Phylum Cnidaria
(=Jellyfish & Corals)

9,000 living, 9,300 fossil

include:
- jellyfish
- sea anemones
- corals
- sea fans
- sea whips

another very **ancient group** with lots of **fossil** representatives

longest fossil history of any animal

known fossils are even more ancient than sponges

going back at least 700 M years

(plenty of hard parts – corals)

in terms of evolutionary history they were the 1st animals to appear that had a definite shape

all known animals at that time were sessile organisms; cnidaria (jellyfish) may have been the first animals to swim

radial symmetry

most members of the phylum (eg. corals) are **sessile**

often beautiful and graceful "plant-like" or "flower-like" forms with one or more rows of large tentacles extending from body

like sponges, ancient scholars considered them some kind of plant

not considered animals until 1700's

but some (eg. jellyfish) swim weakly as part of the **zooplankton**

though sessile almost all are extremely effective **predators**

jellyfish are among the **longest** of animals
up to 9' diameter with 120' tentacles

some colonial forms can grow up to 150' long

as a colony, they rank as some of the longest – lived animals on earth

eg. a gold coral colony off the coast of Hawaii was recently (2009) dated at 2742 years old

eg. a black coral in the same area was dated at 4265 years old

all are **aquatic**

widespread in marine habitats
→ especially shallow waters, warmer oceans

a few found in freshwaters

all but 1 species of fw cnidarians are polyps

but there is one small fw jellyfish: *Craspedacusta*

many are **colonial**

→ groups of individuals usually living together and interconnected eg corals

eg. a single coral colony can contain millions of individuals

tissue level of organization

more complex than sponges but still very simple

do have true **tissues**

only a few very simple organs

Body Forms

many cnidarians are **polymorphic**

→ with 2 or more separate body forms

with an alternation between forms

→the same species has 2 distinct forms

polyp (=hydroid)
medusa (=jellyfish)

polyp

tubular body
usually sessile – though some can move
upward facing mouth surrounded by tentacles

medusa
umbrella shaped
mouth facing downward
often, thick jelly-like layer in body wall
→ jellyfish
motile: contractions of "bell"
free floating, pelagic planktonic

polyp ⇄ medusa

sessile	motile
asexual	sexual
benthic	pelagic

Cells & Tissues

two true tissue layers, not the 3 typical of animals

=diploblastic
epidermis & **gastrodermis**

2 well defined germ layers:
ectoderm
endoderm

become two adult tissues
epidermis
gastrodermis

between the two tissues is a jelly layer called **mesoglea**

→ very thick in "jellyfish"

nontissue layer of mesoglea in between

in a few species this mesoglea is replaced by 3rd true tissue:

mesoderm → connective tissue

Body Wall

epidermis – tissue layer that lines outer surface

mesoglea – jellylike middle layer; not tissue layer

gastrodermis – tissue layer that lines GVC

1. Epidermis

outer "skin" of the animal

consists of cells that cover and protect

also contain special stinging cells

some areas also have gland cells for attachment

contain nervous and sensory cells

most epidermal cells contain contractile fibers and act like muscle cells to produce movement

Cells of Epidermis:

a. epitheliomuscular cells
- covers outside of body
- tall T shaped, columnar cells
- base elongated with myofibrils
- muscular contractions

b. interstitial cells
- undifferentiated cells
- can form cnidocytes, nerve cells, sex cells, etc
- but not epitheliomuscular cells

c. gland cells
- around basal disc and mouth
- secretes mucus and adhesives
- those in basal disc can secrete gas bubble for floating

d. cnidocytes
- stinging cells, more later

e. sensory cells
- scattered but especially near mouth and tentacles
- respond to chemical and tactile stimuli

f. nerve cells
- most multipolar (3 or more processes)
- form synapses with sensory cells and other nerve cells
- connect to epitheliomuscular cells and cnidocytes

2. Mesoglea

not really a tissue layer, just a layer of jelly-like secretions

very thin layer in polyps; much thicker in medusa thus "jellyfish"

3. Gastrodermis

inner lining of the digestive sac

mademostly of cells that digest and absorb food

these cells also contain contractile fibers for movement

Cells of Gastrodermis:

a. nutritive muscular cells
- tall T shaped, columnar cells
- ciliated
- base elongated with myofibrils
- lines GVC
- in some freshwater species cells contain green algal symbionts
- in some marine species cells contain dinoflagellate algal symbionts

b. Interstitial cells
- scattered
- transform into other cells as needed, see above

c. gland cells
- in hypostome and scattered throughout
- some secrete digestive enzymes
- mucous glands around mouth

