Animals with a Body Cavity

The animals discussed so far lacked any kind of body cavity

→ organs, when present, were embedded in mesoglea or parenchyma tissue

Virtually all other major animal phyla have some kind of body cavity

They are “hollow” with organs packed into this hollow space

'Tube within a tube' body plan:

→ allows an increase in size

→ allows more elaborate lengthening and coiling of internal organs

→ allows circulation of gasses, food and wastes in the absence of a circulatory system

→ provides hydrostatic skeleton

2 major kinds of body cavities:

**pseudocoelom** and **true coelom**

Both have:

- Three embryonic tissue layers:
  - **ectoderm**: skin, nervous system
  - **mesoderm**: muscles, bones, circ sys
  - **endoderm**: dig and resp tracts

Phylum Nematoda (roundworms)

= eel worms; thread worms

~25,000 known species

Specialists estimate that only ~20% of existing species have been studied and described so far

→ There may be over 100,000 living species

A few fossils known; some in amber

Very common and diverse group but poorly known and difficult to identify

Very simple and highly adaptable design:

- Generally; cylindrical, unsegmented worms, tapered at both ends

- Externally no distinct head or obvious sense organs

Most are very small 0.5-1.0mm

(100th of an inch to 1/5th inch)

Most are colorless and transparent or with whitish or yellowish tint

Most abundant of the pseudocoelomate animals

All other pseudocoelomate phyla have relatively few species

Nematodes may actually be second only to arthropods in number of species

Over two hundred species have been found in a spoonful of beach mud

In terms of sheer numbers, nematodes are probably the most abundant animal on earth

→ 4 of every 5 animals on planet are nematodes

→ 90,000 nematodes were found in a single rotting apple

Occur in virtually all habitats from arctic to tropics; marine, freshwaters, and especially in soil

There is virtually no part of the biosphere that doesn't harbor nematodes

→ Anywhere there is organic matter

Have been found in deep ocean trenches and in hot springs & ice

Common as interstitial fauna

Nematodes are especially common in soil

As numerous in soil as arthropods

Eg. Est 6 M individuals in 1 ft³ of soil
eg. upper 1" of soil may contain <1 Bill/acre
eq 3.5M/m² in tundra soils to 9M/m² in grassland soils

→ virtually every soil sample will yield new species

"If all the matter in the universe except the nematodes were swept away, our world would still be dimly recognizable, and if, as disembodied spirits, we could then investigate it, we should find its mountains, hills, vales, rivers, lakes, and oceans represented by a thin film of nematodes. The location of towns would be decipherable, since for every massing of human beings there would be a corresponding massing of certain nematodes. Trees would still stand in ghostly rows representing our streets and highways. The location of the various plants and animals would still be decipherable, and, had we sufficient knowledge, in many cases even their species could be determined by an examination of their erstwhile nematode parasites."

-N. A. Cobb, 1914, Yearbook of the US Dept of Agriculture, p. 472

enormous ecological importance

living species feed on a variety of organic material

→ aerate soil

→ recycle nutrients

→ decompose toxins and wastes

there is no sharp distinction between aquatic and terrestrial species

all nematodes including soil nematodes are essentially aquatic

→ live in water film around soil particles

nematodes also parasitize virtually every type of animal and plant

~60% of all known nematode species are parasitic

virtually every species of vertebrate and many invertebrate groups are hosts to nematode parasites

human parasites are the best known of the nematodes but make up only a small percentage of total species

a study done in 1947 found 99% of people around the world were infected with nematode parasites

"everyone in the world has either had a threadworm infection, has it now, or will have it in the future"

some of the largest roundworms are parasites,

eg. largest nematode is a parasite of a whale → 27 feet long

Body Organization

elongated, wormlike body; mostly small

few external features

difficult at first glance to distinguish front from back end

"tube within tube" design

animals with simple fluid filled body cavity around internal organs=pseudocoelom

persistant blastocoel

mesoderm present only on external face of cavity

gut lacks muscle layer

three true tissue layers (=triploblastic)

ectoderm → skin, nervous system

mesoderm → muscles, bones, circ sys

endoderm → dig and resp tracts

eutely is common

→ fixed number of cells in adult of each species

Body Wall

body wall a syncytial epidermis

adhesive glands usually present,

no cilia

secretes tough, flexible cuticle containing collagen

→ protects worms from abrasion in soil and sediment

→ protects parasites from digestive enzymes

some have an elaborately sculpted cuticle

probably helps them move through soil or sediment

cuticle is sometimes molted as animal grows

cuticle sometimes shows superficial segmentation

their cuticle is highly resistant to fairly extreme environments and conditions

→ some can survive pH's from 1.5-11.5

→ some can survive mercuric chloride solutions that would kill most other animals

