Vermicompost: Promote Global Worming!

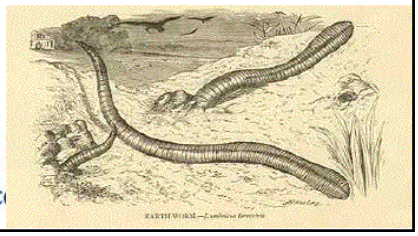
Maria de la Fuente, PhD
University of California Cooperative Extension
Farm and Master Gardener Advisor

University of California
Agriculture and Natural Resources

Darwin ❤ Earthworms

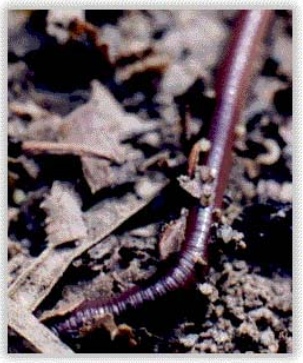
"*The plow is one of the most ancient and most valuable of Man's inventions; but long before he existed, the land … was regularly ploughed, and still continues to be ploughed, by earthworms. It may be (doubtful) whether there are many other animals which have played so important a part in the history of the world as these lowly, organized creatures.*"

- Charles Darwin, 1881



University of California
Agriculture and Natural Resourc

Learning Objectives

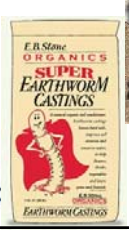


- To understand the importance of earthworms;
- To understand the basic biology of earthworms;
- To become enthused about the prospects of home vermiculture and vermicomposting;
- Promote sustainability – in your own backyard!

University of California
Agriculture and Natural Resources

Why Earthworms?

- Earthworms are living organisms that help with the decomposition of dead plants and animals, breaking them down into soil.
- They supply an abundance of organic fertilizer (castings).
- The presence is virtually hidden, and they don't bark, squeal, crow, nor talk back!



University of California
Agriculture and Natural Resourc

Quick Facts

- Earthworms live everywhere in the world where there is soil
- Earthworms eat as they burrow through the soil
- Earthworms do not have teeth
- Earthworms help make the soil healthy
- Earthworms are hermaphroditic & all lay eggs
- Earthworms are invertebrates (no backbones)
- Earthworms can be brown, pink or even red
- Colors vary from blue (Philippines) to green (UK) to black
- Sizes vary according to species – from 1/3 inch to 4 feet

Benefits of Earthworms

- Improved physical structure of the soil
- Better drainage and aeration
- Enhanced soil fertility (nutrients become more readily available to plants after they have been consumed by earthworms)
- Surface litter incorporation and recycling of nutrients back into the soil
- Better water infiltration and reduced run-off of water
- Improved root penetration

University of California
Agriculture and Natural Resources
UC CE

Taxonomical Classification

- A long time ago a man named **Linneus** determined a method of classifying (or categorizing) all living things.
- This was a method to put all plants, animals, bacteria, fungi, and organisms called protista (which have plant AND animal like characteristics) into specific categories.

University of California
Agriculture and Natural Resources

Taxonomical Classification

- This was done in the following method:
  - **Kingdom**
  - **Phylum**
  - **Class**
  - **Order**
  - **Family**
  - **Genus**
  - **Species**
- **K**ing **P**hillip **C**ouldn't **O**rder **F**ive **G**ood **S**andwiches

University of California
Agriculture and Natural Resources
UC CE

Earthworm Taxonomic Details

- Kingdom Animal
- Phylum *Annelida* (Latin for "rings")
  - Class *Chaetopoda*
    - Order *Oligochaeta*
      - Five families
        - » Most common to N. America = *Lumbricidae*
        - » 3000 species worldwide

University of California
Agriculture and Natural Resources

Phylum Annelida

- Many marine, freshwater, and terrestrial worms
- Example leeches and earthworms
- "**Segmented worms**"
  - Division of rings or segments
- **Septa/septum** (walls) separate segments
- **Setae:** small, bristle-like appendages

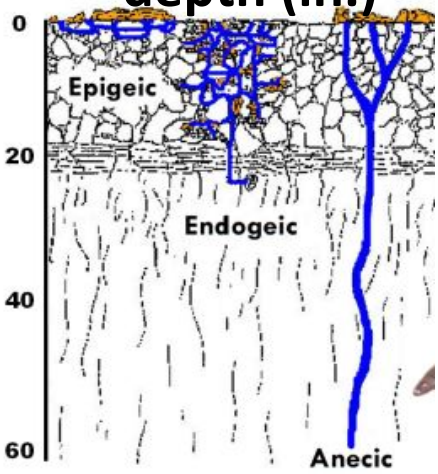
University of California
Agriculture and Natural Resources
UC CE

Some Common Genus and Species

- *Lumbricus terrestis* – Night crawler
- *Allolobophora caliginosa* – Grey worm
- *Allolobophora chlorotica* – Green worm
- *Lumbricus rubellus* – Red worm
- *Eisenia fetida* – **Red Wiggler** or Brandling Worm

University of California
Agriculture and Natural Resources

Types of Earthworms based on soil depth (in.)

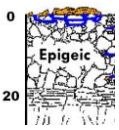


University of California
Agriculture and Natural Resources
UC CE

Different earthworms….

Compost Dwellers (Epigeic).
Like to live in high organic matter environments

Eisenia fetida →
(Wigglers or Tiger worm)



Soil Surface Dwellers (Epigeic).
Feed on decaying roots, shoots, leaves and dung and live near the soil surface (0-15 cm depth)

Lumbricus rubellus →
(Red Earthworm)

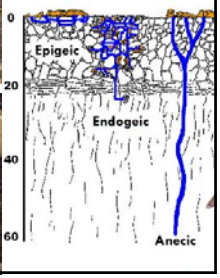
University of California
Agriculture and Natural Resources
UC CE

Topsoil Dwellers (Endogeic).
Live in the top 20-30 cm depth of soil.
Burrow through soil, eating and excreting it.

- *A. caliginosa* (grey worm)
- *Octolasion cyaneum* (blue-grey)
- *Lumbricus terrestris* (nightcrawlers)

Subsoil Dwellers (Anecic).
Tend to live in permanent burrows as deep as 4' below soil surface.

- *Aporrectodea longa* (fishing bait)



University of
Agriculture and N

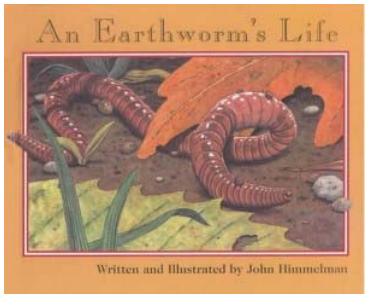
What Affects Earthworms?

- Temperature (they don't like it too hot or too cold)
- Moisture (they don't like it too wet or too dry)
- Food availability/type (some sources of organic matter are of better quality/contain more nutrients than others)
- Soil type and texture (soil organic matter is a good food source; sand can be abrasive to the earthworm's skin)
- pH of soil/organic material (most earthworms prefer a pH closer to neutral)
- Land management (avoid cultivation & concentrated fertilizer)
- Predators (such as birds, ants, gophers, moles)
- Toxic substances (pesticides, soaps, oils)

University of California
Agriculture and Natural Resources
UC CE

Lifespan of the Earthworm

- Lifespan
  - Conservative estimate 4-8 years
  - Some estimates 15+
  - Redworms only 2 years
  - Mortality **by accident**
- Primitive physiology is unchanged
- Body composition:
  - 70-95% water
  - Balance = protein, fat, minerals absorbed from soil
  - Mostly muscles & nerves



University of California
Agriculture and Natural Resources
UC CE

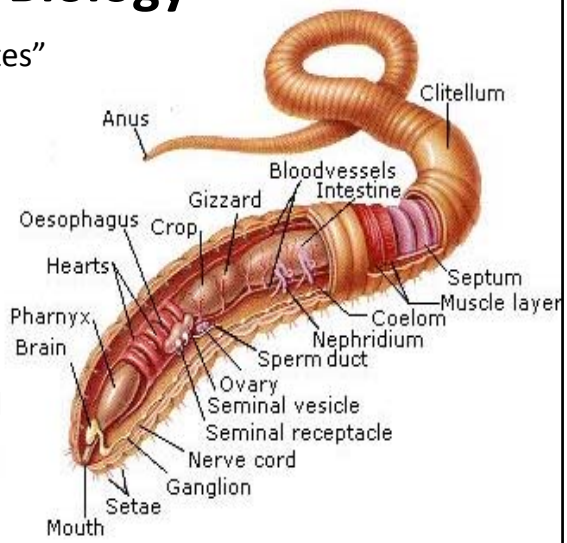
Life Habits

- Negatively Phototactic
- Nocturnal
- Locomotion
- Burrowing
- Feeding
- Breeding
- Regeneration

University of California
Agriculture and Natural Resources
UC CE

Earthworm Biology

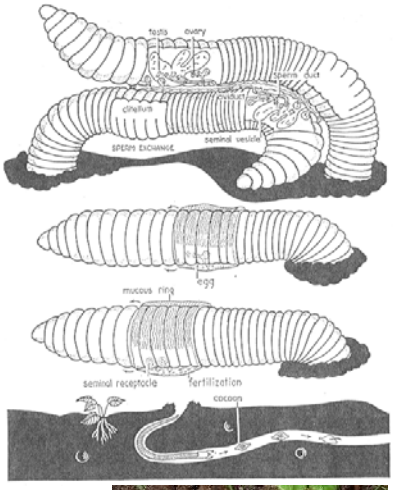
- Segmented body "somites"
  - Somites with setae
- Five "hearts"
- Poikilothermic (Cold-blooded)
- Peristonium = mouth
  - Prostonium for prying
- Clitellum splits the head region from the tail
- Each worm contains male & female organs



