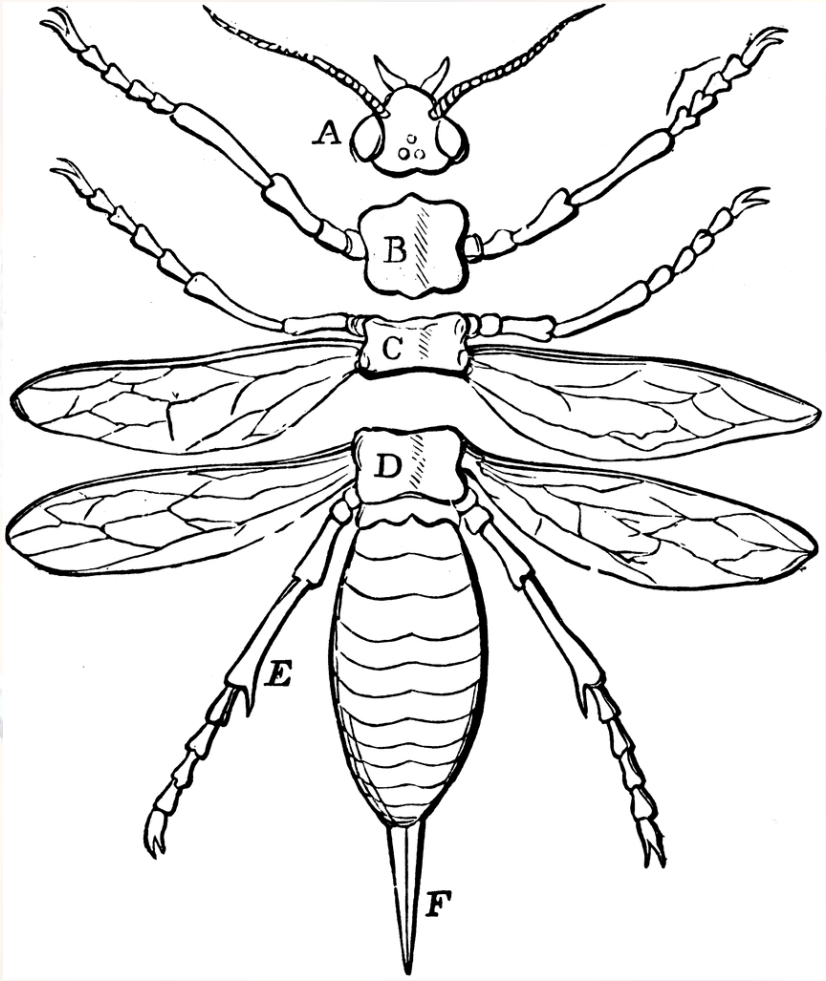
- About 925,000 species of insects have been named thus far.
- Insects are distinguished by having head, thorax, and abdomen body regions, with three pairs of walking legs on the ventral side of the thorax. In most species, two pairs of wings are mounted on the dorsal side of the thorax.
- Typically the head contains a total of four sets of mouthparts, a pair of antennae, and a pair of compound eyes.
- Insects feed on almost every type of food source on land.

Insecta

- More species of insects than all other animal species combined
- Wings crucial to success – outgrowths of body wall
- ~30 orders – differences in wings and mouthparts
- Separate sexes with internal fertilization
- Metamorphosis
  - Complete – 4 stages with adult and larval stages very different
  - Incomplete – 3 stages with young resembling miniature adults

Subphylum: Hexapoda

- Head, thorax, and abdomen
- 1 pair antennae
- 3 pairs of legs
- Most with 2 pairs of wings
- 3 ocelli and compound eyes
- Respiration through spiracles and tracheae
- Gut with digestive ceca



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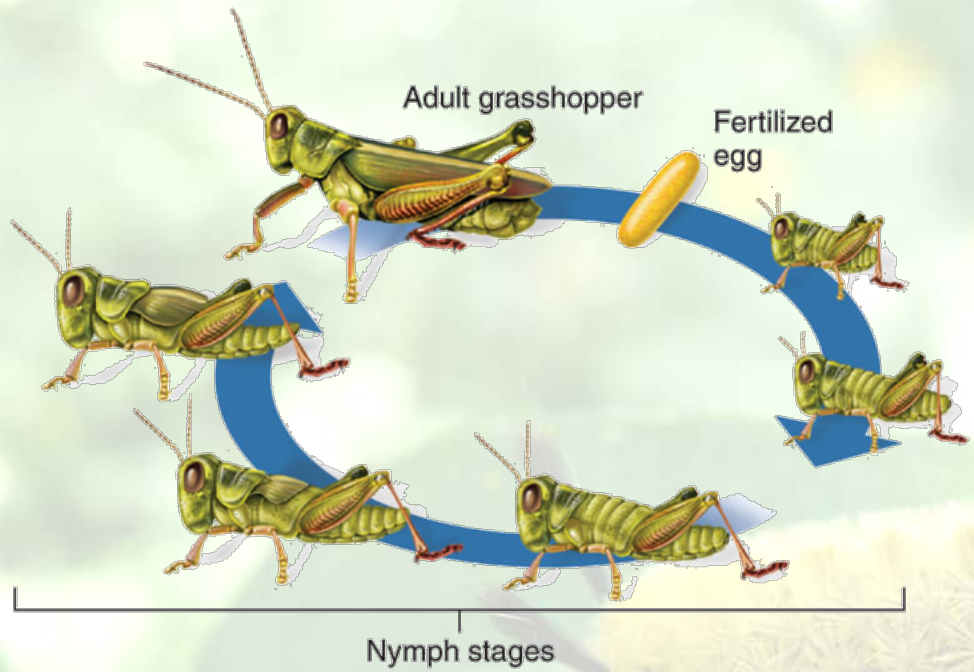
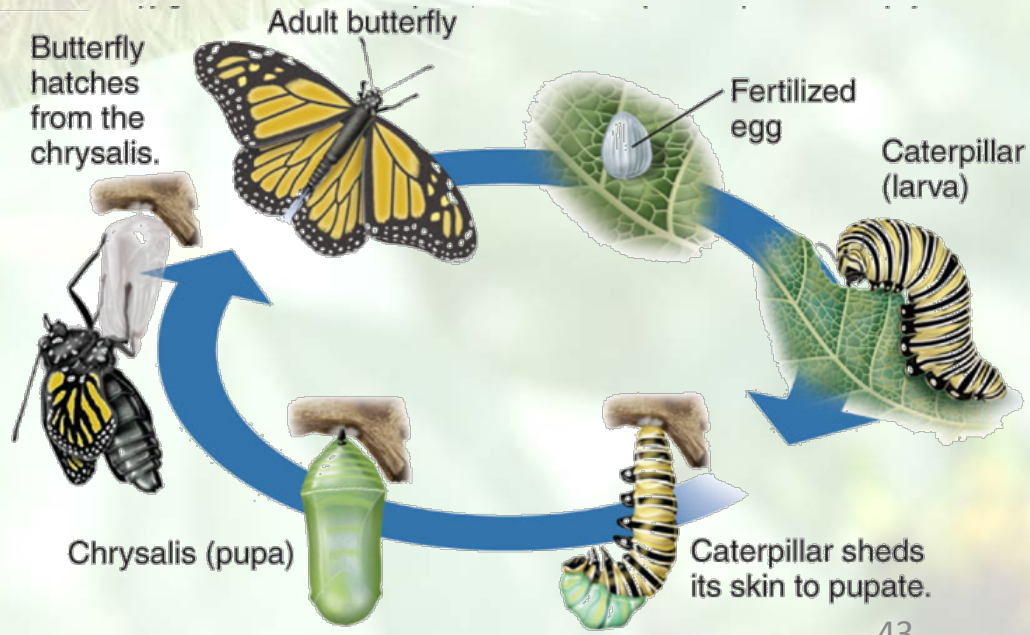
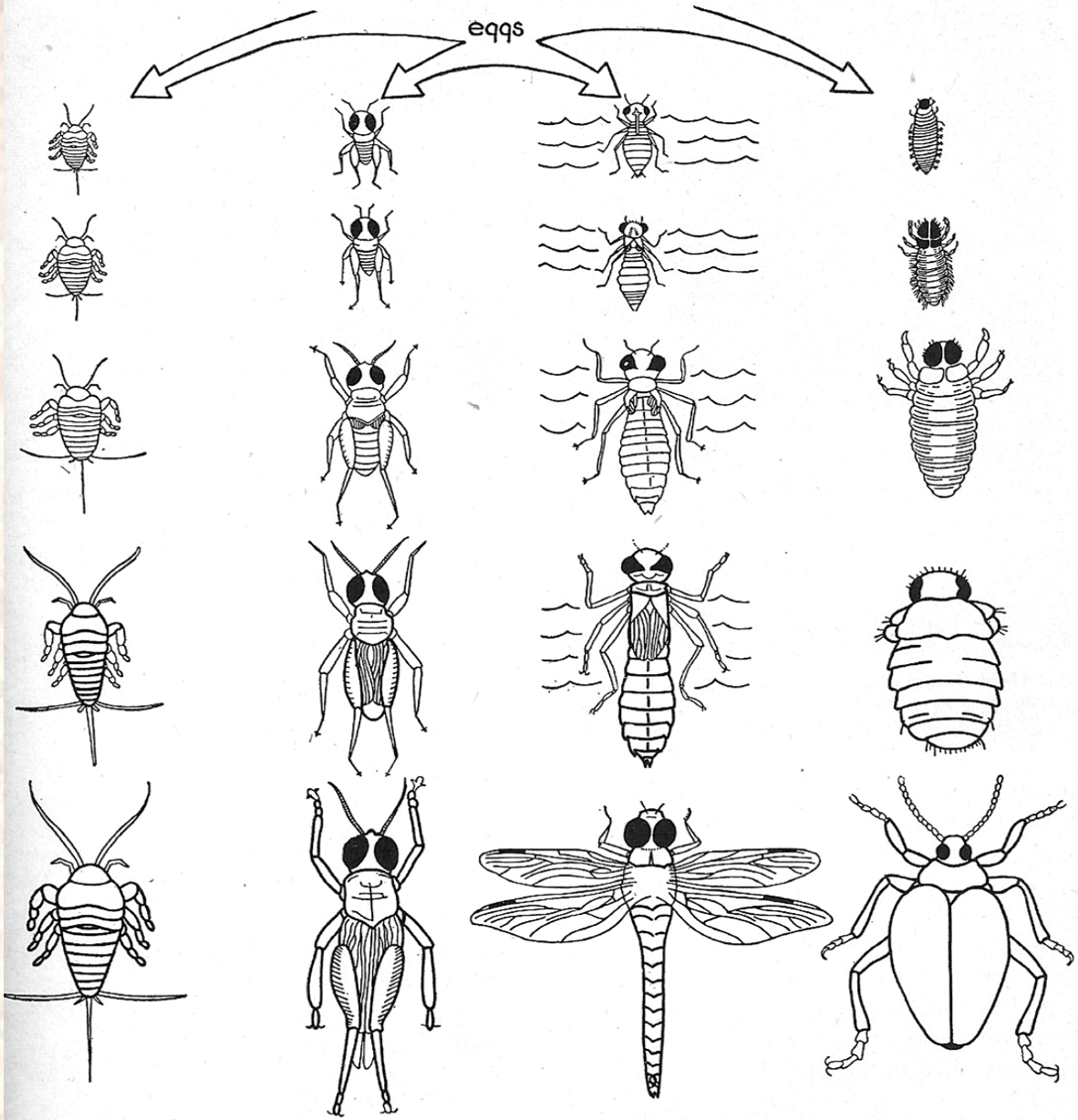
1967
IN GOD WE TRUST