Movement

typically polyp is sessile and often secretes a cup like

cavity in which it lives

muscle layers in body wall contract against **hydrostatic skeleton**

some polyps of noncolonial forms are motile

eg. fw hydras are not permanently attached
- → can glide on pedal disc
- → inchworm movements using tentacles
- → gas bubbles and float to surface

medusae are more mobile

have **hydrostatic skeleton**

nerve net controls contractions of bell for swimming

Feeding and Digestion

all are carnivores

most species have one or more rings of **tentacles** surrounding mouth

armed with **cnidocytes** (=stinging cells) for capturing prey

Stinging Cells (cnidocytes)

one of the most characteristic features of the phylum

used for feeding and defense

inside each cell is harpoon-like **nematocyst**

→ highly coiled tubular thread
→contained within a capsule like organelle
→ triggerlike cnidocil (tactile trigger)

when triggered can fire in a fraction of a second

discharge due to:

high osmotic pressure within (140 atm; 10x's sea level)
when stimulated to discharge water rushes in
forces thread out with great force – turns inside-out as it extends at 2m/sec
causes barb to flick out like tiny switchblades to impale prey

each cell operates independently

can differentiate between animate and inanimate objects

→ doesn't just fire at anything

cnidoblast must grow new nematocyst after firing

over 20 different kinds

some wrap around prey or are sticky

some with tiny barbs that impale prey & inject poison

most are not harmful to humans

eg. most sea anemones stings are harmless

but a few are very painful

eg. Portuguese Man-O-War and some corals

a few can be fatal

eg. cubomedusae (box jellies)

digestive system is a **mouth** that opens into a saclike cavity

= **gastrovascular cavity** lined with gastrodermis

single opening = **mouth**

incomplete digestive tract → mouth only

digestion mostly extracellular, but some intracellular

most are **predatory**

use cnidocytes to capture and paralyze prey
use tentacles to move prey toward mouth
engulf prey with mouth

inside GVC gland cells secrete digestive enzymes

nutritive muscular cells take in particles by pseudopodia

intracellular digestion completes the process

indigestible material is expelled through mouth

No respiratory or excretory system

<u>Coordination and Control</u>

no head, no cephalization, no CNS

very simple nervous system, no brain

= **nerve net**

mostly for coordinating contractions in body

diffuse network of nerve fibers connect to:
sensory cells
cnidocytes
epitheliomuscular cells
nutritive muscular cells

some simple sense organs:
statocysts → balance
ocelli → light

polyp
simple sensory cells scattered in epidermis

medusae
clusters of sense organs = **rhopalium**

at margins of bell
often between lappets
contains
ocelli → detect light
statocysts → balance organs
sensory pits → chemoreceptors

<u>Reproduction</u>

both sexual and asexual reproduction

asexual:
asexual reproduction usually by **budding**

if buds remain connected = colonial

fission
sea anemones only
pedal laceration

sexual:
most are dioecious
many shed gametes into water
gonads are epidermal in hydrozoa
gonads are gastrodermal in other groups

little is know of **lifespans** but one sea anemone kept in an aquarium lived for 80 years until the tank was accidentally drained

some jellyfish can live up to 10 years

embryo in marine species is usually a **planula**

in many members of the group there is an **alternation of generations** between

polyp which reproduces **asexually** and the

medusae which reproduces **sexually**

Classification

Class: Hydrozoa

most are marine, a few are freshwater
individuals usually small and inconspicuous
polyp is dominant stage, some completely lack medusa
medusa when present has velum around margin
no septae in GVC, no pharynx (=throat), no cells in mesoglea
most are colonial - small plant-like appearance
most have polymorphism with alternation of generations

Class: Scyphozoa (true jellyfish)

most of the larger jellyfish belong to this group
medusae without velum, cells in mesoglea
all are marine
solitary polyp stage reduced or completely absent
thick jelly layer (=mesoglea)

Class: Cubomedusa (box jellyfish, sea wasps)

cubical jellyfish with extremely potent toxins - some lethal

Class: Anthozoa (Corals and Sea Anemones)

="flower animals"
all are marine
polyp only; no medusa stage
many cells in mesoglea
polyp with septae and pharynx
some are solitary = sea anemones, usually larger
most are colonial = corals, polyps usually small
most secrete skeleton of calcium carbonate or protein