University of California
Agriculture and Natural Resources
UC CE

Earthworm Biology

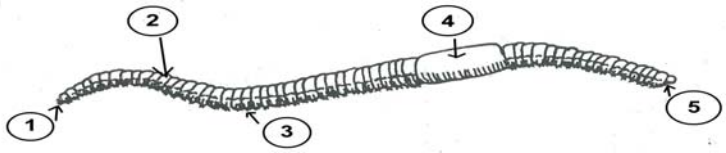
- Mucus is critical:
  - Holds in moisture
  - Aids in respiration
  - Protects body while burrowing
  - Sperm carrier during reproduction
- Hermaphrodites
  - Dual sex, non self-fertilizing
  - Mutual exchange of sperm
  - Ova are fertilized in cocoons
  - Clitellum: light-colored band, produces cocoons
  - Cocoons contain ~ 4 eggs
  - Eggs incubate 3 weeks



University of California
Agriculture and Natural Resources

UC CE

External Anatomy of a Worm



(1) **Anus**—where waste is excreted from worm

(2) **Segments**—areas of worm's outer body that bend, stretch and aid in movement

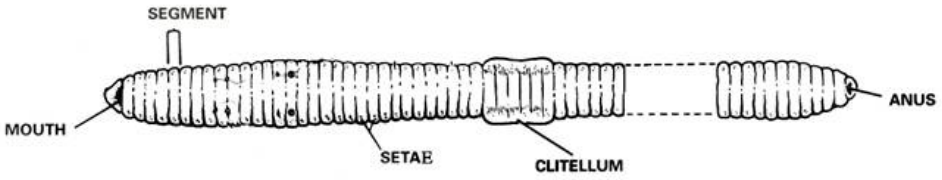
(3) **Setae**—stiff hairs on exterior of worm that help it move

(4) **Clitellum**—located near worm's head; genitalia is located here

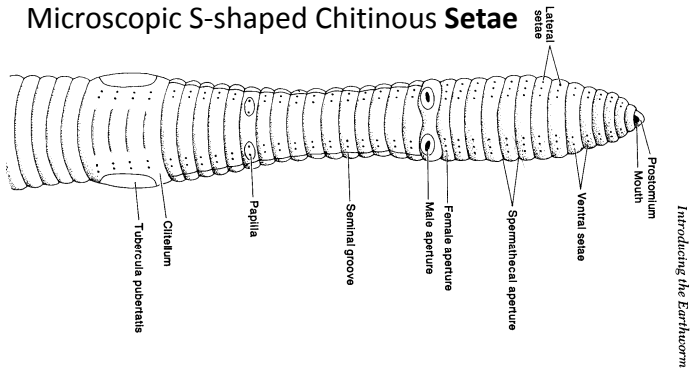
(5) **Peristonium**—where worm ingests food

University of California
Agriculture and Natural Resources

External Anatomy

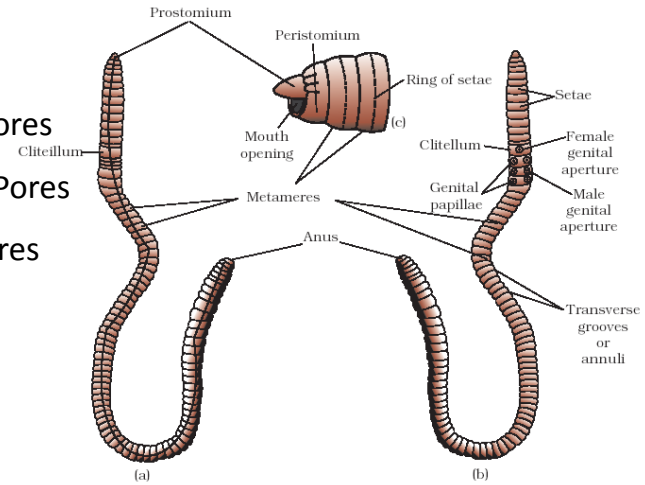


Microscopic S-shaped Chitinous **Setae**

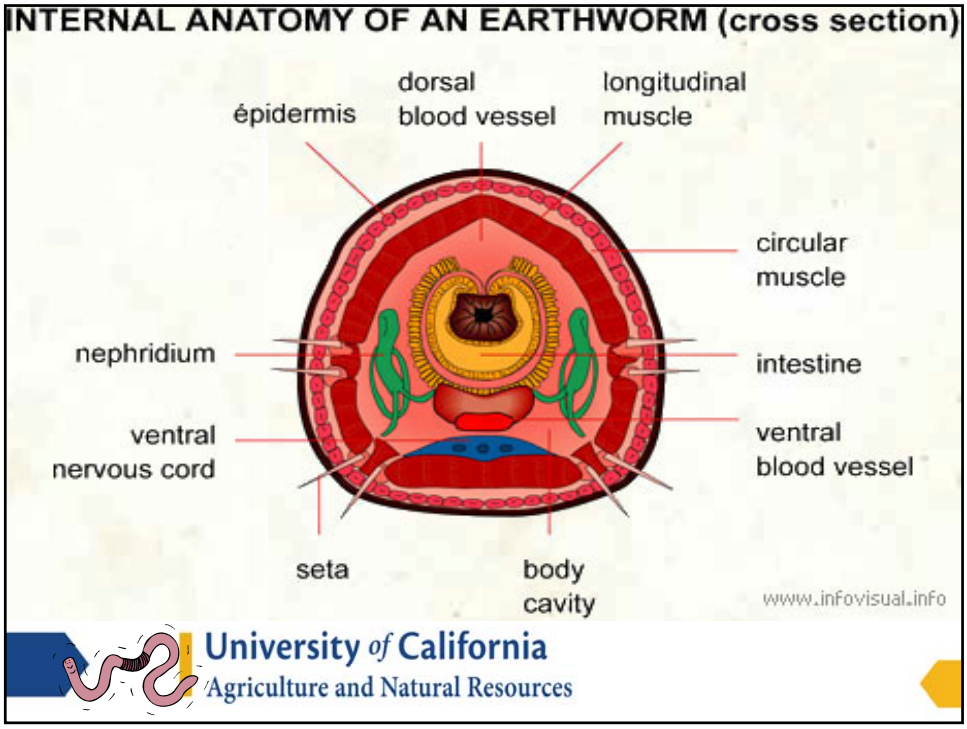


Body Orifices

- Mouth opening
- Spermathecal Pores
- Female Genital Pores
- Male Genital Pores
- Nephridiopores
- Dorsal pores
- Anus



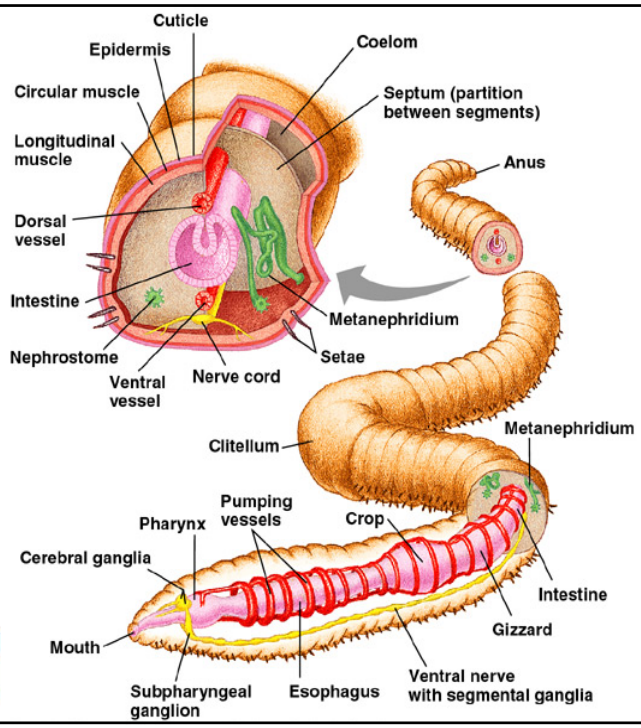
University of California
Agriculture and Natural Resources
UC CE



- The body wall is covered externally by a thin non-cellular **Cuticle**.
- It is followed by two **Muscle Layers** and an inner most **Coelomic Epithelium**.
- The **Epidermis** consists of single layer of **Columnar Cells**.
- **Secretory Gland Cells** are also found among the columnar cells

University of California
Agriculture and Natural Resources

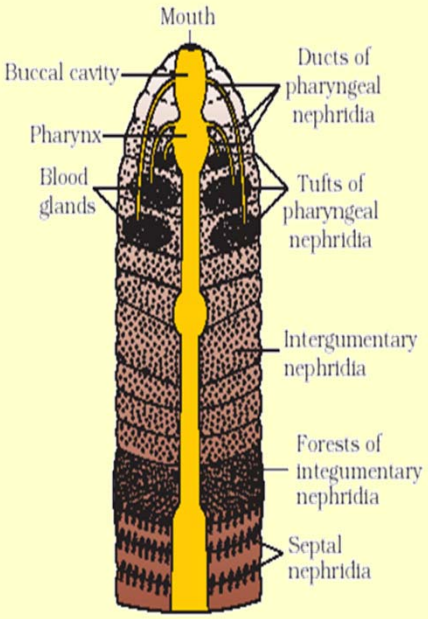
Excretory System



Excretory System

- Nephridium
- Segmentally arranged nephridia are the excretory organs
- Three types of nephridia
  - Septal
  - Integumentary
  - Pharyngeal

University of Californ
Agriculture and Natural Res



Excretion

- Excretion is the process by which the cell's **liquid and gas wastes are removed** from the worm and released into the environment.
- The end products of this waste are carbon dioxide, water, mineral salts and nitrogenous wastes such as ammonia, urea and uric acid.
- The worm has a special, complex system for excretion.
- The moist skin of the earthworm serves as a respiratory surface for releasing carbon dioxide gas from the blood.