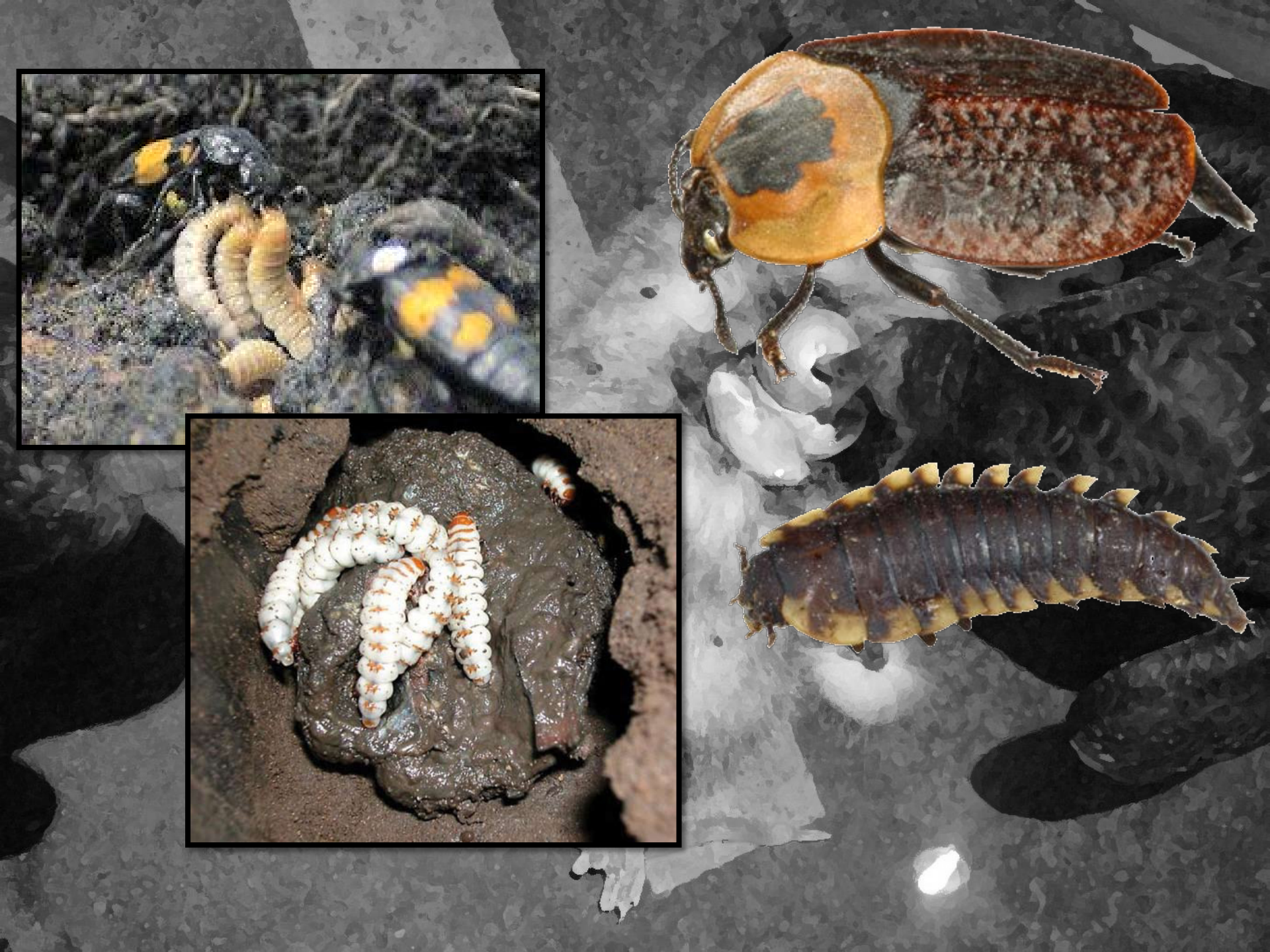
(b) Incomplete metamorphosis

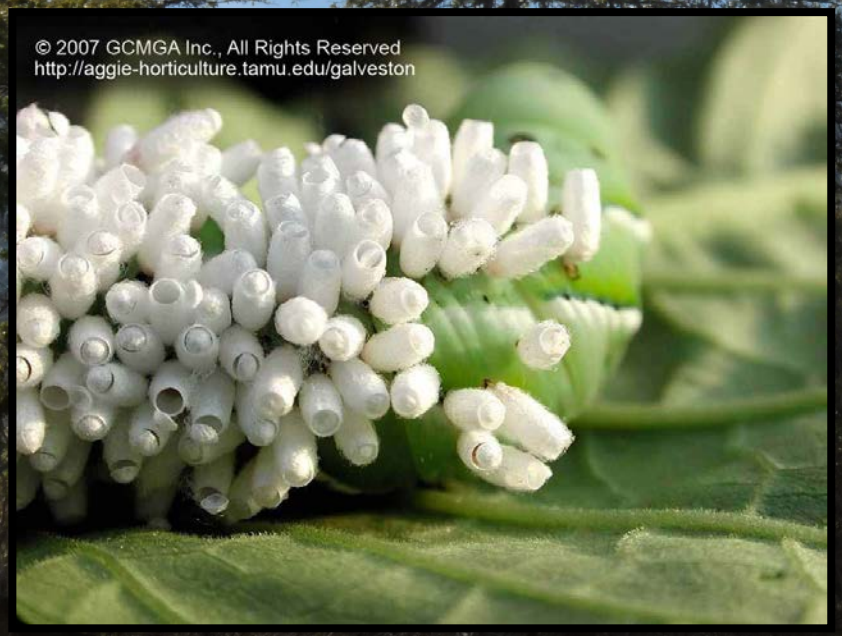


(a) Complete metamorphosis



WITHOUT	GRADUAL	INCOMPLETE	COMPLETE
fire brats	grasshoppers	dragon flies	beetles
bristle tails	aphids , lice	damsel flies	bees , ants
spring tails	termites, bugs	may-flies	wasps, flies, fleas
	thrips	stone-flies	butterflies, moths

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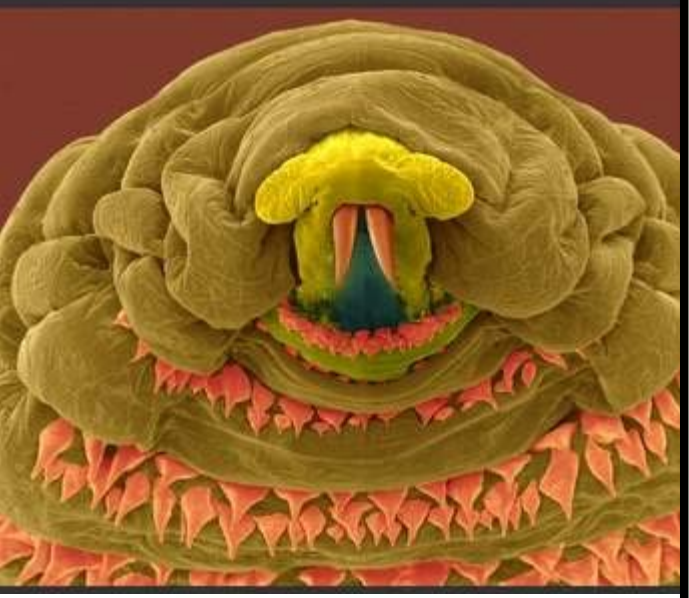