→ only living organisms to survive a space shuttle explosion

eg. 6 canisters of C. elegans survived the Columbia disaster

allows them to survive in many unusual habitats including:

eg. as parasites of both plants and animals

eg. in hot springs

eg. vinegar eel can live in concentrated mercuric chloride that would kill most other animals

eg. vinegar eels

a very common soil animal

feeds on rotting fruit; can thrive in a wide pH range from 1.5 to pH=11.5
before vinegar was pasteurized it was usually found in commercial vinegars (cider vinegar from fermented apples)

eg. a related species is found in pitcher plants

eg. another species has only been found in the felt coasters under beer mugs in German pubs

body wall with **longitudinal muscles** only

fluid filled **pseudocoelom**

→ important as a **transport** medium for oxygen, foods and wastes

→ pressure created by tough cuticle and muscle layer creates **hydrostatic skeleton**

**Movement**

unlike most wormlike animals they have only **longitudinal muscle** in body wall

hydrostatic pressure in fluid filled pseudocoelom maintains internal pressure and keeps body wall from collapsing

(circular muscle does this in other worm phyla)

produces characteristic whiplike or snake-like thrashing motion; "S"

**Feeding and Digestion**

nematodes feed on a wide variety of foods:

but almost all nematodes eat **living cells**

some are predatory **carnivores**

beef small or microscopic animals

some are **phytophagous**

→ pierce plant cells and suck out contents

many marine worms feed on diatoms and other algae

many are **parasitic** in plants and animals

roots of practically all plants are attacked by some kind of nematode worm

~20-35% of nematodes found in soil are actually plant parasites

some feed on bacteria and fungi and are typically found on or in dead organic matter such as dung or decomposing bodies

a very few may be **saprobics**:

eat dead or decaying matter
digestive system with muscular **pharynx**

often with retractable piercing **styles**

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all the root eaters have a syringe-like **stylet**

that injects digestive juices into root to liquify meal

**complete digestive tract:**

**mouth** is at front end leads to

**muscular pharynx** which is able to produce a suction to draw in food

food passes into a

**long straight intestine** where it is digested and absorbed

no muscles lining intestine

- collapsed thin tube

intestine only 1 cell layer thick

almost all digestion is extracellular

undigested material exits through **anus** near (but not at) posterior end

they have a "**postanal tail**", unusual in inverts

**Nervous System**

"brain" = nerve ring with **ganglia** around pharynx
dorsal and ventral nerve cords

→ mainly controls dorsal and ventral muscle layers

muscles send processes to nerve cord

(opposite more common structure where nerve cells extend to muscle cells)

(this also occurs in some flatworms, gastrotrichs, and others)

muscle cells are interconnected so muscles on each side contract together

→ produce whip-like or thrashing contractions characteristic of these organisms

**Senses**

especially chemoreceptors sometimes in head or tail

**Excretion**
unique excretory system:

excretory system a series of canals or tubules or interconnected glandular cells (=renette cells)

sometimes with protonephridia

tubules form lateral line along sides of animal visible from the outside

empties through excretory pore near front of animal

no circulatory or respiratory system

pseudocoelem fluids circulate nutrients, oxygen and wastes

**Reproduction**

all nematode species show incredible reproductive abilities

most species have separate sexes (dioecious)

and show sexual dimorphism

sperm lack flagella or cilia

→ they are amoeboid

most with internal fertilization

after mating, females lay 100,000 eggs/day

eggs often extremely resistant to environmental extremes

eg. Ascaris eggs remain viable in 5% formalin

development is usually direct; no larval stage

usually 4 juvenile stages; but resemble adult

juveniles grow by shedding (molting) old cuticle

in some species one of the juvenile stages becomes an inactive, resistant stage

→ can survive for months or years until conditions improve

some can enter a state of arrested activity = cryptobiosis

→ makes them successful in seemingly unfavorable environments

eg. some have been dried for several years then rehydrated

eg. some have been placed in liquid air (-194°C (= -317°F)) and revived afterwards

**Ecological Effects of Nematodes**

while rarely studied and relatively unknown, they occur in large numbers in virtually every habitat

→ nematodes are of enormous ecological importance

they feed on a variety of organic materials and are an important part of all food webs

they are fundamental in recycling nutrients in all ecosystems

they also help decompose toxins and wastes

soil nematodes help to aerate the soil

since many nematodes parasitize plants and animals they play key roles in population and community ecology within most ecosystems

**Human Impacts of Nematodes**

1. Plant Parasitic Nematodes

cause extensive crop damage and billions in food & fiber damage each year

up to 15% of our agricultural crops are damaged by nematodes each year; or $8 billion/yr in US