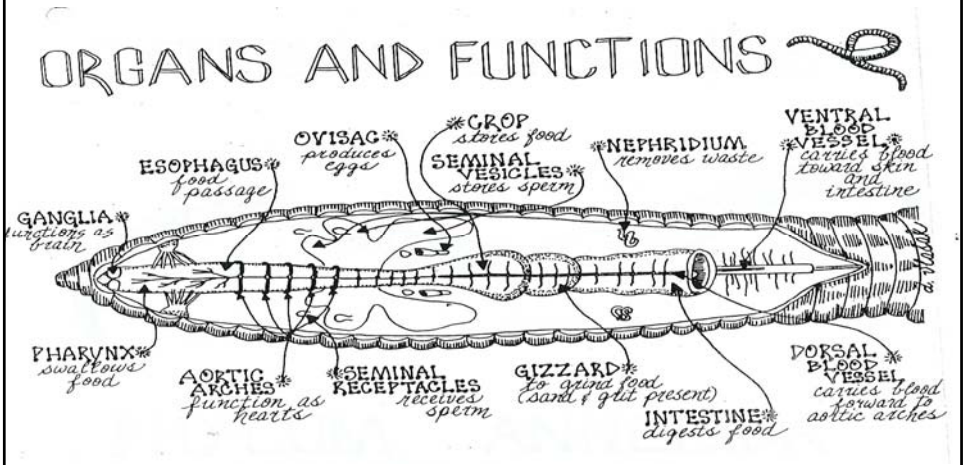
University of California
Agriculture and Natural Resources
UC CE

Excretion

- The nitrogenous wastes, salts and water are collected in specialized organs known as **nephridia**.
- A pair of these are located in each of the earthworm's somite segments.
- Once concentrated in the nephridia, these wastes are released into the soil through small pores in the earthworm's skin.
- The oxygen is absorbed through the moist skin and simultaneously the carbon dioxide is released through it.
- Other liquid wastes are collected in the nephridia and released through the **nephridiopore.**

University of California
Agriculture and Natural Resources
UC CE

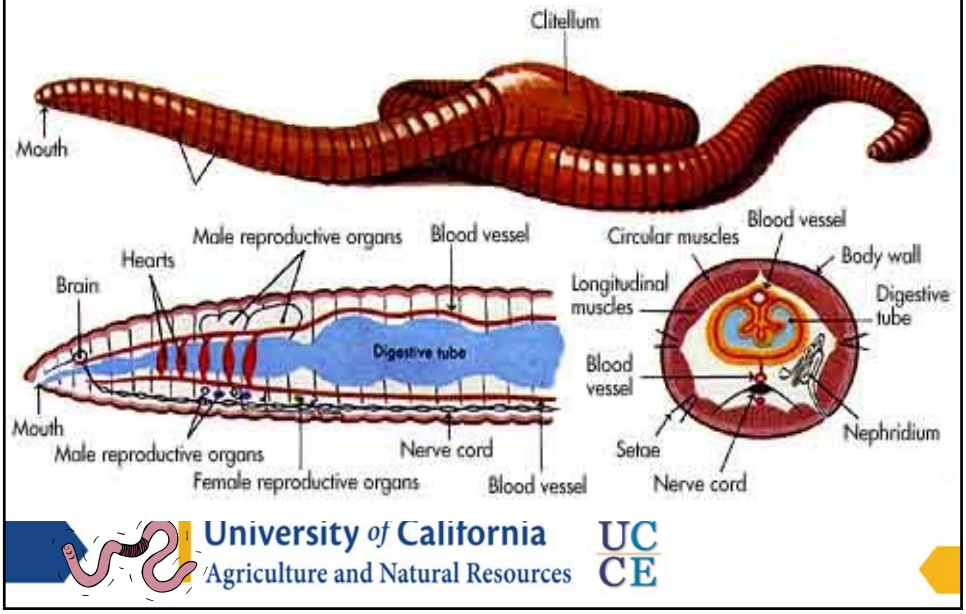
Earthworms' Internal Organs



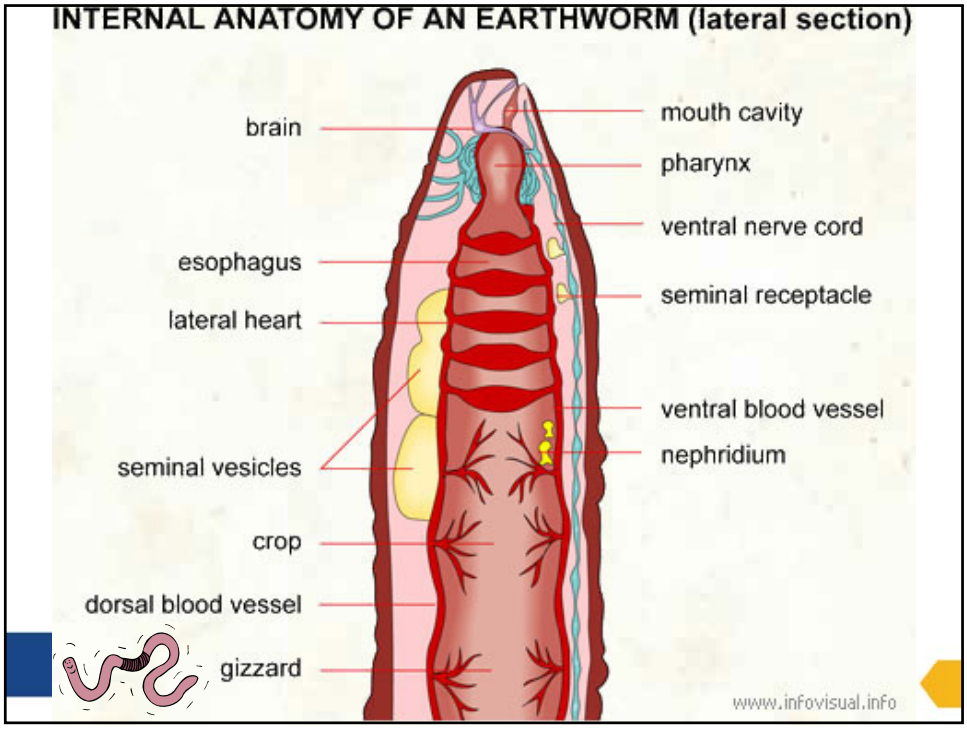
An earthworm is an **invertebrate** (has no backbone)

University of California
Agriculture and Natural Resources

Internal Anatomy

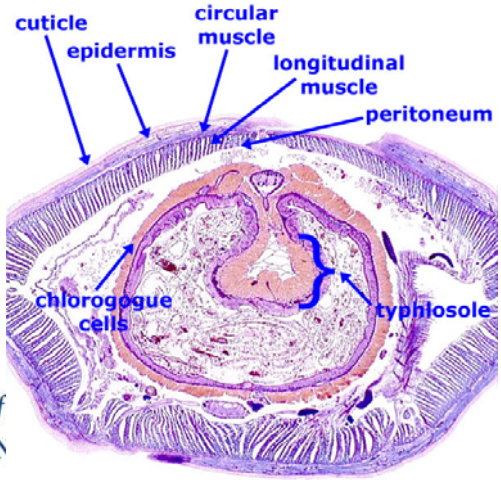


University of California
Agriculture and Natural Resources
UC CE



Musculature

- **Cuticle-** thin external layer.
- **Epidermis**- outer cellular layer
- **Circular muscle layer**
- **Longitudinal muscle layer**



University of Agriculture and N

Locomotion

- Locomotion is the life process by which organisms **move from place to place** within their environment, allowing greater opportunities to locate food, shelter, stay away from predators, move away from toxic wastes and find mates.
- They have a **specialized muscle tissue system** capable of producing movement of the earthworm's long body.
- Muscles are able to provide lengthening and shortening motions, as well as the expansion and contraction of body width.
- To promote this movement, short bristles, known as **Setae** provide anchorage of the worm's body against soil in which it lives.

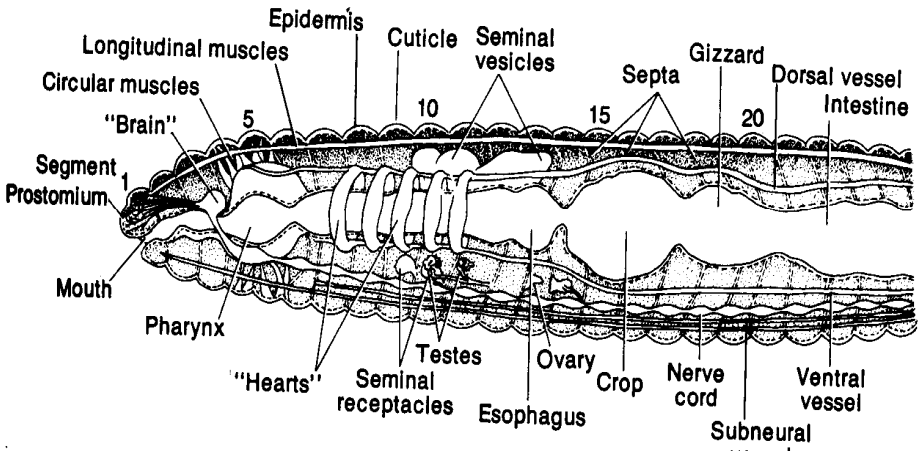
University of California
Agriculture and Natural Resources
UC CE

Regeneration

- **What happens when an earthworm is cut in half? Can it form two separate worms?**
- Worm needs at least 13 segments
- Will re-grow body segments (equal number)
- Most organs are in anterior part
- Anterior can regenerate a new posterior end
- Posterior end can **not** regenerate a new anterior
- So, **no** you don't get two new worms

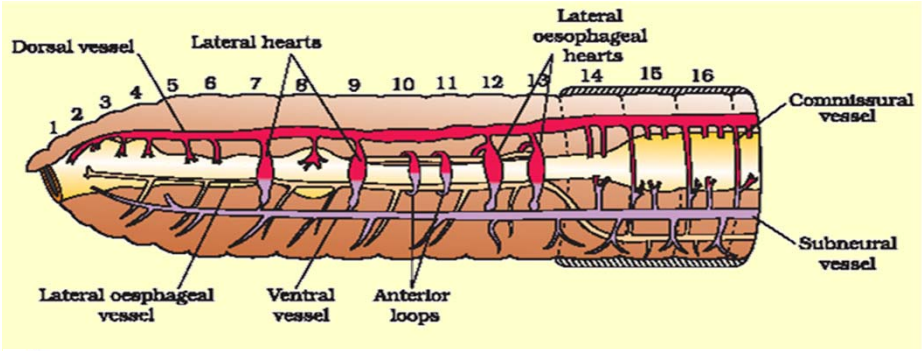
University of California
Agriculture and Natural Resources
UC CE