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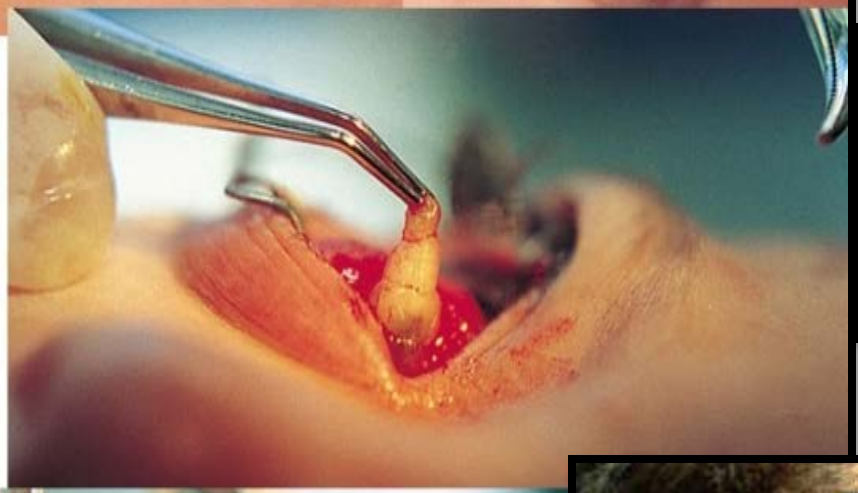
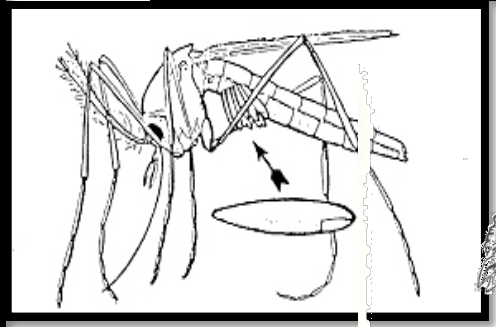
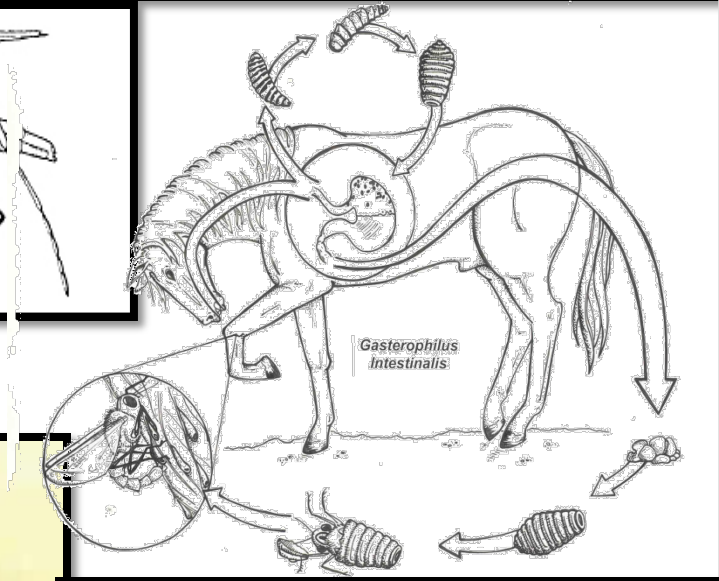
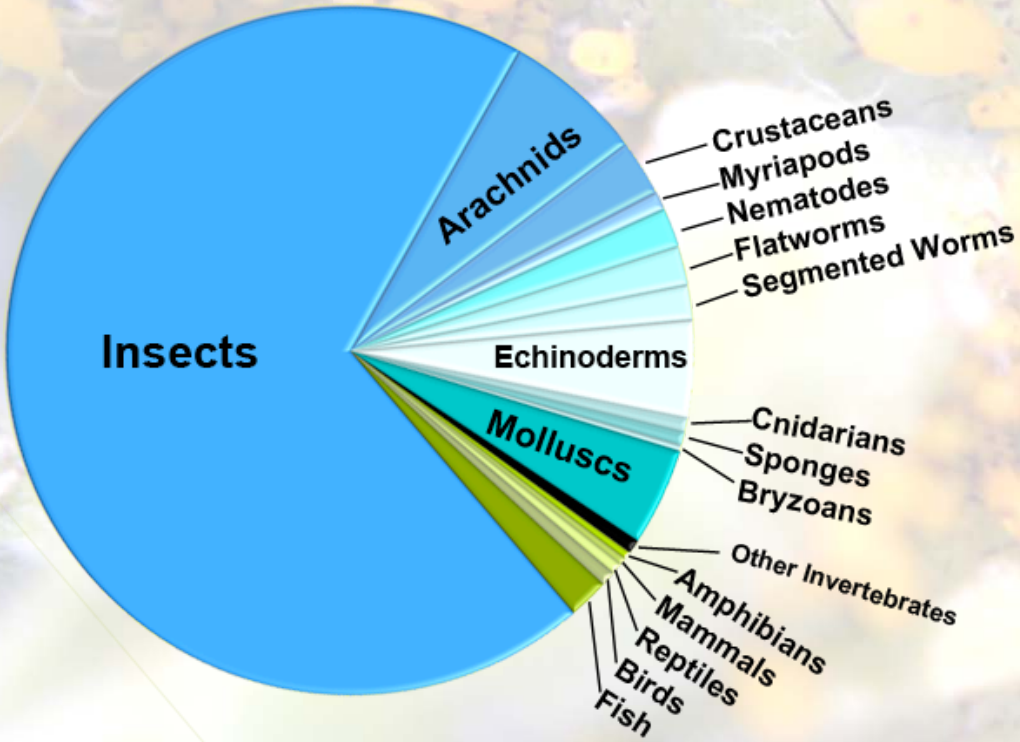





Gasterophilus
Intestinalis

F.Slansky/L.R.Kenyon

insects do have a unique combination of characteristics which, as a whole, have given them an unusual survival advantage



these attributes include:

- Exoskeleton
- Small body size
- Ability to fly
- Jointed appendages
- High reproductive potential
- Complete metamorphosis
- Genetic variation

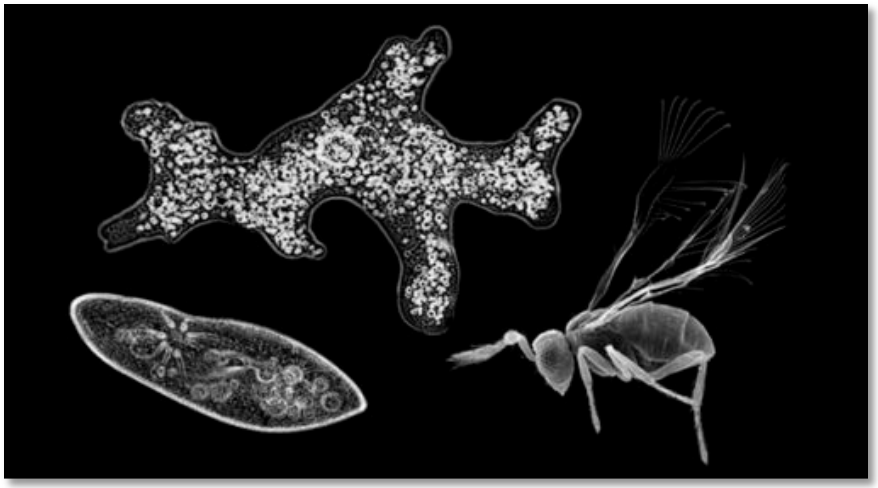
Survival Advantage

Exoskeleton

- Support & shape
- Protection
- Prevents desiccation
- Large mechanical leverage
- Insect communication

Small Size

- 0.139 mm—551mm
- Minimal resources
- Avoid predation
- Open niches



Survival Advantage

Flight

- Dispersal
- Transport
- Escape
- Protection
- Insect Communication

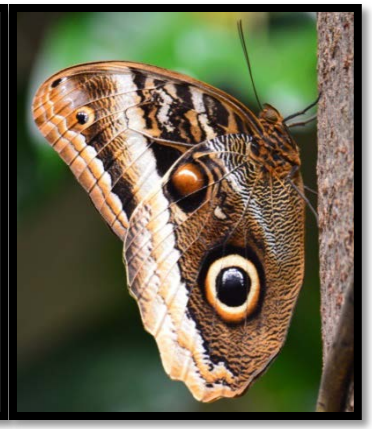
Reproductive Potential

- High fecundity
- High Fertility
- Short life cycle

Survival Advantage

Metamorphosis

- 9 orders complete metamorphosis comprise 86% of all insect spp.
- Limited competition with larvae and adults
- Exploit different environment resources
- Occupy different habitats



Adaptability

- Large population size
- High reproductive potential
- Short life cycle

Genetic diversity = adapt quickly

Importance of Insects

- Nutrient recycling
- Pollination
- Food for other organisms
- Maintenance of communities
- Dominate food chains
- Plant Propagation

Less than 1% of the energy from the sun, powers all major the ecosystems of the world

Plants convert sunlight to plant tissue

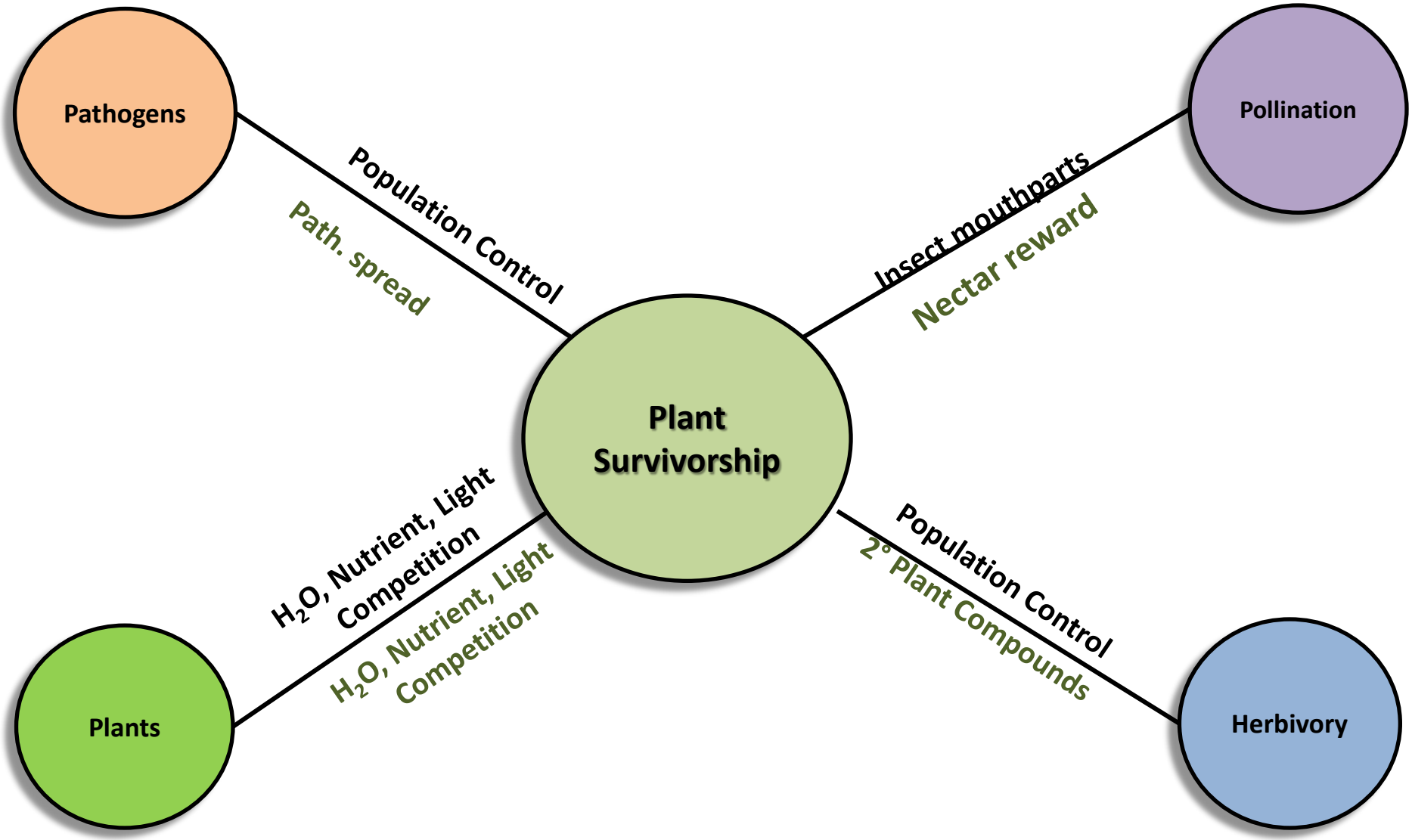
Insects convert plant tissue to insect tissue