$78 billion/yr worldwide

→ these are probably low estimates

most plants can tolerate these parasites to some degree

but when the balance is tipped in favor of the parasite large scale damage may ensue

also damage ornamental plants, turf grasses and greenhouse plants

eg. Golden nematode (Heterodera)

parasite of potato plants

chemical in soil diffusing from plant stimulates emergence of larva from cyst and attracts it toward plant

2. livestock & pets also suffer heavy losses

eg. Dog Heartworm (Dirofilaria immitis)
a major global pest that affects dogs, cats, wolves, coyotes, foxes among others
in US common in all 50 states, but especially common in SE US in which ~45% of pets are infected
requires two hosts
mosquito is the intermediate host
ingests juveniles when it bites dog
transfers it to uninfected dog when another is bitten
in final host (dog) the juveniles undergo further development
dogs can have juveniles circulating in their blood and lungs without symptoms
once the number of worms exceeds a certain
number based on size of host the adult worms move to the heart (usually 6-7 mo.)
and establish themselves in the right side of the heart
adult worms can reach 12” long and live for several years
after mating, females bear live juveniles (=microfilariae) into the blood
the microfilariae can circulate for up to 3 years “waiting” to be picked up by a mosquito
symptoms begin years after initial infections
begin as soft cough which worsens as the infection increases
leading to congestive heart disease
untreated dogs die; treatment is difficult and takes several weeks of discomfort to the dog to rid it of the parasites
a few human cases are known
eg. _Toxocara canis_
common intestinal helminth infection in dogs and kittens
virtually all puppies and 20% of kittens are infected until wormed
relatively mild symptoms in pet
can infect children but wont complete life cycle → usually killed in liver or lungs
but can wander through various tissues and organs causing inflammation
human infections are fairly common; 3-20% in children, especially in SE US especially urban children
similar life cycle to _Ascaris_
may be associated with neuropsychological effects

3. some species are important human parasites
about 50 species of nematodes are able to parasitize human hosts
virtually every human is host to some parasitic nematode at some time in their life
they are not really parasites, they feed on material in intestine
if another worm of opposite sex is there they mate
female can release ~200,000 eggs/day (~8 M/lifetime)
symptoms of infection:
juveniles:
local inflammation if they get into wrong tissue
if large numbers in lungs → fever, spasms, coughing, severe pneumonia-like symptoms, allergic rxns
adults:
a few adults → minor effects
many adults → if “worm burden” is to great may cause blockage
adults also have a tendency to “wander”; particularly if living conditions become unfavorable
eg. fever, anaesthetics, worming tablets
they may exit the anus or out the mouth
occasionally may perforate intestine or enter bile ducts
eg. _Pinworms (Enterobius vermicularis)_
the most common nematode infections of humans worldwide
small; ~12mm (0.5-.75”)
unusually, its more common in temperate areas than in tropical areas

Some Examples of Nematodes

eg. _Ascaris sp._
the largest human nematode parasites; ~ 10 - 12” (up to 30 cm) long
found exclusively in humans
1 Billion people in world are infected
common in tropics; in some countries over 50% of children are infected
even in US infections are not uncommon
main cause of infection is fecally contaminated food
Ascaris eggs are resistant to concentrated bleach and formalin
they are also coated with an extremely sticky coating to adhere to almost anything
egg can survive >7 yrs after any trace of feces is gone
after ingestion the juvenile burrows into blood/lymph vessels
→ circulates into lungs
→ enters alveoli and ascends trachea or is coughed up and reswallowed
become adults in the intestine
adult worms can survive for 25 years
the most common helminth infection in US
30% children infected
16% adults infected
more common in US in Caucasians than African Americans - don't know why

seldom a health problem
adult feeds on bacteria and wastes; not on hosts tissues
dioecious
after copulation male dies
eggs are not released into feces
instead female crawls to anus to deposit ~1500 eggs when host is asleep
day or night → worm keys on sleep physiology of host
infections not dependent on fecal contamination for spread
→ eggs are spread directly
→ eggs are very resistant
eggs are highly contagious
can cause intense itching
eggs spread on sheets and in the air
infections easily transferred to entire household
eggs can also hatch and reenter the intestine

eg. Trichina worm (Trichinella spiralis)
probably the most serious roundworm disease of humans
causes trichinosis: a potentially lethal disease
smaller than a pinworm → barely visible
in US an estimated 2.5% of the population is infected each year;
~750,000/yr
infections are also common in other parts of world
often appear in small sporadic outbreaks
each worm requires two separate hosts to complete its life cycle:
occurs in several hosts: humans, pigs, rats, bears and other carnivores
each may serve as intermediate or final host
juveniles travel through blood and encyst mainly in muscle tissue of intermediate host
when raw or poorly cooked meat is eaten, juveniles mature into adults in intestine of final host
after mating, the female burrows into the wall of the intestine and releases juveniles into the blood
juveniles circulate to all parts of body
but coil up and encyst only in skeletal muscle cells