Internal Anatomy



University of California
Agriculture and Natural Resources

Circulatory System

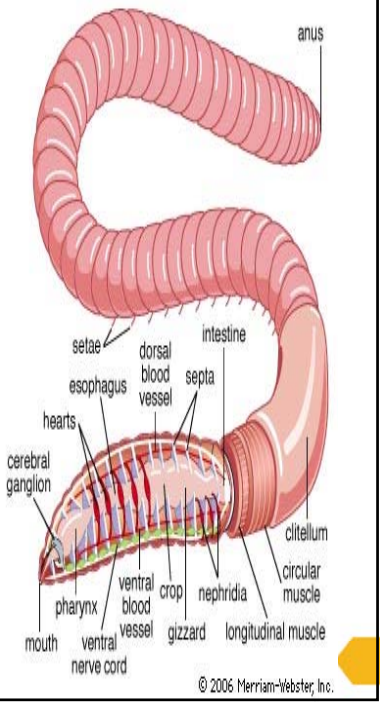


- In earthworms the circulation is closed type.
- The circulatory system consists of **Hearts, Blood Vessels**, **Capillaries** and **Blood Glands.**

University of California
Agriculture and Natural Resources
UC CE

Circulatory System

- They have true **Blood**, and it's very similar to humans because it contains **Hemoglobin** (which bonds and carries the oxygen to the cells)
- Five pairs of **Pseudohearts or Aortic Arches** surround esophagus and pump blood
- Blood travels through **Dorsal and Ventral Vessel**



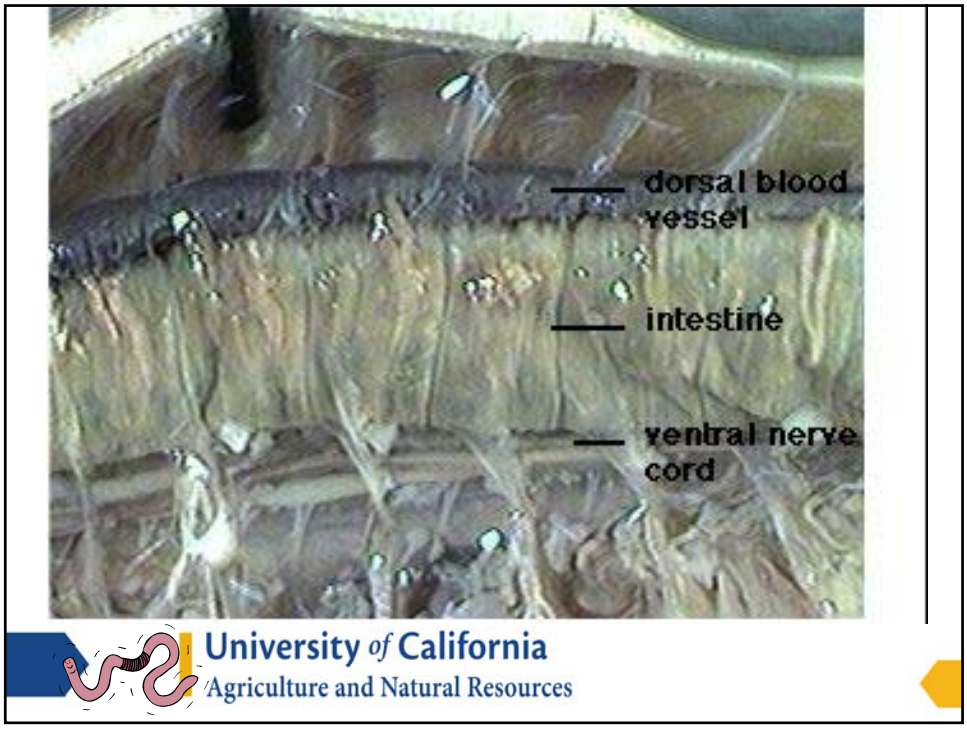
University of California
Agriculture and Natural Resources

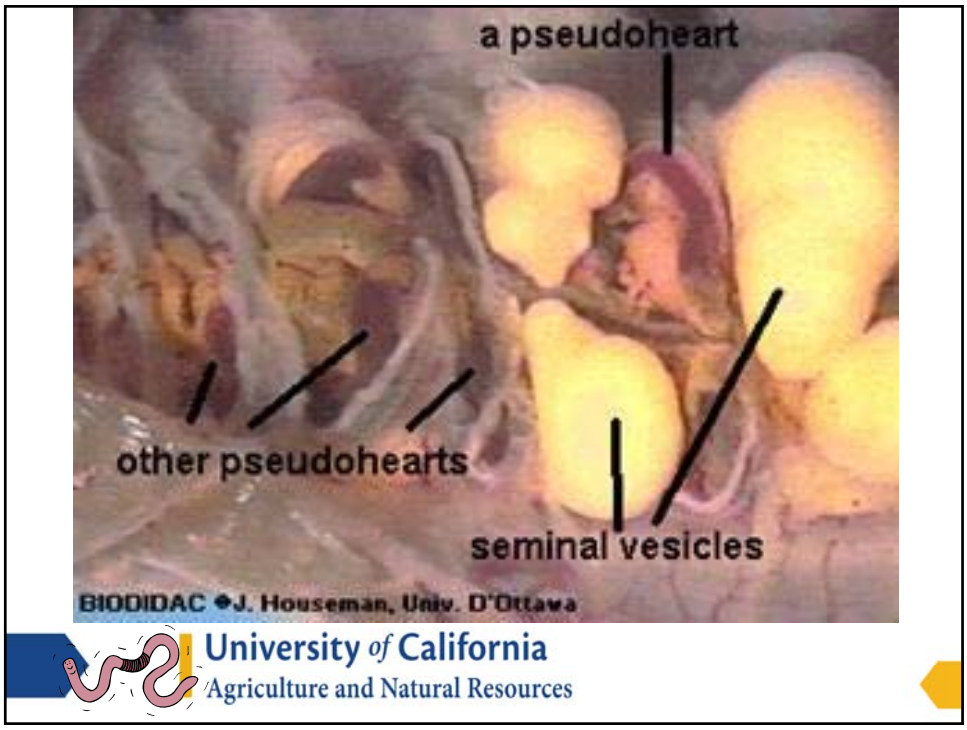
Circulatory System

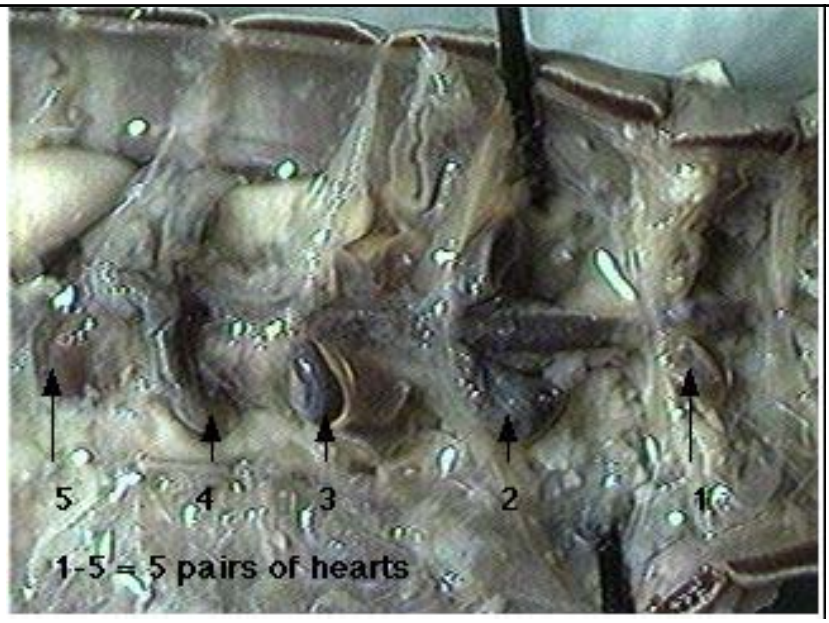
- The circulatory system is the body's **transportation system.**
- It transports the **oxygen and nutrients** that the cells need and **carries the wastes** that are left.
- It's like a super highway with "red" Porsches being the **oxygen carrying Hemoglobin** and garbage trucks carrying the waste products.

- **The top vessel is the dorsal blood vessel,**
- **The bottom is the ventral blood vessel.**

University of California
Agriculture and Natural Resources
UC CE


dorsal blood vessel
intestine
ventral nerve cord
University of California
Agriculture and Natural Resources


a pseudoheart
other pseudohearts
seminal vesicles
BIODIDAC ©J. Houseman, Univ. D'Ottawa
University of California
Agriculture and Natural Resources



University of California
Agriculture and Natural Resources

Nervous System

The nervous system consists of segmentally arranged **ganglia and a ventral nerve cord.** A ganglion is a mass of nerve cells.

- Nerve Ring
- Ventral Nerve Cord
- Sense Organs

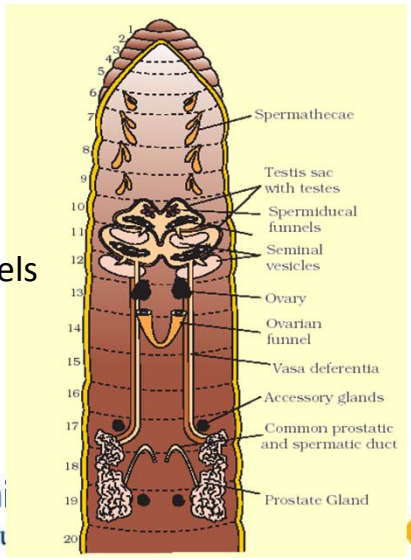
University of California
Agriculture and Natural Resources

Earthworm is **hermaphrodite** or **bisexual .**

Reproductive system

Male Reproductive Organs

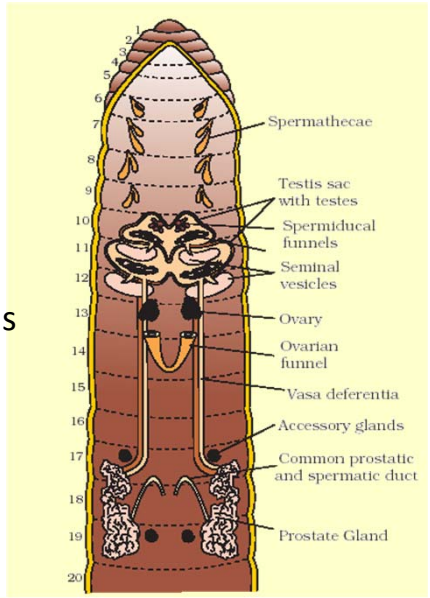
- Testis Sac (2 pair of testes)
  (Somites 10 & 11)
- Seminal vesicles
- Seminal or spermiducal funnels
- Vasa differentia
- Prostate glands