A. Class Hydrozoa

most are marine, a few are freshwater

some are colonial

most have **polymorphism** with **alternation of generations**

polyp is dominant stage

some, eg *Hydra*, lack medusa stage

colonial species often have more than two body forms in same organism

different forms act like separate organs and are specialized for feeding, stinging, reproduction

eg. *Hydra* (hydra)
freshwater species
very common in ponds and creeks
feeds on small crustaceans
seems to "prefer" Daphnia
no medusa stage
→ polyp reproduces both asexually and sexually
asexual:
budding as outpockets of body wall
continuous GVC
eventually detach
sexual:
dioecious ovaries or testes are temporary organs on side of polyp
usually appear in autumn (low temp, low O_2)

eggs usually mature 1 at a time
eggs fertilized by sperm, then shed
cyst forms around embryo – overwinters
no larval stage
young hydras hatch from cyst in spring

eg. *Obelia*
common in nearshore marine habitats

more representative of class

have both **polyp** and **medusa** stage

colonial hydrozoan → interconnected hydroid colony

attaches to substrate by rootlike hydrorhiza

branching body = **hydrocaulus**

living tissue = **coenosarc**

chitinous protective covering = **perisarc**

attached to hydrocaulus are individual polyps

two types of **polyps**:

1. **hydranths = feeding polyps**
tubular or vaselike
mouth surrounded by tentacles
capture and ingest prey: worms, crustaceans, larvae
provide nutrition for whole colony
→ digested broth passes thru common GVC of whole colony
cilia of nutritive muscular cells move it

2. **gonangia = reproductive polyps**
no tentacles
medusa bud off sides

medusae

produced by gonangia
small; 2-3mm
velum surrounds inside of bell margin
mouth at end of manubrium
radial canals extend from GVC to margins of bell and ring canal
GVC also extends into tentacles from ring canal

eg. *Craspedacusta*

the only freshwater medusa
hydroid colony is microscopic in size; <2mm
medusa .5 – 1″ in diameter

eg. *Physalia* (Portuguese Man-O-War)

colonial hydroid form
irridescent purple color
common on gulf coast
can produce painful sting even if dead
but with several different kinds of polyps
float = swimming bell filled with gas
gastrozoid polyps = each with single long tentacle
dactylozoids = fishing tentacles
gonophores = sacs of ovaries or testes

a symbiotic fish, *Nomeus*, swims among the tentacles

B. Class Scyphozoa (true Jellyfish)

most of the larger jellyfish belong to this group
a few up to 2 m in diameter

contains one of the longest animals; lion's mane jellyfish → over 120'

all are marine

with few or many tentacles around margin of bell

medusa stage is dominant

solitary polyp stage reduced or absent

thick jelly layer (=mesoglea)
may contain amoeboid cells and fibers

medusa has no velum

Movement

jellyfish are the most motile members of the phylum

more complicated muscle layers:

muscles arranged in radiating and circular bands

contractions of these muscles allow the organism to propel itself to some degree

still, jellyfish are considered part of the **zooplankton** (the largest members) since they are not strong enough swimmers to go against the current

watching some jellyfish swim looks like they're not going anywhere

but contractions of bell creates water currents that draw food through tentacles and toward mouth
→ its not 'trying to go anywhere'

in a few species the medusa is sessile and spends its life laying upsidedown on the sediment

Feeding

mouth hangs down under umbrella on the end of a throat-like **manubrium**

GVC extends into radiating canals or pouches

all jellyfish are **carnivorous**

they eat mostly zooplankton, smaller fish and other jellyfish

larger ones may eat shrimp and other crustaceans

jellyfish are eaten by spadefish, sunfish and loggerhead turtules

only a few dozen of the 500 or so species of jellyfish are dangerous to humans

Nervous system & senses

since jellyfish are motile their sense organs are better developed than other members in the phylum

jellyfish in this class have a greater variety of sense organs than other jellyfish

scalloped margins of bell with indentations bearing **lappets** and **rhopalia**

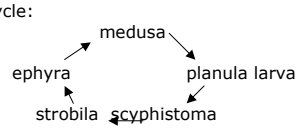
with **ocelli**, **statocysts** and **sensory pits**

reproduction & life cycle:

medusa stage is the sexual stage

polyp is asexual stage
buds off small medusa

jellyfish life cycle:



many jellyfish live less than a year

but a few arctic species live up to 10 years

eg. *Aurelia* (moon jelly)

common off Texas coast

7-10 cm diameter; some up to 2 feet
scalloped margin with indentations bearing lappets and rhopalium with ocelli, statocysts and sensory pits
mouth on manubrium drawn out into 4 frilly **oral arms**
feeds on small planktonic organisms

male releases sperm threads into water

female collects and eats them to fertilize eggs

eg. Cannonball jellyfish

eg. Lion's mane jellyfish

one of largest
can be 8' in diameter
tentacles can extend to 200'

C. Class Cubozoa (box Jellyfish, sea wasps)

poorly known group

once considered as a group of scyphozoa

medusa is dominant form, polyp is inconspicuous

most are relatively small; <1"

tentacles are at each corner of cubical bell

eg. sea wasp (Chironex fleckeri)

ranges from Indian ocean to coral sea

the most poisonous sea creatures known

since 1884, it has killed more people along the northern Australian coast than have sharks in the area