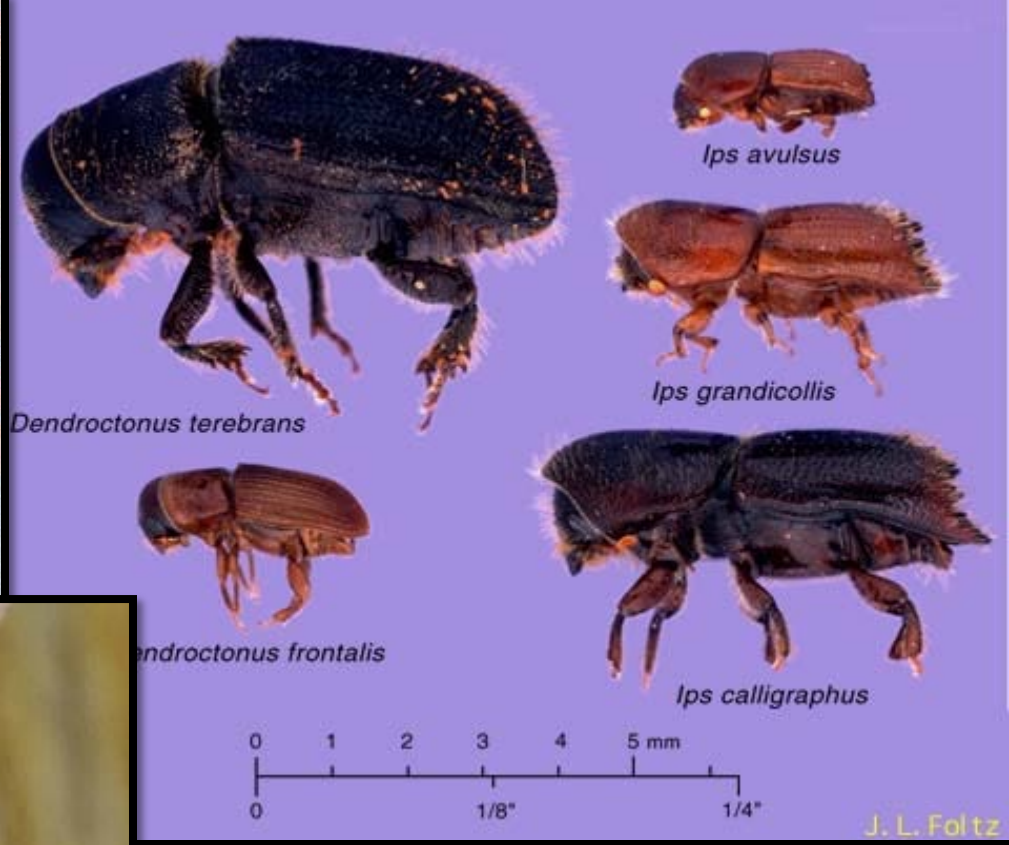
Birds convert insect tissue to bird tissue

Larger birds convert bird tissue to big bird tissue

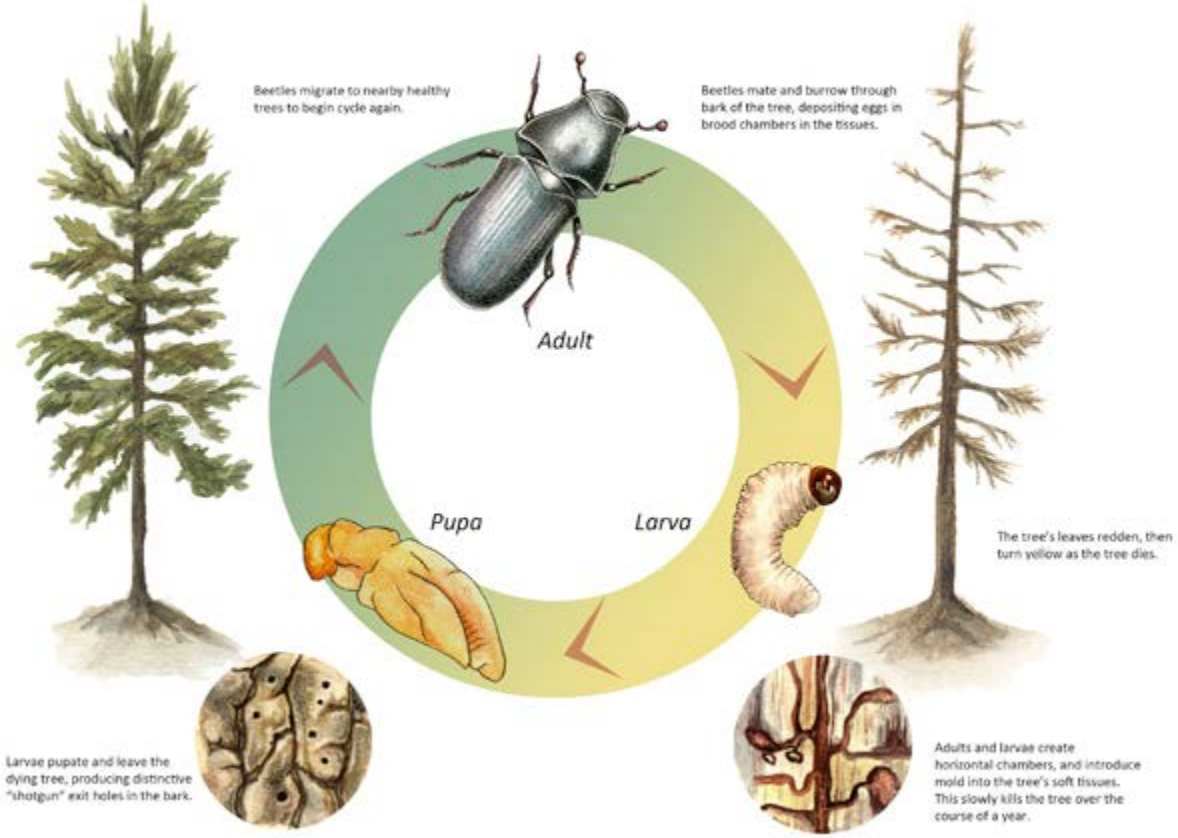
Interacting Components

Ecological interactions relationship between two species that influence the survivorship of each.




Dendroctonus terebrans
Ips avulsus
Ips grandicollis
ndroctonus frontalis
Ips calligraphus
0 1 2 3 4 5 mm
0 1/8" 1/4"
J. L. Foltz

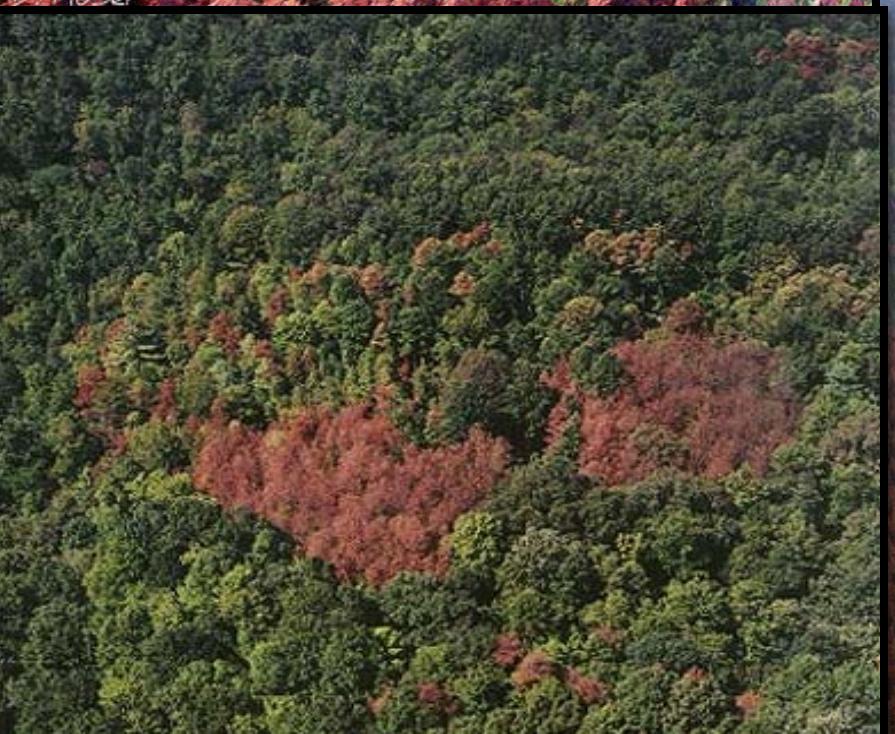
Life Cycle of Mountain Pine Beetle, *Dendroctonus ponderosae*



Source: D.A. Leatherman, J. Aguayo, and T.M. Wolf

MOUNTAIN PINE BEETLE LIFE CYCLE

D. Huber



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Ecologically Important Taxa

Ecosystem form and function depends on many factors.

We can evaluate ecological importance of any taxa by considering:

- **Trophic impact**
- **High biodiversity** - interactions w/ many other species
- **Dominant species** - in numbers
  in biomass
  in niches
- **Ecological roles**

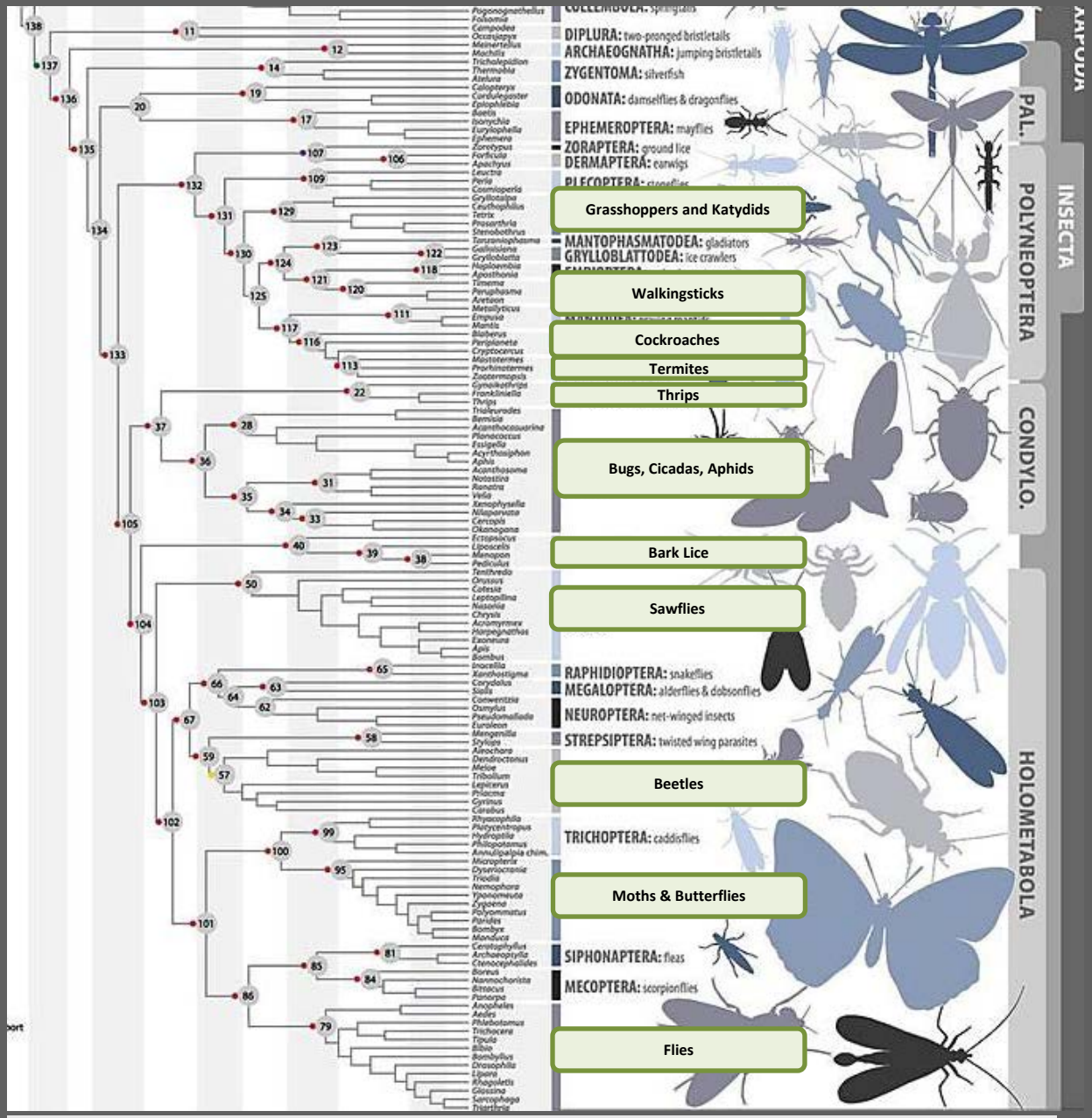
Major Players in Ecology

Plants Roles in Ecosystems

- Energy transformation
- Nutrient movement
- Erosion
- Carbon cycle
- Nitrogen cycle
- Soil formation
- Food

Insects Roles in Ecosystems

- Pollination
- Decomposers
- Disease vectors
- Population control (herbivore, parasitoids)
- Soil formation
- Food for wildlife



This Figure represents the evolution of all living groups of insects.