University of Californi
Agriculture and Natural Resou

Female Reproductive Organs

- Ovaries (Small Pair)
  (Somite 13)
- Oviduccal or ovarian funnels
  (Somite 14)
- Oviducts
- Spermatheca



University of California
Agriculture and Natural Resources

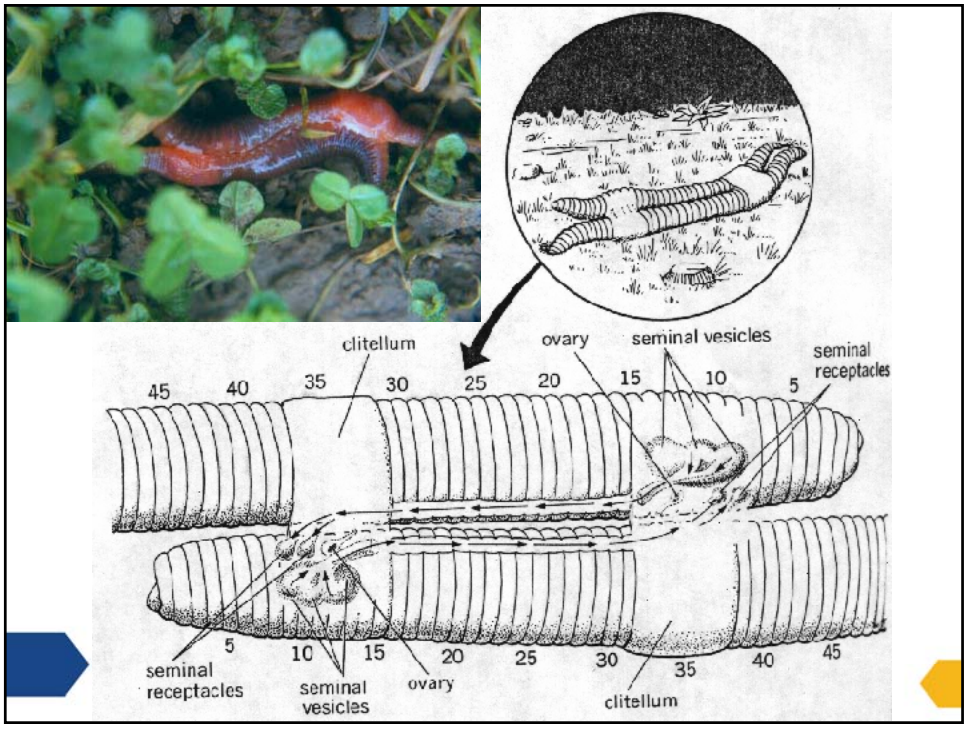
UC CE

surendranaduthila@gmail.com

Reproductive System

- Earthworms are **hermaphrodites.**
  - Male and female reproductive organs present in each individual
  - Not self-fertilizing, but cross fertilize
- Mate by attaching at **clitella,** mutual exchanging sperm, then separating.
  - Sperm stored while clitellum secrete a mucous cocoon
  - Cocoon slides along worm to collecting sperm and also eggs
  - Slips off worm's head
  - Cocoons contain ~ 4 eggs
  - Ova are fertilized in cocoons
  - Embryos develop in cocoon
  - Eggs incubate in 3 weeks

University of California
Agriculture and Natural Resources
UC CE



Redworms

- *Eisenia fetida* & *Lumbricus rubellus*
- Live in the top 12 inches of soil or substrate
- Feed on organic decaying matter
- Can eat their body weight in food every day
- Generate 75% of body weight in worm poop (castings) each day
- Lay one cocoon every week or so
- Each cocoon produces 3 to 4 baby worms
- **Begin breeding at 4 to 6 weeks of age**
- Worms can double population every 90 days
- Live up to 2 years

University of California
Agriculture and Natural Resources

Reproduction/Cocooning/Hatching

- You will need <u>two</u> to start a colony, even though each has both male and female sex organs
- Earthworms mate in the spring or fall
  - Cocoons are laid
  - Newly hatched wormlets look like pieces of white thread
  - Young worms hatch from their cocoons in 2-20 weeks
  - Conditions like temperature and soil moisture factor in here...if conditions are not great then hatching is delayed
    - The ideal temperature is around 55°F
    - Soil/substrate must remain moist

iversity of California
riculture and Natural Resources
UC CE

Worm Cocoons

- Worms' cocoons contain an average of 3 baby wormlets
- Cocoons are shaped like lemons 1/8 of an inch long

University of California
Agriculture and Natural Resources

Reproduction

- The worm must be a **mature worm**.
- This can be recognized by the mature **clitellum** (or band) that appears at around segment 30-35.
- Typically it is in the spring time, the ground is soft, warm and moist.
- The worms attach mouth to anus, anus to mouth and "**copulate**" or exchange sperm.
- The worms EACH release sperm that travel to the other's seminal receptacles.
- This process of sliming usually takes about 2 hours**.**

University of California
Agriculture and Natural Resources
UC CE

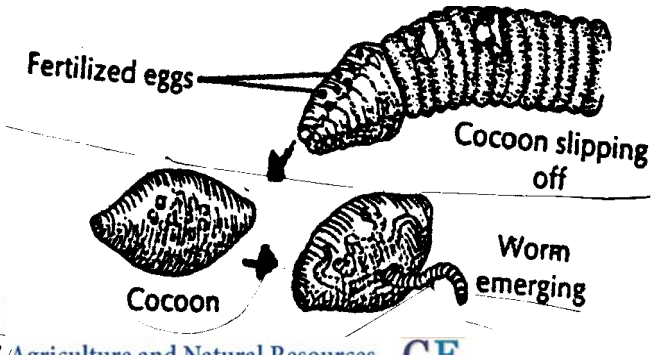
Reproduction

- After copulation, the worms separate, each having the other's sperm stored in the **seminal receptacles** until used for fertilization.
- When the eggs have reached maturity and have been released, the clitellum secretes a tube of mucus which slips over the front of the worm.
- The tube receives the eggs as it passes segment (somite) 14, and receives the other worm's sperm cells as it passes segments 9 & 10.
- Fertilization occurs inside the tube as it slides forward until it finally slips off the anterior end.
- The tube, which is then sealed, is usually left in the burrow to form a cocoon containing several zygotes.

University of California
Agriculture and Natural Resources
UC CE

Reproduction

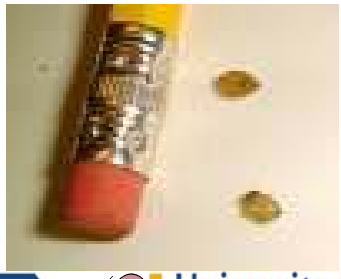
- After 3-4 weeks, pale, whitish **wormlets** crawl out as miniature adults.
- If the moisture and temperature are not quite right, the eggs can stay in the case for a year or more.
- The adult worms do not stay with the cocoon, but crawl off.



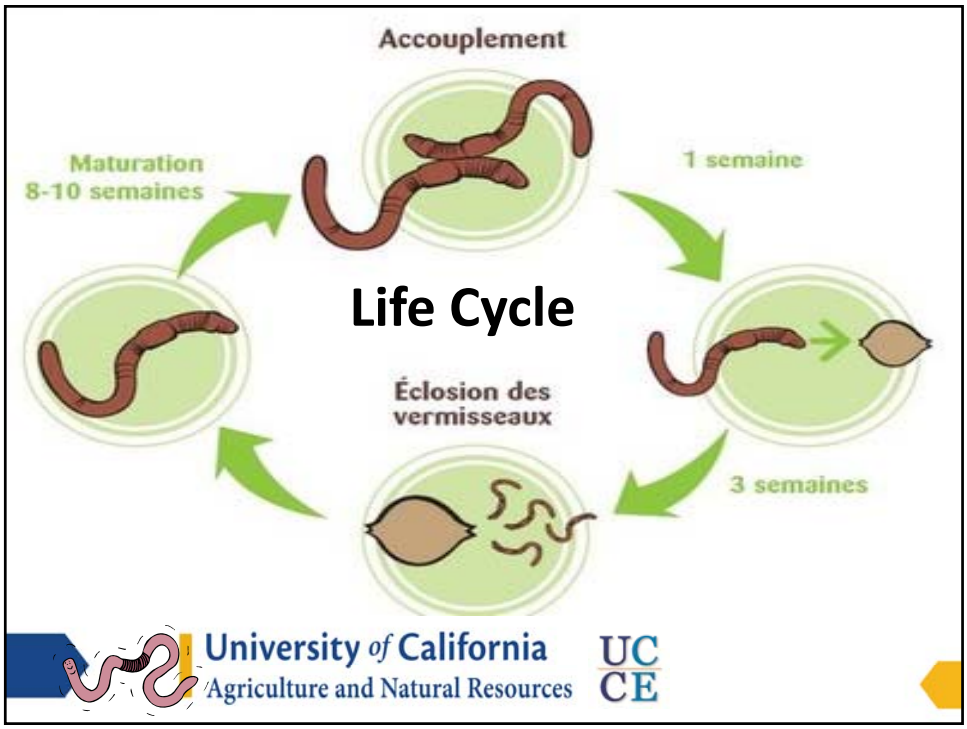
Agriculture and Natural Resources
CE

Reproduction

- Worms become mature (adults) at 10 weeks (4-6)
- Will produce 2 to 3 cocoons a week
  - Each cocoon holds 2 to 5 babies (wormlets)
  - Cocoons take 3 weeks to hatch
- In 6 months, 8 worms will multiply into 1500



University of California
Agriculture and Natural Resources
UC CE



University of California
Agriculture and Natural Resources
UC CE

Respiratory System (Gas Exchange)

- True **Respiration** is a biochemical process consisting of **molecular oxygen coming into the cells and the carbon dioxide going out** of the cells.
- All annelids live in moist environments.
  - Most are aquatic.
- Earthworms can survive only in damp soil.
  - Gas exchange occurs at body surface through diffusion through the moist skin absorbing oxygen and releasing CO_2.
  - The earthworm contains many cells that are not in direct contact with the environment.
  - No lungs or gills!