eg. Hookworms (Necator sp. & Ancylostoma)
named for its hooklike anterior end where the head is bent into a curved shape
up to 11mm long
found in tropics and subtropics
one of the most dangerous roundworm parasites
> 600 Million infected worldwide
adults live in intestine; blood feeders
large plates in mouth cut into intestinal lining to suck blood
often cause excessive blood loss while feeding

symptoms of infection
from encysted juvenile
range from mild to life threatening
light → soreness; achy muscles
heavy → esp dangerous if in heart
juveniles can remain viable for up to 2 years, but are slowly calcified

eg. Filarial Worms
8 species (include Wuchereria bancrofti, Loa loa, river blindness (=onchocercosis))

eg. a “mild” infection of ~1000 worms can cause a loss of 100 mL/day (3.3 oz)
heavy infections can cause anemia and weakness in children can cause retarded physical and mental growth

Reproduction & Life Cycle
dioecious: male smaller than female
female can produce 25000-3000 eggs/day for up to 5 yrs
eggs released in feces
juveniles hatch in soil
feed on bacteria, 2-3 days
juveniles climb to the top of a blade of grass and wait for a host to walk by
when juvenile contacts skin it immediately burrows into blood vessels to lungs, then climb up trachea
swallowed and reattach as adults in intestine

eg. Filariasis
8 species (include Wuchereria bancrofti, Loa loa, river blindness (=onchocercosis))
females up to 10 cm (4") long
250 Million humans are infected
common in tropical countries
highest rates of infection are in Sri Lanka

(not easily detected by fecal exam since female lays eggs on skin outside anus; use ‘scotch tape test’)

female worms release live young (=microfilariae) into blood
mosquito or fly is an intermediate host and vector of spread

**microfilariae** move to peripheral blood on periodic basis
corresponds to "biting hours" of local vector
eg. Loa loa → diurnal vector
eg. *Wuchereria* → nocturnal vector = mosquito
but in S Pacific vector bite in day so are diurnal here
eg. in some places, no cycling of vector so no cycling
of movement to peripheral blood

eg. several species of filarial worms, including *Wuchereria* sp., cause
Elephantiasis
infects 120 Million/yr in Africa & Asia
the juvenile worm is carried by mosquitoes
in host adult worms live in lymphatic system
symptoms associated with inflammation and obstruction of
the lymphatic ducts
results in excessive enlargement of affected parts
esp in arms, legs, scrotum

eg. Human Whipworm (*Trichurus*)
a medium sized worm (3-4cm)
1st 2/3rds of animal is thin and hairlike, last one third is thick;
animal resembles a whip
found throughout the world, especially tropics

has been eliminated throughout the world except for Southern
Sudan mainly by clean drinking water

almost 1 Billion humans infected
other species infect many other kinds of vertebrates
lives in large intestine
after mating eggs are passes with feces
can release 7000 eggs/day
eg. in some places, no cycling of vector so no cycling
of movement to peripheral blood
juveniles in intestine mature into adult
new data shows the eggs are triggered to hatch by gut
bacteria → prevents them hatching in stomach
adults feed on living tissue resulting in more severe symptoms:
normal: diarrhoea, abdominal pain, nausea
heavy infection may lead to intestinal bleeding and anemia
or rectal prolapse (protrusion of the rectum out through the
anus

treatment is difficult since *Trichuris* is resistant to commonly
used drugs

eg. Guinea Worm
a water borne parasite
emerges painfully through the skin to release its eggs into the
water

4. evidence is mounting that some parasitic infections
may have benefit in decreasing allergies and
asthma
→ it dampens an overactive immune system
proteins secreted by some parasites dampen our
immunity
eg. 2007-a study of 1600 vietnamese children infected
with hookworm only 60% were allergic to dust mites

helminths are able to survive in hosts because
they can suppress the host's immune system
light infections of flukes and other helminths are
used to control allergies and some
autoimmune diseases

nematodes are often able to suppress the immune
system of the host to produce a more
favorable environment

5. some parasitic nematodes show promise as
biological controls against insect crop pests

6. *Caenorhabditis elegans* important biological
“model” in research (one of a handful; eg. lab rat,
fruit fly, E. coli, etc

used to study: genetics, nervous physiology, cell
physiology, aging, etc.
we know:

its complete wiring diagram of nervous system

origin and embryological lineage of all 959 cells making up its body

entire genome of 19,820 genes has been mapped