The majority of insect orders have all or some species being phytophagous.

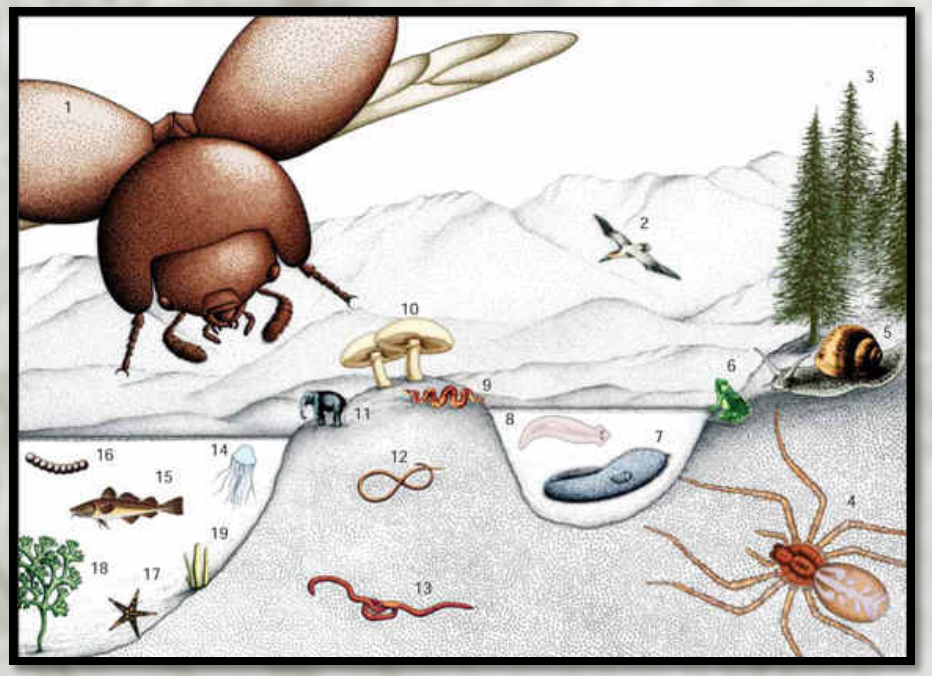
Feeding behaviors of these insects have greatly influenced the evolution of land plants--plants producing defenses such as hairs, spines, and 2˚ compounds eg. Nicotine, Caffeine, Tannins, resinoids, & cardenolides

Insects evolve counter these defenses

with the animals each representing: leopard –mammals, toucan – birds, butterfly – non-social insects, lizard – reptiles, spider – spiders, ant – social insects, frog – amphibians, and worm – annelids.

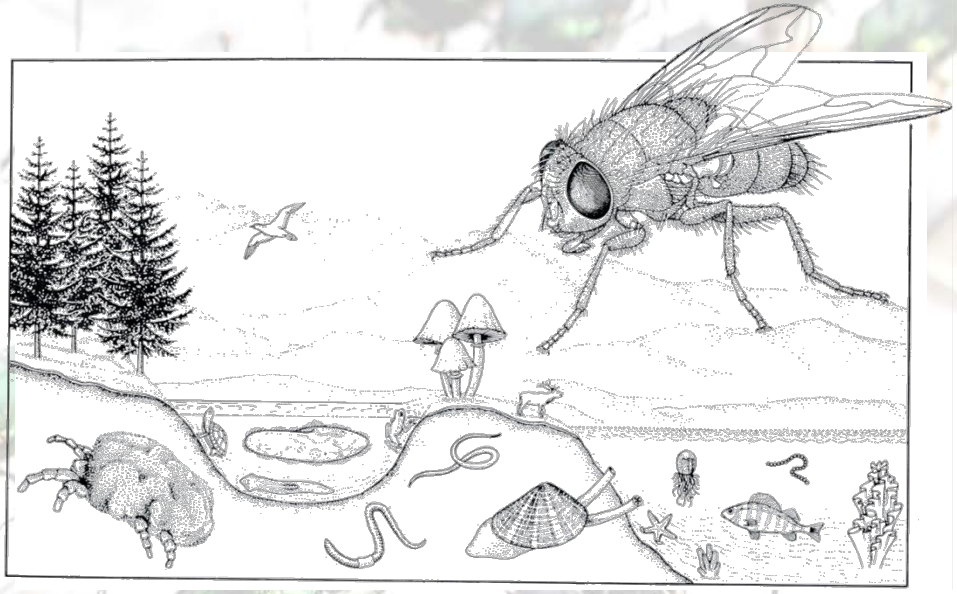
Ants as an Example

- Ants = 15% of total biomass in Amazonian rainforest (Fittkau & Klinge 1973)
- In Erwin's canopy studies 69% of sample were ants
- In Malaysia 20 m^2 of leaf litter, produced 104 spp. 41 general (Agosti et al. 1994)
- Turn more soil than earthworms (Lyford 1963)
- 35% of herbaceous plant seeds dispersed by ants (Beattie 1985)



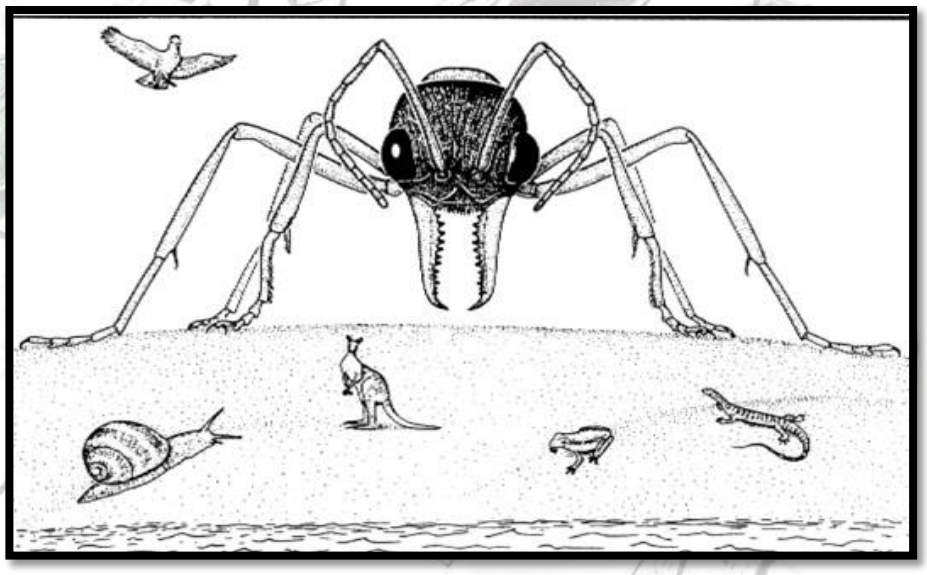
Insect Biodiversity

- When we examine composition of 1° consumers, insects rule.
- Plan-insect relationships are complex and facilitate many evolutionary paths.