University of California
Agriculture and Natural Resources
UC CE

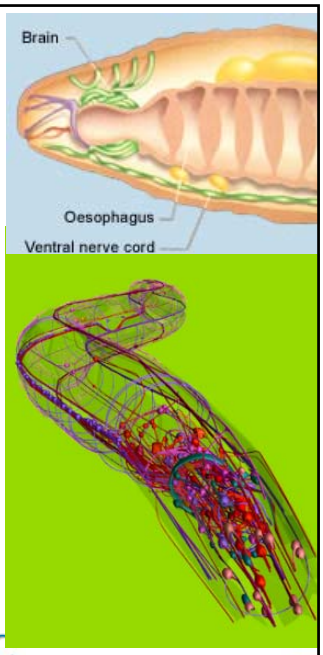
Regulatory System

- The **Nervous System** (for nerve control).
- The **Endocrine System** (for chemical control).
- These are the life functions by which organisms control and coordinate their other life functions to maintain life.

University of California
Agriculture and Natural Resources
UC CE

Nervous System

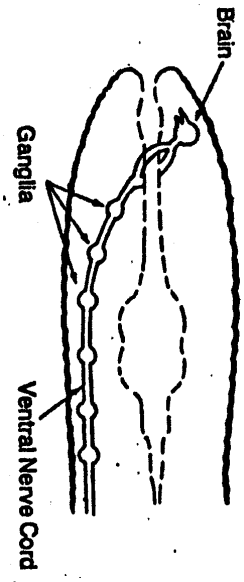
- Regulates body's activities
- Nervous responses are very rapid and short duration
- Cerebral ganglia, two-lobed primitive "Brain"
- Brain = a knot of nerves & fused ganglia
  - Ganglion serve as impulse centers
- Ganglia (bunched nerve cells)
  - Located in each somite
  - Connect peripheral nerves to nerve cord
- Nerve Cord, ventral side



University of California
Agriculture and Natural Resources
UC CE

Nervous System

- Prostomium, tongue like lobe above mouth, allows earthworm to "feel" through soil
- Super sensitive to touch
  - Allows worm to select food, avoid predators and objects, and reproduce;
  - Can feel bird's footsteps
- No eyes, but sensitive to blue light and skin to ultraviolet rays = burrowing action



University of California
Agriculture and Natural Resources
UC CE

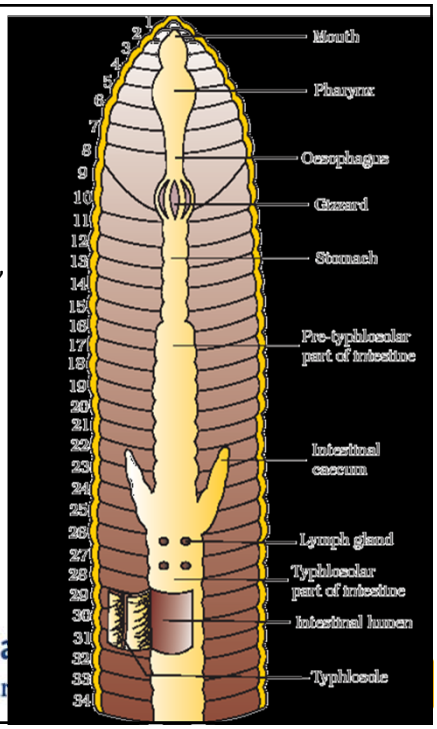
Endocrine System

- **Chemical control is done by hormones** secreted in specialized tissues known as **endocrine glands.**
- The role of these hormones **regulates growth, reproduction and general metabolism.**

University of California
Agriculture and Natural Resources
UC CE

Digestive System

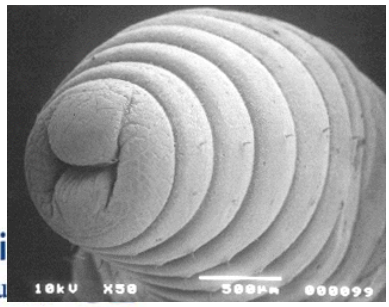
- It is a straight tube (tubular) and runs from the first to the last segments.
- It consists of
  - Mouth (peristomium & prostomium),
  - Buccal cavity,
  - Pharynx,
  - Esophagus,
  - Crop (storage compartment),
  - Muscular gizzard (soil ground up and churned),
  - Intestine (digestion and absorption),
  - Anus (undigested materials are "egested" or pooped) .



University of California
Agriculture and Natural Resour

Digestive System

- Eats weight in soil & OM daily
- Processed in alimentary canal
  - Muscular mixing with enzymes to release amino acids, sugars, organic molecules
  - Includes microorganisms
  - Molecules absorbed through intestinal membranes



University of Californi
Agriculture and Natural Resou

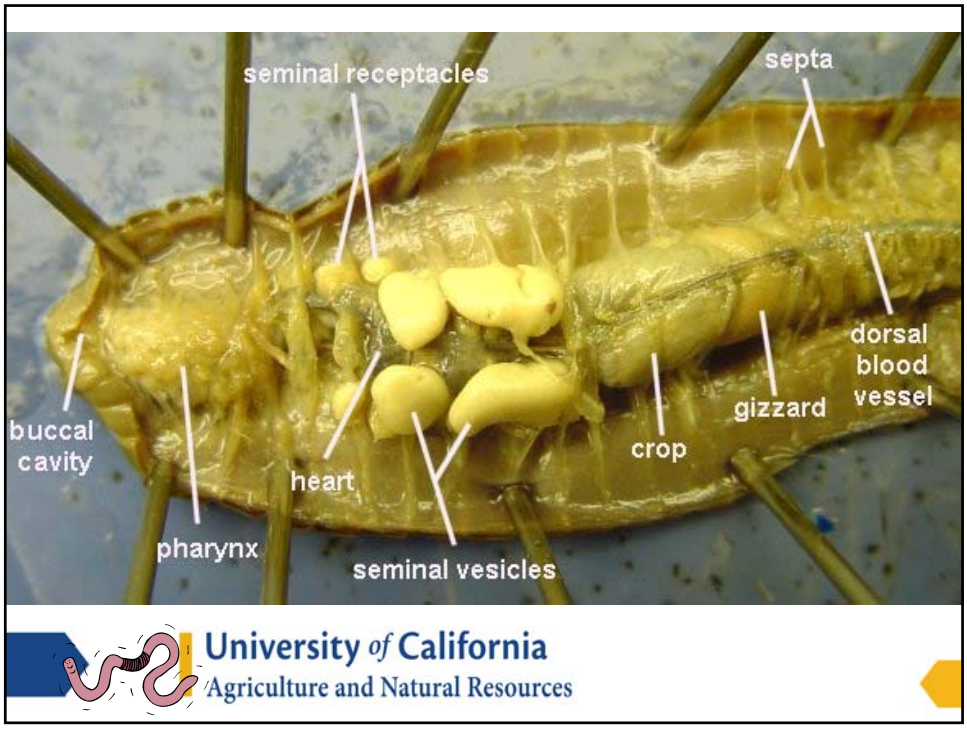
Digestive System

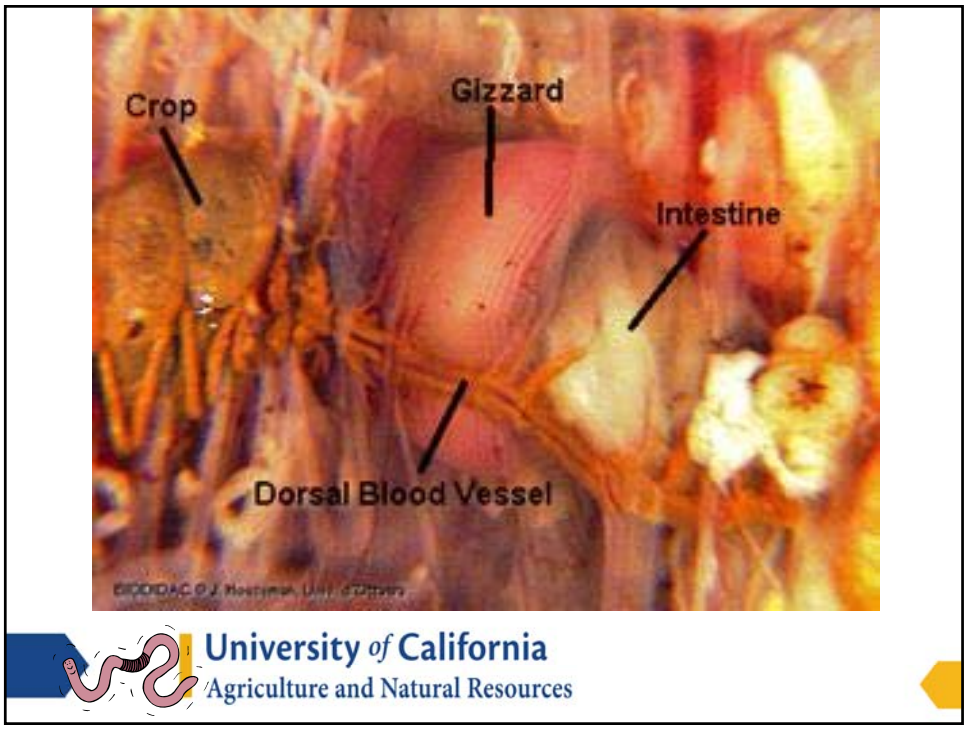
- Result: ***CASTINGS***

Nutrient Values

Nitrogen 1.80 – 2.05 %	Phosphorus 1.32 – 1.93 %
Potassium 1.28 – 1.50 %	Calcium 3.0 – 4.5 %
Magnesium 0.4 – 0.7 %	Iron 0.3 – 0.7 %
Manganese Traces to 0.40 %	Zinc 0.028 – 0.036 %
Organic Carbon 20-30%	pH 6.0 – 7.0

University of California
Agriculture and Natural Resources
UC CE


seminal receptacles
septa
dorsal blood vessel
gizzard
crop
heart
buccal cavity
pharynx
seminal vesicles
University of California
Agriculture and Natural Resources


Crop
Gizzard
Intestine
Dorsal Blood Vessel
University of California
Agriculture and Natural Resources

Definitions:

- **Vermiculture** is the art of raising worms for profit, for fishing, for fun
- **Vermicomposting**, or worm composting, allows you to compost your food waste rapidly, while producing high quality compost soil and fertilizing liquid.