D. Class Anthozoa (Corals and Sea Anemones)

="flower animals"

all are marine

→range from deep to shallow water

some are solitary = sea anemones, usually larger

most are colonial = corals, polyps usually small

polyp only; no medusa stage

GVC large

muscular infolding of mouth = **pharynx**

GVC partitioned by **septa** (=mesenteries)

mesenteries can be complete or incomplete

free edge of incomplete septae form **septal filaments** with nematocysts

in some, lower septal filament prolonged into **acontia**

also with nematocysts

→ can be extruded thru mouth or

pores in body wall to help catch prey

3 major groups in class:
1. sea anemones and stony corals
2. sea fans, sea pansies, sea pens, soft corals
3. tube anemones and thorny corals

eg. anemones

especially common in tropical waters

much larger than their coral relatives; some 3' dia

mostly sessile, but some can glide on **pedal disc**

some form interesting mutualistic relationships with other organisms

almost every specimen is a host to a variety of fish and other reef animals (shrimp, crab, fish)

immune to the lethal stinging cells

eg. clown fish
over 50 species of fish associated with anemones (also some shrimp)

fish symbionts are stung on first contact (on tail or nonvital body part)

→ then body mucous or slime is chemically altered so the fish is not affected by further stings

must continually refresh mucus layer

eg. zooxanthellae – algae

eg. attach to shells of hermit crabs

reproduce by fragmentation; they leave pieces behind as they move

eg. hard corals (stony corals)

colonial polyps

produce rock-like calcareous cups (=theca)

secreted by lower half of polyp

=exoskeleton for support and protection

form extensive structures in warm shallow waters

reef structure consists of compressed & welded together:
calcium carbonate coral skeletons
encrusting coralline algae
foraminiferan shells
bivalves
sea urchin plates

continually destroyed by:

sponges, worms & clams bore into reef

waves reduce it to white sand

crown of thorns starfish (*Acanthaster*) feeds on polyps and decimates populations

highly resilient communities → regenerate quickly

eg. soft corals (octocorallia)

secrete a flexible **endoskeleton** of spicules or keratin-like protein

eg. sea pens, sea pansies, sea fans, whip corals, pipe corals

toxins from soft corals, *Palythoa*
→ used as antitumor medication

sea whips & sea pens

sea fans

eg. tube anemones

secrete tubes

Ecological Interactions

1. most are aggressive **predators**

eg. a single lions mane jellyfish was found with >200 fish within its tentacles

many jellyfish species congregate into large swarms of up to 1000's of individuals and can devastate prey in an area

-often triggered by eutrophication

2. also **prey** for a variety of specialized predators

eg. parrot fish, butterfly fish, tangs eat coral polyps

eg. sea turtles like jellyfish

unfortunately many are suffocated by eating plastic bags floating in the ocean

eg. a number of sea slugs (nudibranchs) eat them but store unfired nematyocysts in their skin and use them for defense

3. numerous **symbioses** within this phylum

many live as commensals on shelled animals

eg. **anemones** form interesting mutualistic relationships with other organism

eg. decorator crabs

eg. clown fish (immune to nematocysts)

over 50 species of fish associated with anemones (also some shrimp)

fish symbionts are stung on first contact (on tail or nonvital body part)

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eg. most **corals** are mutualistic with **zooxanthellae** (dinoflagellate algae)

4. Coral Reefs
(see separate set)

Economic Importance:

1. in orient a few jellyfish are eaten

   eg. people in China and Japan eat the mushroom jellyfish; fresh or pickled

2. stinging cells of some cnidaria are lethal to humans

   eg. box jelly or sea wasp (*Chironex fleckeri*)

   from Indian ocean to coral sea - esp around coast of Australia

   can have up to 60 tentacles as long as 15 feet.

   most poisonous sea creature known

   stings can kill a human in 5 minutes

   each has enough toxin to kill 50 humans

   since 1884 at least 5,567 deaths have been attributed to these creatures.

3. Pharmaceuticals

   anti-inflammatories, painkillers for arthritis, antimicrobials

   cardiac stimulant from sea anemone

4. in clinical trials (2009) is a process developed to harvest stinging cells, remove their venom and then use them to inject painkillers or insulin into the skin

5. a green fluorescent protein extracted from jellyfish (also found in fireflies) and used to build tiny fuel cells which could be useful in powering nannodevices used to diagnose and treat diseases in the body

6. in 1991 2500 moon jellies flew aboard the Columbia space shuttle

   to study how their balance organs develop under weightlessness