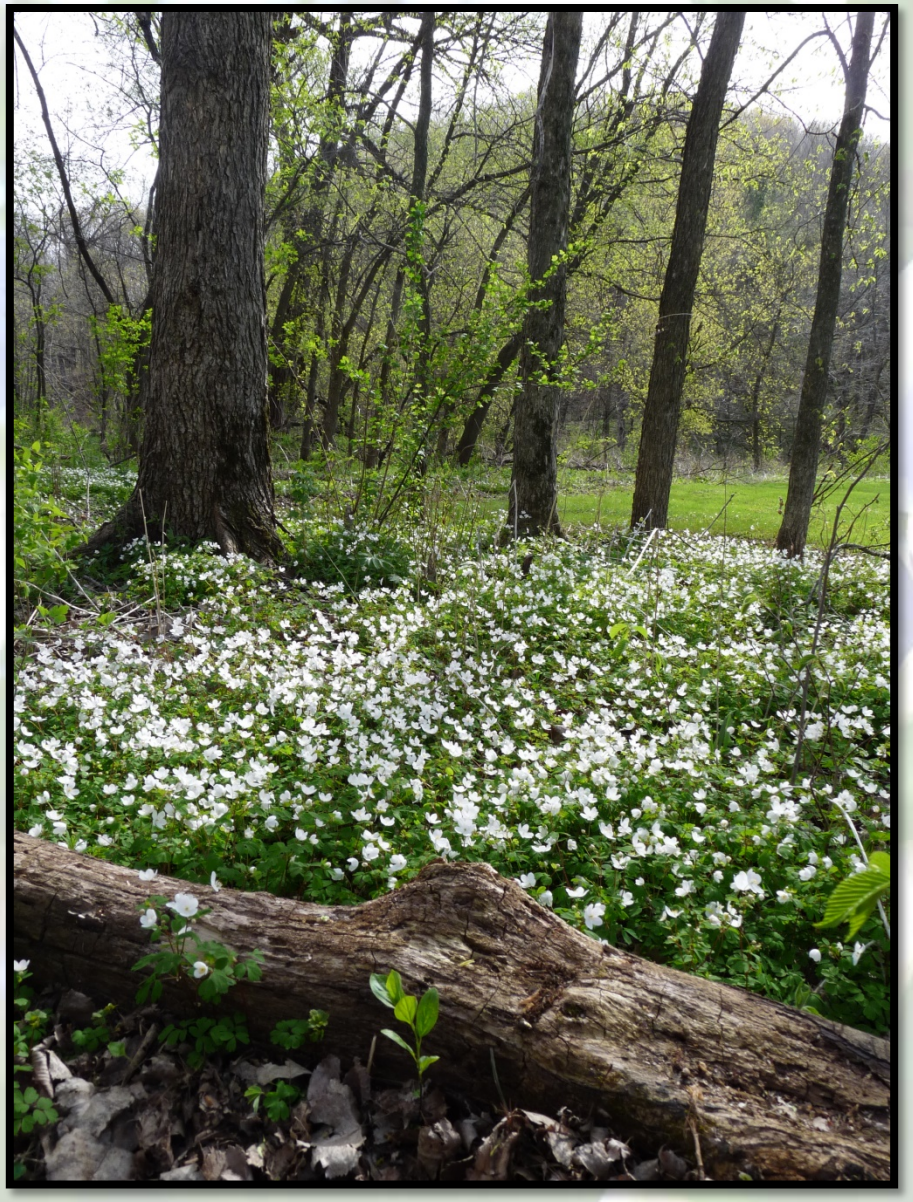


<u>Insects rule by:</u>

- Numbers of species
- Numbers of individuals
- Ecological Influence



Agents of Pollination

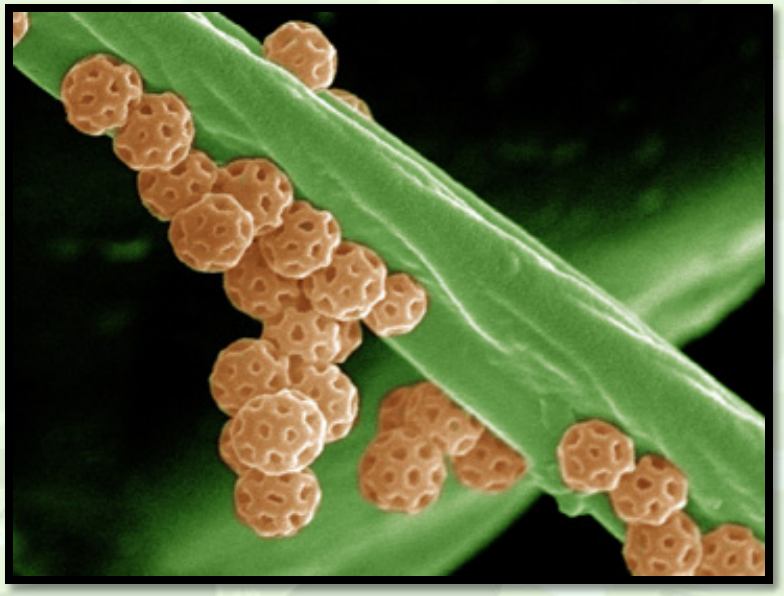


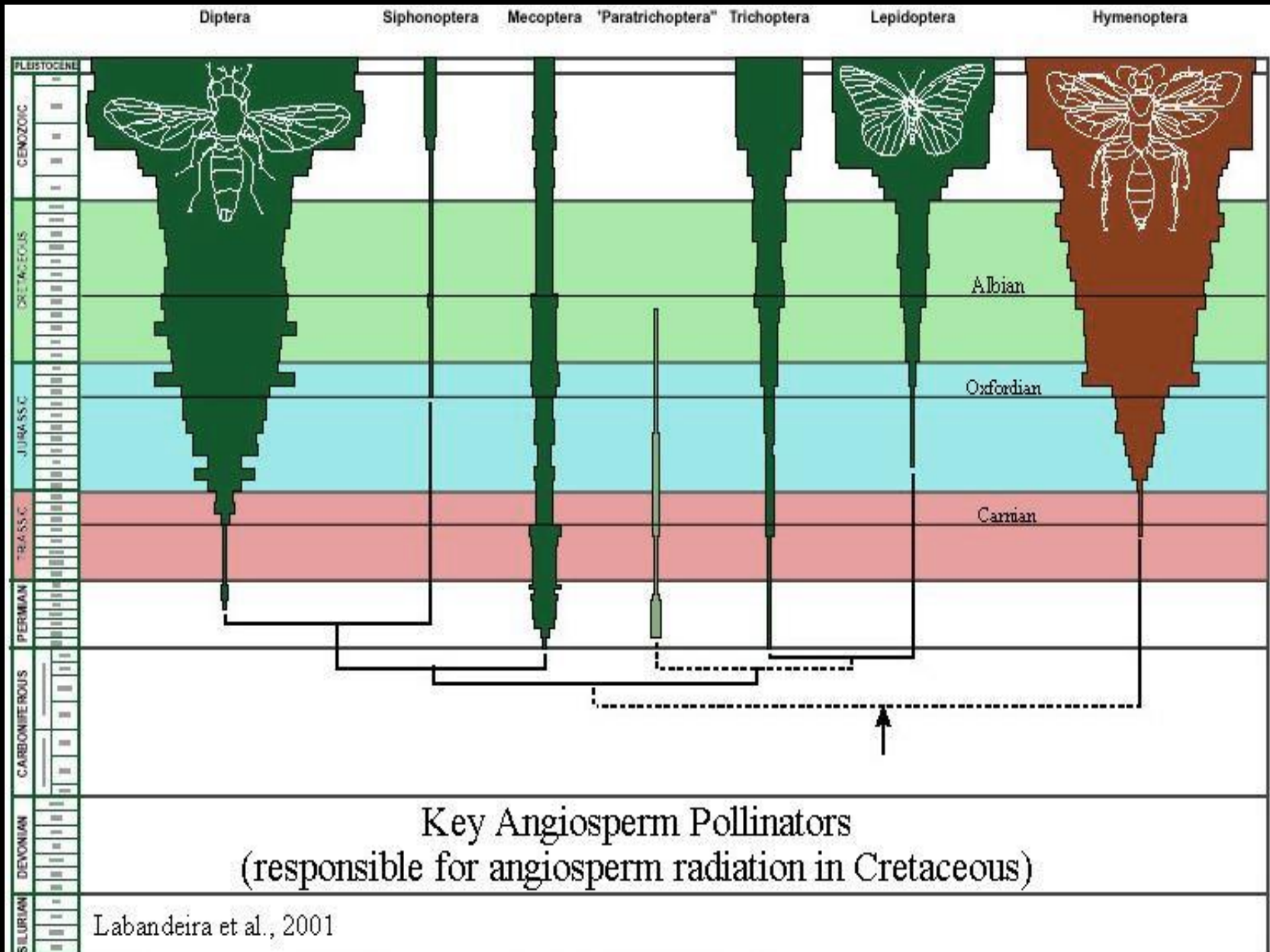
- Pollination depends on pollinators visiting flowers of the same species in sequence.
- To help ensure that this happens, the plants have various characteristics that aid pollinators including: color, size, shape, scent, as well as a food reward.

Animals as Pollinators

The majority of flowering plants rely on animals for pollination:

- **Insects** – bees, wasps, flies, butterflies, moths, and beetles
- **Birds** – hummingbirds and honey creepers
- **Mammals** – bats, mice, and even monkeys

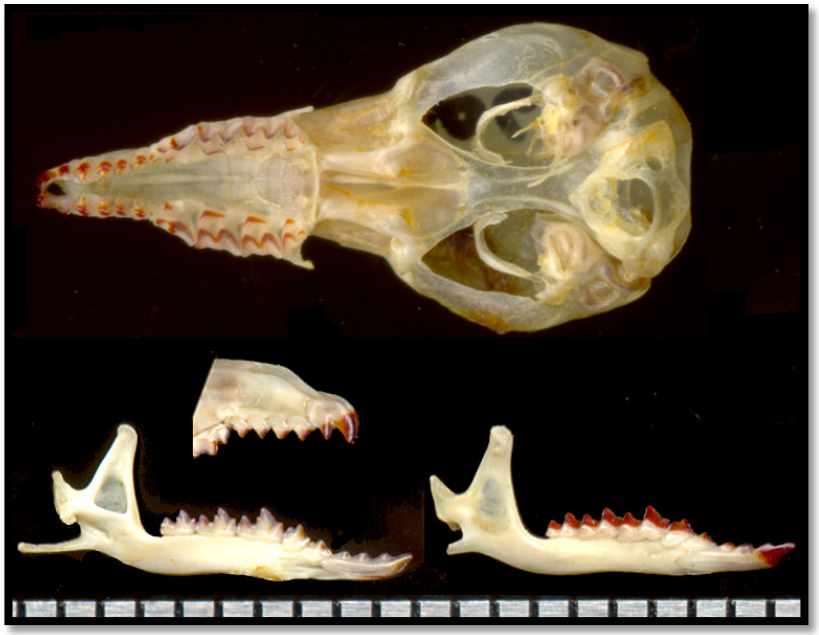


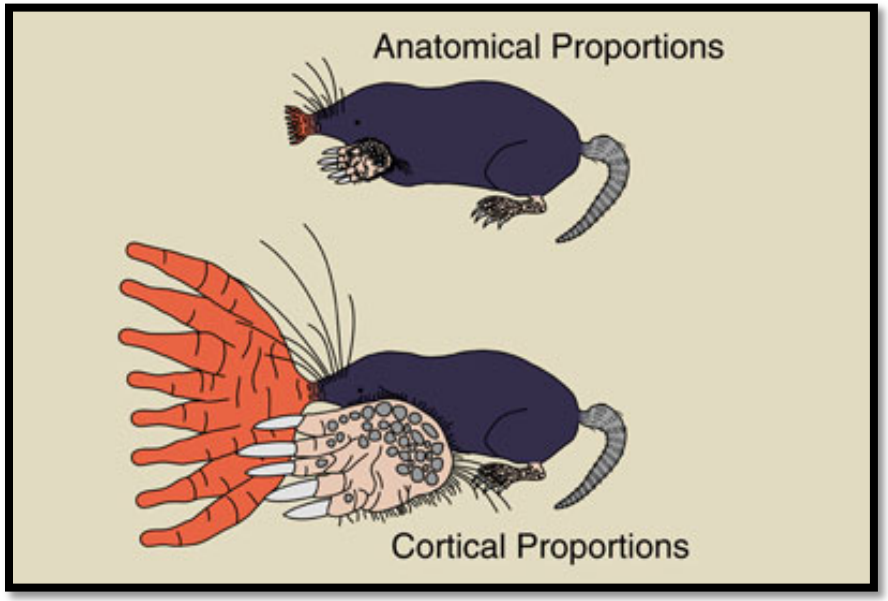

Diptera
Siphonoptera
Mecoptera
'Paratrichoptera'
Trichoptera
Lepidoptera
Hymenoptera
PLEISTOCENE
CENOZOIC
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
CARBONIFEROUS
DEVONIAN
SILURIAN
Albian
Oxfordian
Carnian
Key Angiosperm Pollinators
(responsible for angiosperm radiation in Cretaceous)
Labandeira et al., 2001