- *Why*:
  - Year-round compost & organic plant fertilizer
  - Reduce, reuse, recycle
  - Non-polluting
  - Profitable commercial business
  - Interesting for all ages

University of California
Agriculture and Natural Resourc

How to Vermicompost?

Three E's:

- Education
- Equipment
- Environment

University
Agriculture a

1st E: Education

- Books
  - *Worms Eat My Garbage* by Mary Appelhof
  - *The Earthworm Book: How to Raise and Use Earthworms for Your Farm and Garden*, by Jerry Minnich
- Extension office bulletins
  - "Earthworm Biology and Production" by the University of California Cooperative Extension, leaflet #2828
  - http://soilquality.org/indicators/earthworms.html
  - http://soils.usda.gov/sqi/concepts/soil_biology/earthworms.html
  - http://www.soils.usda.gov/sqi/assessment/test_kit.html
  - http://whatcom.wsu.edu/ag/compost/easywormbin.htm

University of California Agriculture and Natural Resources UC CE

2nd E: Equipment

Suppliers

- Bins
- Foodstock
- Worms

University of California Agriculture and Natural Resources UC CE

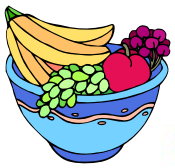
Worm Bins

- Size
- Construction
  - Plastic vs. Wood construction
  - Commercial
    - Can-O-Worms™
    - Worm-A-Way®
    - Worm-A-Roo™

University of California
Agriculture and Natural Resources
UC CE

Size of Worm Bins

- Track food waste for a week
- Allow one square foot of surface per pound of waste
- Example problem:
  - Five pounds of food waste per week will require 5 ft² of surface.
  - Bin should measure 1’ x 2’ x 3’ (6 ft²)



University of California
Agriculture and Natural Resources
UC CE

Worm Bin Construction

- Wooden Bin
  - Organic
  - Breathes
  - Heavy
  - Deteriorates faster
  - Can be built as furniture
  - No treated lumber or fragrant woods (ie: cedar)

- Plastic Bin
  - Lightweight
  - Holds moisture
  - Will not rot
  - Requires more holes for aeration
  - Inexpensive
  - Many bins available

University of California
Agriculture and Natural Resources

Commercial Bins

- Several brands to choose
- Popular & effective
- Lightweight
- Enclosed tier system
- Bottom catch tray & spigot for harvesting tea
- Stackable mesh trays
- Worms migrate vertically
- Easy to harvest castings
- $70 -200 + shipping

University of Cali
Agriculture and Natural

Commercial Bins

- **Can-O-Worms™**
  - Most popular
  - Enclosed tier system
  - Bottom catch tray & spigot
  - Stackable mesh trays
  - Worms migrate vertically
  - Easy to harvest castings
  - $130.00 + shipping

University of California
Agriculture and Natural Resources

Commercial Bins

- **Worm-A-Way®**
  - Plastic
  - Ventilated
  - Several sizes
  - Lightweight
  - $90-$100 includes Worms & shipping

University of California
Agriculture and Natural Resources

Commercial Bins

- **Worm-A-Roo™**
  - Double bin system
  - Plastic
  - "Migration device"
  - Lightweight
  - $140-$170 includes Supplies, worms, and shipping

University of California
Agriculture and Natural Resources

3rd E: Environment

A worm bin must be:

- Convenient
- Easily accessible
- Close to a water source
- In a well-ventilated location
- Covered and protected from wind, sun, and animals

Foodstock:

- Variety
- Mix (bury) foodstock with bedding
- Don't overload system
- Maintain aerobic conditions
- C/N ratio (green:brown)

University of California
Agriculture and Natural Resources
UC CE

Bedding

- Various materials:
  - Shredded newspaper
  - Sphagnum Peat Moss
  - Manure
  - Leaf litter
  - Coir (Coconut fiber)
  - Wood chips

- Dampen bedding with tap water
- Mix well

University of California
Agriculture and Natural Resources
UC CE

Bedding

- Possible additions to bedding
  - Calcium carbonate to control pH
    - Do NOT use slaked or hydrated lime
  - Rock dust for grit
  - Zeolite – for grit; also balances pH, controls odors, absorbs ammonia

University of California
Agriculture and Natural Resources
UC CE

Bin Temperature

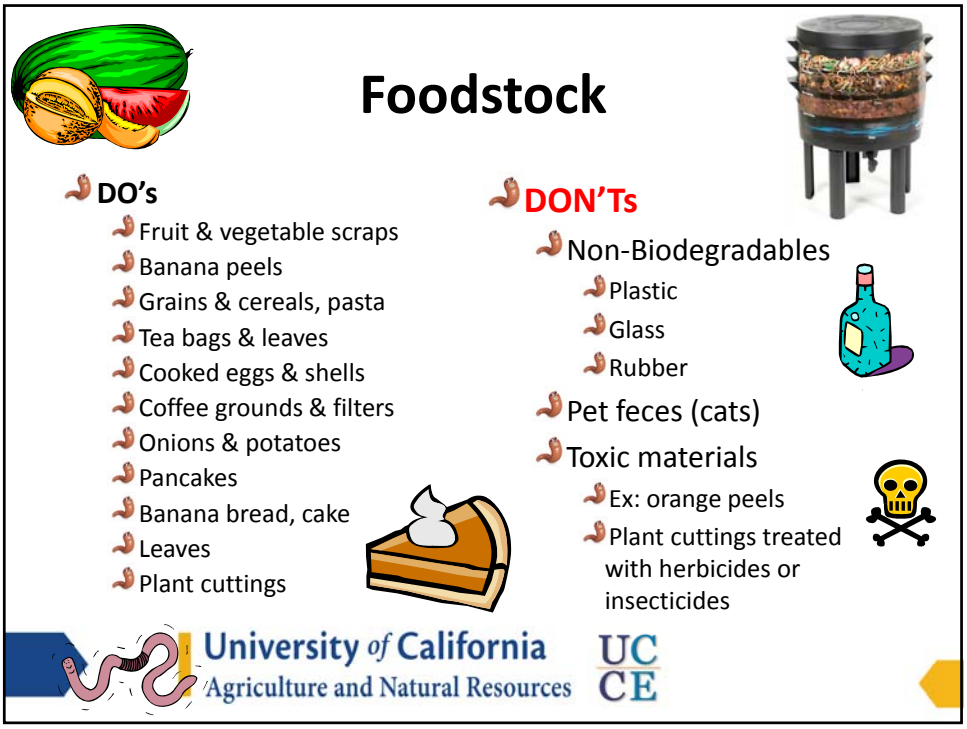
- Recommended: 59-77°F
  - A cooler bin …
    - Stays moist
    - Worms appear more active
    - Bedding is thicker
    - May have more mites
    - Easier to maintain consistent conditions
  - A warmer bin…
    - Dries out quickly
    - Worms appear more lethargic
    - Bedding appears to be settled
    - Harder to maintain non-ambient temperature
    - Additional moisture required

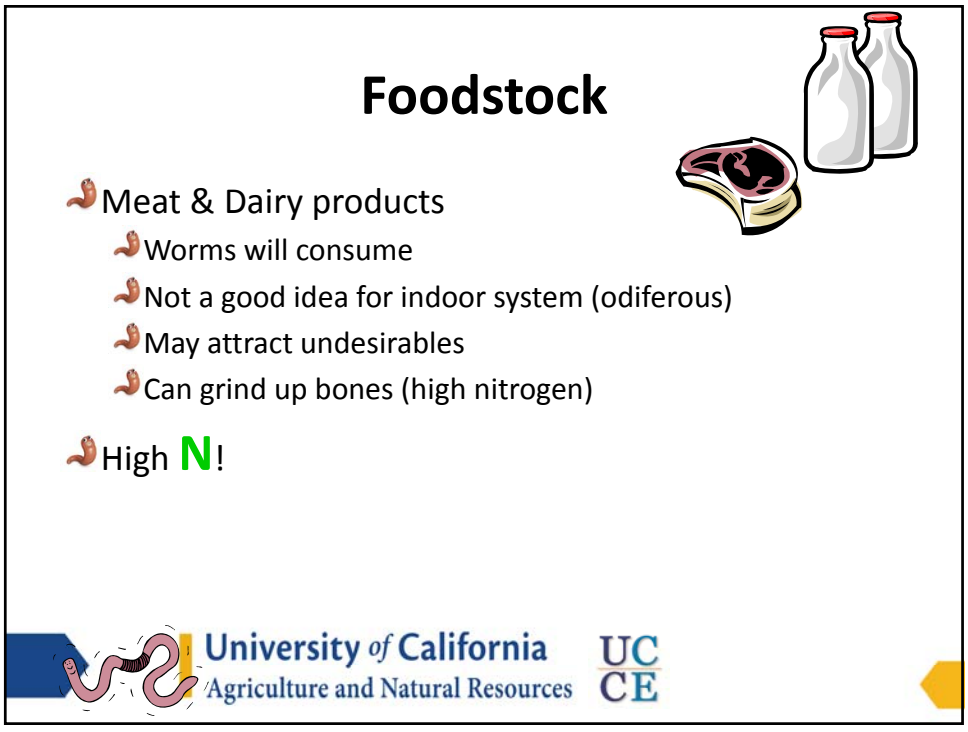
University of California
Agriculture and Natural Resources
UC CE

Bin Care & Maintenance

- Provide adequate bin and bedding mixture
- Maintain moisture level
- Maintain temperature 59-77°F
- Provide air circulation in bin via adequate holes
  - Provides aeration
  - Controls odors by eliminating anaerobic conditions

University of California
Agriculture and Natural Resources
UC CE


Foodstock
DO's
Fruit & vegetable scraps
Banana peels
Grains & cereals, pasta
Tea bags & leaves
Cooked eggs & shells
Coffee grounds & filters
Onions & potatoes
Pancakes
Banana bread, cake
Leaves
Plant cuttings
DON'Ts
Non-Biodegradables
Plastic
Glass
Rubber
Pet feces (cats)
Toxic materials
Ex: orange peels
Plant cuttings treated with herbicides or insecticides
University of California
Agriculture and Natural Resources
UC CE


Foodstock
Meat & Dairy products
Worms will consume
Not a good idea for indoor system (odiferous)
May attract undesirables
Can grind up bones (high nitrogen)
High N!
University of California
Agriculture and Natural Resources
UC CE

Simple Steps – Single-Tiered Bin

- Drill at least twenty ¼" holes into the bottom and upper sides of a plastic or wooden bin and its lid
- Select site to place the bin
- Prepare bedding
  - Shredded newspaper – wet & squeeze
  - Sphagnum Peat Moss – wet & squeeze
  - Manure
  - Leaf litter
  - Old sawdust
- Place bedding material in the bin
- Add a quart of **garden** soil
- Mix the soil and bedding material
- Add worms and cover the bin

University of California
Agriculture and Natural Resources

Simple Steps – Single-Tiered Bin

- **Easy as 1, 2, 3,….**
- After one day add kitchen waste, mix lightly with bedding & cover
- Keep adding scraps and mixing lightly until the bedding and scraps give way to the bulk of castings that are produced and the bin is filled.
- Carefully remove the worms,
  - sell or trade the access
  - save some to restart the process
  - use, sell, store or trade the castings
  - and, start the process over.

University of California
Agriculture and Natural Resources

Simple Steps Multi-Tiered Commercial Bin

- **For a 3+ tier worm bin**
- Set up the legs, spigot, collector tray and the working tray 1
- Prepare bedding – either:
  - Shredded newspaper – wet & squeeze
  - Sphagnum Peat Moss – wet & squeeze
  - Rotted manure - moist
  - Old leaf litter - moist
  - Old sawdust - moist
- Place bedding material in the bin
- Add a quart of **garden** soil to supply microbes
- Mix the soil & bedding,
- Irrigate with one quart of water

University of California
Agriculture and Natural Resources
UC CE

Simple Steps Multi-Tiered Commercial Bin

- Add worms to working tray 1, set aside tray 2 & 3 for later, and cover the bin with the vented lid for 24 hours.
- After one day add kitchen waste, mix lightly with bedding & cover.
- Keep adding scraps & mixing lightly until the bedding & scraps give way to the bulk of castings that are produced.
- Irrigate as needed.
- Let the casting heap 1" above the top of tray 1
- Carefully remove the worms,
  - sell or trade the access
  - save some to restart the process
  - use, sell, store or trade the castings and, start the process over with tray 2

University of California
Agriculture and Natural Resources
UC CE

Simple Steps Multi-Tiered Commercial Bin

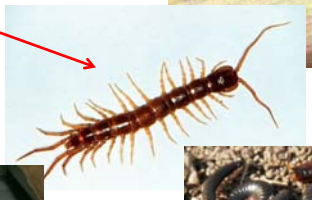
- After tray 2 is filled and the casting heap 1" above the top of tray 2:
- Carefully remove the worms,
  - sell or trade the access
  - save some to restart the process
  - use, sell, store or trade the castings
  - and, start the process over with tray 3
- Scrape off the 1" layer.
- Add working tray 3 and start the process over with the 1" scraped off in step 14.
- When all trays are completely full of casting start the entire process over again.
- Sell or use the casting and sell the worms.

University of California
Agriculture and Natural Resources

UC CE

Other organisms that might "pop-in"

1. Mites & flies
2. Predatory flatworms
3. Centipedes & millipedes
4. Enchytraeids (white worms)

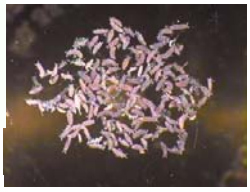


ia
urces

UC CE

Other organisms that might "pop-in"

5. Springtails
6. Sowbugs & pillbugs
7. Bacteria, mold, fungi
5. Ants
6. Blind snake




California
ural Resources
UC CE

Do I need to wait for castings?

- No!
- While worm castings are deposits that have moved through the worm's digestive system and is considered the "final" stage of vermicompost, vermicompost can be considered a combination of :
  - Worm castings and **humic acid** (most degraded organic matter)
  - Worm castings and OM at various stages of decomposition
  - Worm castings, OM and its earthworms and cocoons
  - All of the above + other microorganisms
- It's all good!

University of California
Agriculture and Natural Resources
UC CE

Vermicomposting in Action

- **Redworms**
  (*Eisenia fetida* & *Lumbricus rubellus*)
- Live in the top 12 inches of soil
- Feed on organic decaying matter
- Can eat their body weight in food every day
- Generate 75% of body weight in worm poop (castings) each day
- Lay one cocoon every week or so
- Each cocoon produces 3 to 4 baby worms
- Begin breeding at 4 to 6 weeks of age
- Worms can double population every 90 days
- Live up to 2 years

University of California
Agriculture and Natural Resources

Composting vs. Landfilling

- **Some Numbers to Consider**
- Food and yard waste account for at least 25% of landfill materials
- Most dining halls generate 700 pounds food waste each week
- 12% of total greenhouse gas emissions generated from growing, preparing, and shipping food
- Eating 1 pound of food daily generates 1.5 tons of carbon dioxide (CO_2) annually
- CO_2 impact from edible food waste per person equates to taking 1 to 4 cars off the road
- CO_2, methane (CH_4), and nitrous oxide (N_2O) generated as organic waste decays in landfills
- CH_4 **21 times worse** and N_2O **300 times worse** than CO_2
- Proper composting minimizes greenhouse gas emissions and extends life of landfills by saving space

University of California
Agriculture and Natural Resources

Properties of end product from vermicomposting

- Very finely structured, uniform, stable and aggregated particles of humified organic material.
- Excellent porosity, aeration and water holding capacity.
- Rich in available plant nutrients, hormones, enzymes and (benign) microbial populations.
- **Mostly pathogen-free** since plant and human pathogens are killed during passage of the earthworm gut.
- Earth-like, soil building substance that forms a beneficial growing environment for plant roots.
- Valuable and marketable product.

University of Calif
Agriculture and Natural R

Vermicomposting is practically odor-free

- Earthworms release coelomic fluids into the decaying waste biomass which have anti-bacterial properties and kill pathogens.
- By creating aerobic conditions, the release of foul-smelling hydrogen sulphide from anaerobic microorganisms is inhibited.

University
Agriculture and

Small Scale Vermicomposting

Home Made Bin

University of California
Agriculture and Natural Resources

Small Scale Vermicomposting

Home Made Bin

Small Scale Vermicomposting

Commercial Bin Can-O-Worms

University of California
Agriculture and Natural Resources

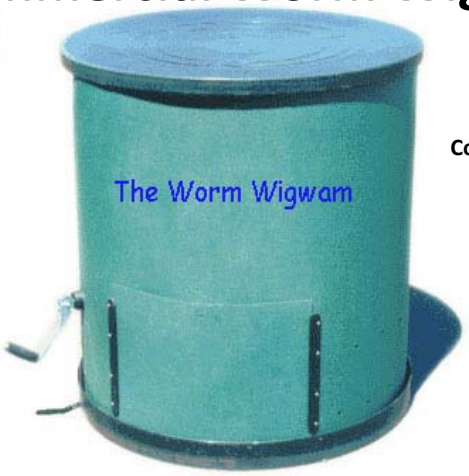
Mid Scale Vermicomposting

Home Made

University of California
Agriculture and Natural Resources

Mid Scale Vermicomposting

Commercial Worm Wigwam

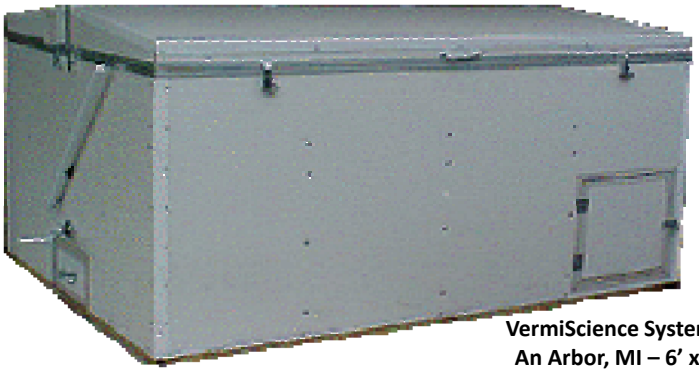


Consuming about 15 Lbs waste/day

University of California
Agriculture and Natural Resources

Mid Scale Vermicomposting

Commercial VermiScience



VermiScience System – U of M,
An Arbor, MI – 6' x 8' 4' deep

University of California
Agriculture and Natural Resources

Large Scale Vermicomposting

EPM Worm Wigwam

50 – 100 Lbs Food Waste/day

University of California
Agriculture and Natural Resources

EPM Flow Through System

EPM manure handling system, 4' x 32', capacity of about 125 lb/day

Agriculture and Natural Resources

Vermitech Food/Paper Digester

Vermitech System – Metro Hall , Toronto – 150 Lbs/Day Food & Paper

Agriculture and Natural Resources

Worm Composting Windrows

Worm Composting Windrow Beds

Vermicycle, Tarboro, NC
15000 Lb/Day Hog Manure

Vermicomposting Castings Utilization

Worms eat only second courses

- Worms eat the microbes that feed on the decaying food, not the food itself;
- Food won't attract them until it starts to spoil;
- Consider pre-composting food.

University of California
Agriculture and Natural Resources
UC CE

Day 1

Day 10

University of California
Agriculture and Natural Resources

Day 20

Day 30

University of California
Agriculture and Natural Resources

Learning Objectives

- To understand the importance of earthworms;
- To understand the basic biology of earthworms;
- To become enthused about the prospects of home vermiculture and vermicomposting;
- Promote sustainability – in your own backyard!

University of California
Agriculture and Natural Resources

Maria de la Fuente, PhD
University of California Cooperative Extension
Farm and Master Gardener Advisor
medelafuente@ucdavis.edu
831-759-7358

University of California
Agriculture and Natural Resources