NATURAL HISTORY MUSEUM LONDON

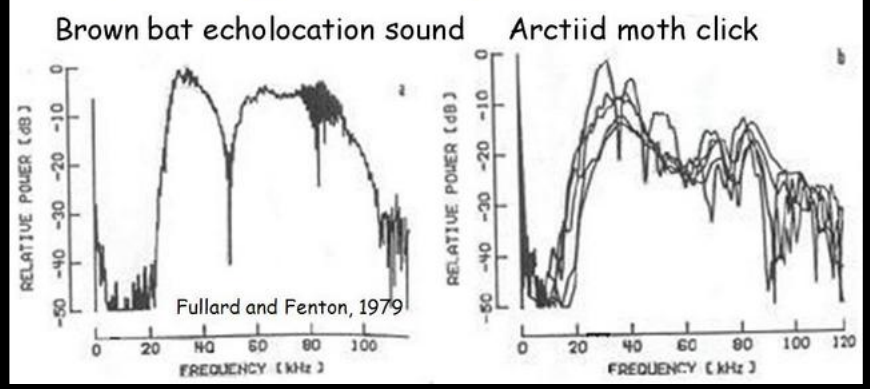
Insectivores

- Insects, other small invertebrates
- Incisors pointing forward for prey capture
- Digestive system
  - Simple stomach
  - Short intestine
  - Usually no cecum
- Enhanced tactile and auditory senses for locating prey
  - Ex. Star-nosed mole





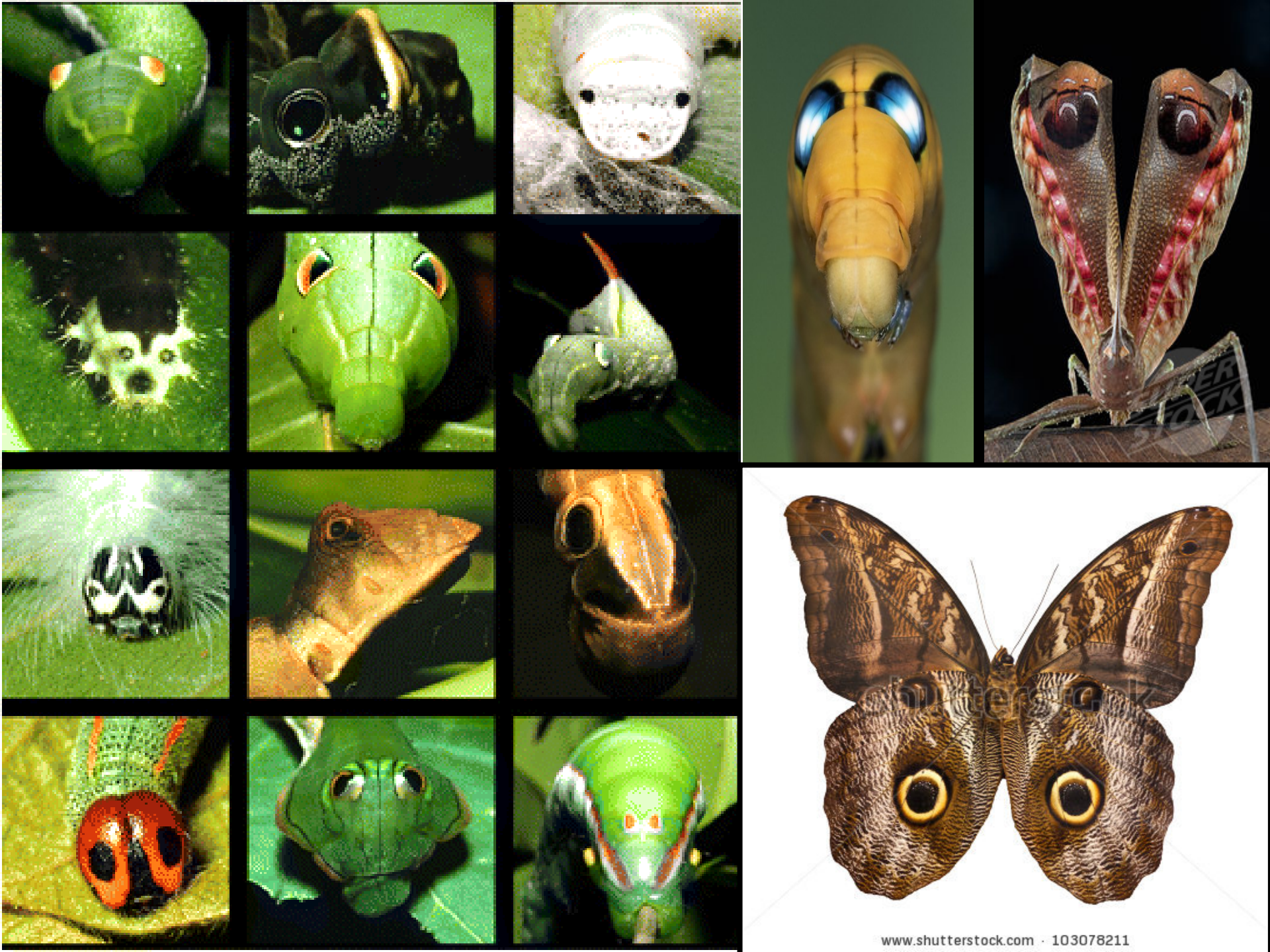
Jamming click response of moths



<u>myrmecophagous mammals often</u>:

- are homodont
- have lots of teeth
- have a long tongue
- have a delicate dentary
- strong claws for digging
- elongate rostrum

- **Hawking** is a feeding strategy in birds involving catching flying insects in the air
- **Gleaning** birds catch invertebrate prey, mainly arthropods, by plucking them from foliage or the ground does not refer to foraging for seeds or fruit.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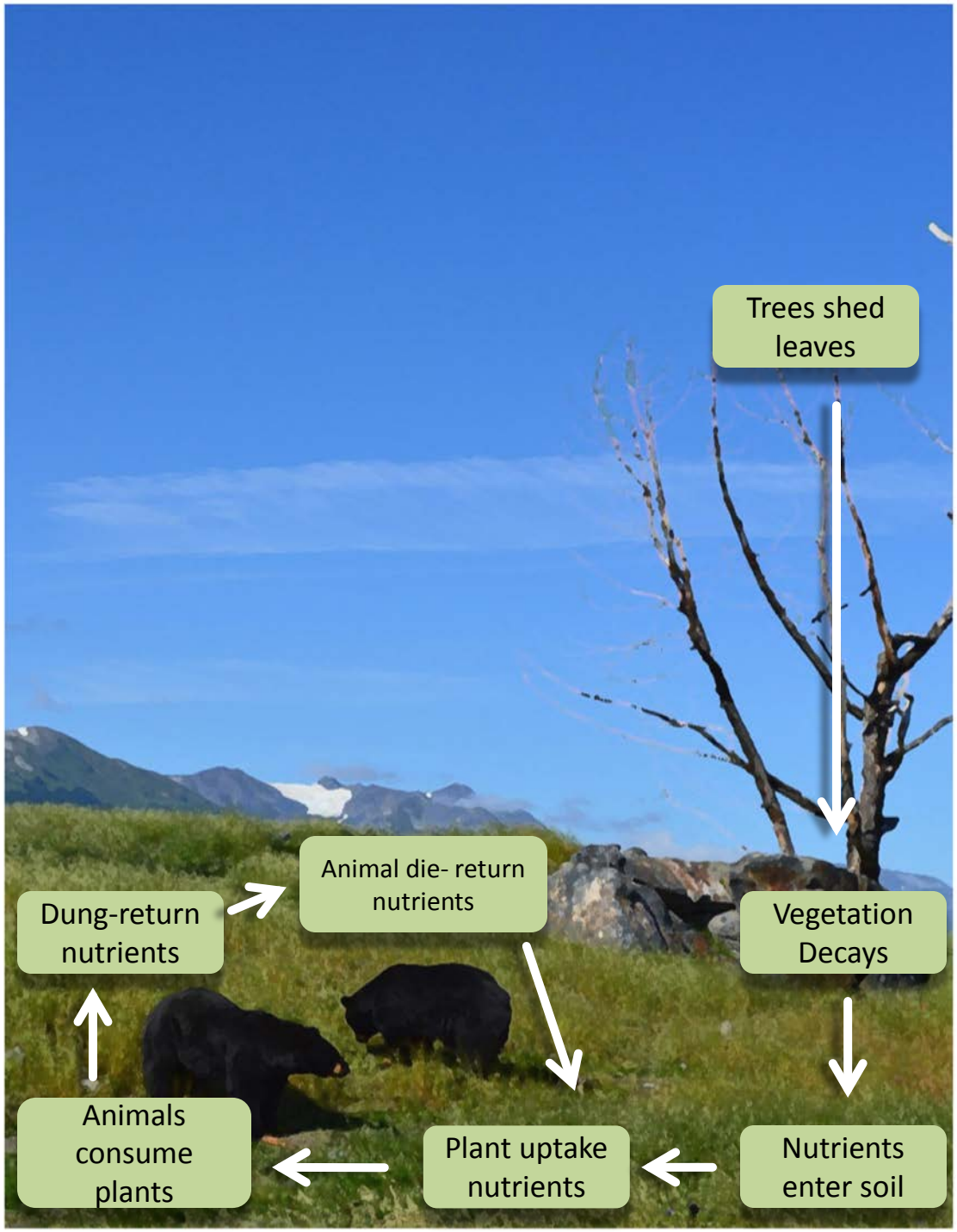
Nutrient Cycles

All life requires nutrients to grow and carry out life functions.

Four main nutrients cycles

- Water
- Carbon
- Nitrogen
- Phosphorus

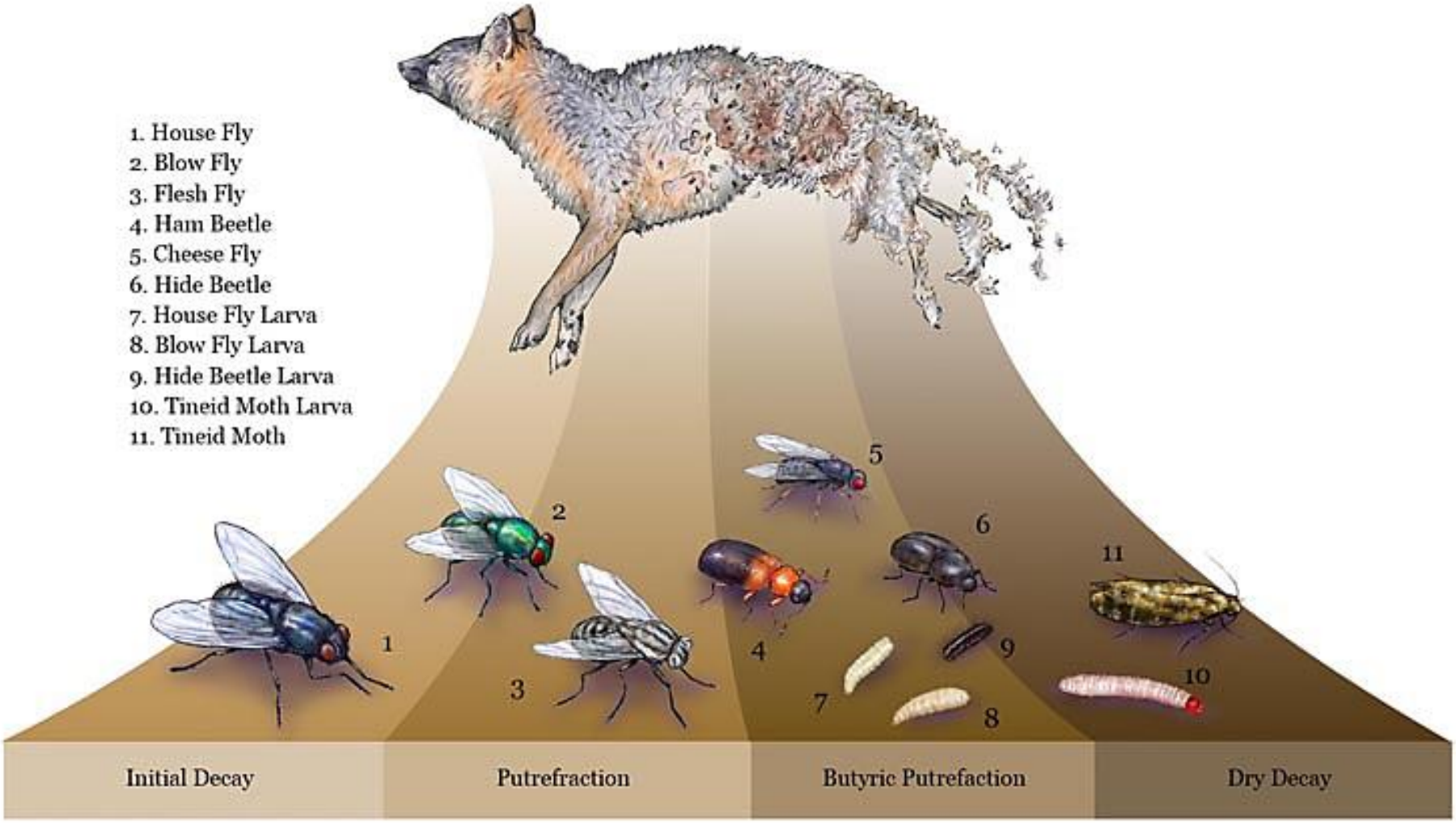


Chemical Building Blocks

Carbon	All organic molecules
Oxygen	Many bio molecules
Hydrogen	Carbohydrates, energy
Water	Chemical *Rxns*
Nitrogen	Proteins & nucleic acids
Minerals	Cellular physiology & protein cofactors
Phosphorus	Nucleic acids & bones
Sulfur	Protein struture

The Decomposers

Insects that aid in the decomposition process



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Termites

- Feed on dead wood, and grasses
- The termites do not really aid in the digestion of the material.
- They do help to greatly reduce the surface area
- Only move into wood where fungi have spread
- 1/3 of weight from gut bacteria and protozoa

Termites removed an estimated 835.5 kg ha of wood litter (60% of annual wood-fall), and 68.4 kg ha leaf litter (3% of annual leaf-fall), i.e. 24% of total annual litter production in a Southern Guinea savanna.

Carpenter ants do not consume wood but they do increase the rate of decomposition by opening up galleries allowing other decomposers entry.

Coleoptera – Beetles

Plant and Fungal Material

Long-horn, **Jewel, Bark beetles etc** have larvae that feed on plant materials (such as in wood)

Darkling Beetles as well as many families of **fungus beetles** feed on fungal hyphae but also help to break down and feed on fungus

Burying Beetles

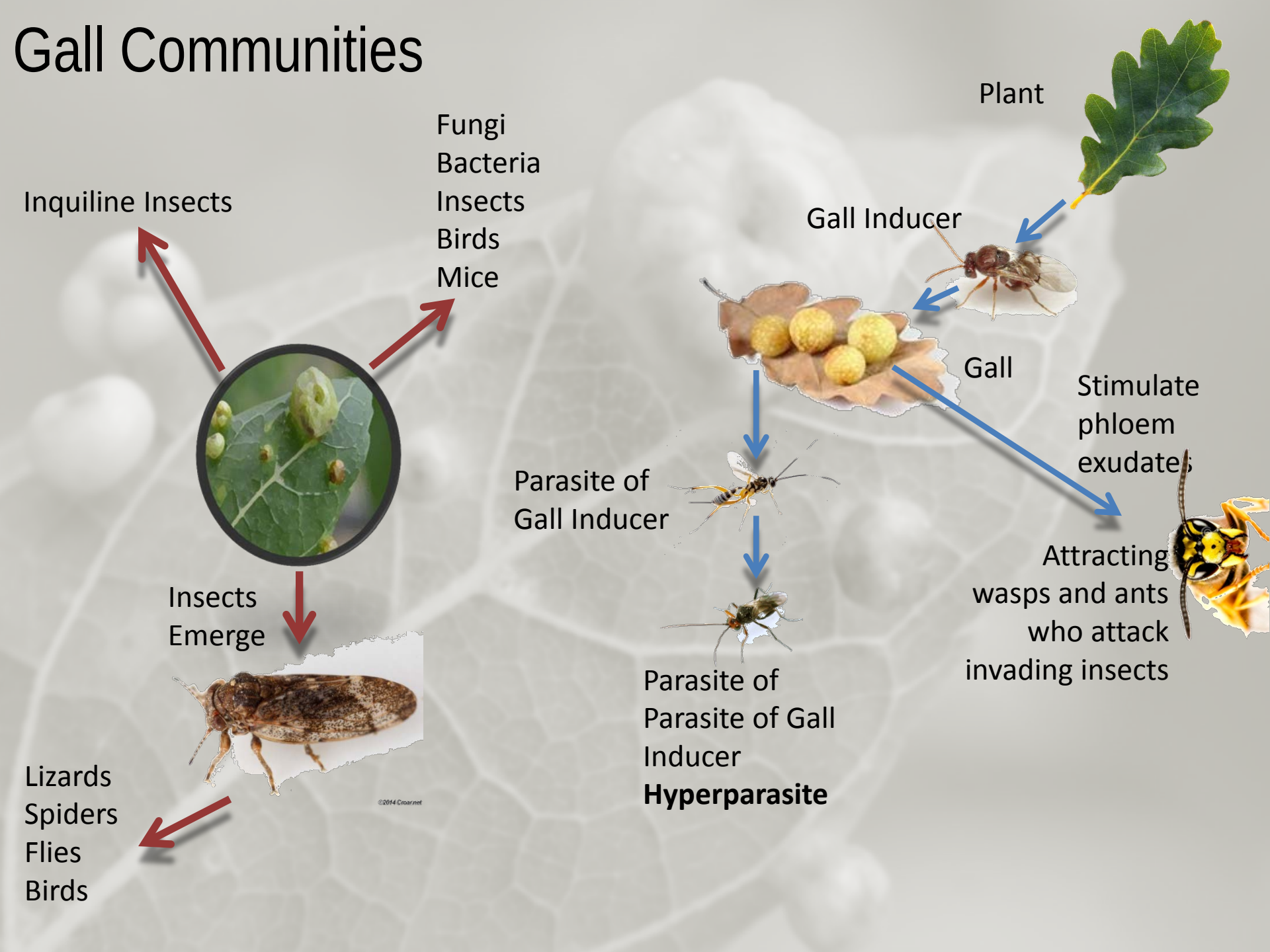
Milkweed

The *Asclepias* Community

- 122 spp. On *A. syriaca* and *A. incarnata* NJ
- 25 Beetle families on A. *syriaca* OH
- 16 spp. herbivorous insects on 12 milkweed spp. in greater Chicago region
- 126 documented pollinators

Ecological Role	Taxa	Milkweed Part
	True Bugs	
Predator	Spined Solider Bug	Insects on plant
Herbivore	Large Milkweed Bug	Seeds
Herbivore	Small Milkweed Bug	Seeds
Herbivore	Yellow Milkweed Aphid	Stem and leaves
Herbivore	Black Aphid	Stem and leaves
Herbivore	Green Peach Aphid	Stem and leaves
Herbivore	Red Aphid	Stems and leaves
	Thrips	
Herbivore	Eastern Flower Thrips	Flowers
	Beetles	
Herbivore	Milkweed Longhorn Beetle (3 spp.)	Leaves
Herbivore	Milkweed Leaf Beetle	Leaves
Herbivore	Swamp Milkweed Beetle	Leaves
Predator	Ladybird Beetle (9 spp.)	Insects on plant
Herbivore	Milkweed Stem Weevil	Stems
	Flies	
Predator	Syrphid Fly	Nectar/aphids
Parasitoid	Tachind Fly	Nectar/insects
Herbivore	Fruit Fly	Stem and leaves
Herbivore	Milkweed Leaf miner Fly	Leaves
	Bees and Wasp	
Pollinator	European Honey Bee	Flowers
Pollinator	Yellow-faced Bees	Flowers
Pollinator	Sweat Bees	Flowers
Pollinator	Leafcutting Bees	Flowers
Pollinator	Bumble Bees	Flowers
Pollinator	Carpenter Bees	Flowers
Parasitoid	Ichnemound Parasitic Wasp	insect larvae
Parasitoid	Bracodid Parasitic Wasp	insect larvae
Predator	Polistine Wasp	insect larvae
Nectivore	Forminice/Dolichoderine Ants	tending aphids
Predator	Myrmecine Ants	insect larvae
	Moths and Butterfly	
Herbivore	Monarchs	Nectar/plant
Nectivore	Pearl Crescent	Nectar
Nectivore	Hairstreak	Nectar
Nectivore	Clouded Sulphur	Nectar
Nectivore	Swallowtails	Nectar
Herbivore	Milkweed Tiger Moth	Plant/nectar
Herbivore	Delicate Cycna	Plant/nectar

Gall Communities



Medical Importance

- Biting Nuisance (annoyance)

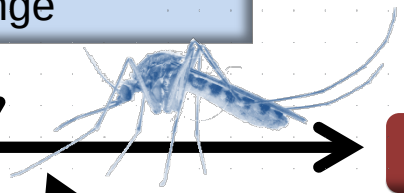
- Arboviruses a group of viruses that are transmitted by arthropod vectors.

- Filariasis is a parasitic disease caused by an infection with roundworms in the superfamliy Filarioidea

- Malaria caused by parasitic protozoans belonging to the genus *Plasmodium*

Climate

Wind
Water pH
Temperature
Seasonal changes
Light
Rainfall
Sunlight
Climate change



Host

Host population size
Population density
Immunity-suscepitiblity
Gregarious behaviors

Pathogen

Infectivity
Pathogenicity
Transmission
dynamics
Co-evolution

Ecosystem

Nutrient cycles
Topography
Nesting sites
Population Size
Territories

Community Structure

Predators
Pathogens
Competitors
Energy dynamics
Biodiversity
Physical structure

Thank you.