Phylum Cnidaria
(=Jellyfish & Corals)

9,000 living species, 9,300 fossil species

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

another very ancient group with lots of fossil representatives

simplest living animals with true tissues

longest fossil history of any animal

known fossils are even more ancient than sponges

(plenty of hard parts – corals)

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

radial symmetry

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

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

body wall is made of 2 layers of tissue

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

Cells & Tissues

two true tissue layers, not the 3 typical of animals

polyp (=hydroid)

tubular body

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

medusa (=jellyfish)

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

epidermis & gastrodermis

2 well defined embryonic layers:

ectoderm endoderm

become two adult tissues

epidermis
Animals: Phylum Cnidaria; Ziser Lecture Notes, 2015-9

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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

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

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

cavity in which it lives

some polyps of noncolonial forms are motile

eg. fw hydras are not permanently attached
gliding 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
intracellular digestion completes the process
indigestible material is expelled through mouth

**No respiratory or excretory system**

**Coordination and Control**
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**

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

**Life Spans**
little is know of lifespans of cnidaria
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

**Reproduction**
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
gonads are epidermal in hydrozoa
gonads are gastrodermal in other groups

most shed gametes into water, often mass spawnings

but one species of box jellyfish actually have a "wedding dance"

begins as male takes hold of female tentacle and pulls her around in the water

he then draws her close, male and female become entwined, so that their manubria touch

male deposits a spermatophore on one of her tentacles and releases her

the female ingests the spermatophore which then fertilizes her eggs

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

some Cnidaria can switch genders

males require less food and energy and can more easily survive harsh conditions

when conditions improve more will turn into females to insure their success in producing offspring

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 vase-like
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

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 O2)

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. Obelia (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

eg. Obelia

common in nearshore marine habitats

more representative of class have both polyp and medusa stage

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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

e.g. Craspedacusta
the only freshwater medusa hydroid colony is microscopic in size; <2mm medusa .5 - 1” in diameter

e.g. Physalia (Portuguese Man-O-War)
colonial hydroid form iridescent 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

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: ephyra planula larva strobila scyphistoma

many jellyfish live less than a year but a few arctic species live up to 10 years

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 → it’s 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 turtles only a few dozen of the 500 or so species of jellyfish are dangerous to humans
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
e.g. Cannonball jellyfish
e.g. 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
e.g. 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

e.g. anemones
especially common in tropical waters
much larger than their coral relatives; some 3’ dia
mostly sessile, but some can glide on pedal disc
although anemone’s move in slow motion, some group living species actually battle each other for territory using specialized tentacles for battle
reproduce by fragmentation; they leave pieces behind as they move

e.g. 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 reef 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 \(\rightarrow\) 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
sea whips & sea pens

**eg. tube anemones**
secrete tubes

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**Ecological Interactions of Cnidaria**

1. most are aggressive **predators**
   eg. a single lions mane jellyfish was found with >200 fish within its tentacles
   eg many jellyfish species congregate into large swarms of up to 1000's of individuals
   can devastate prey in an area
   can clog fish nets
   swarms often triggered by eutrophication
   climate change has caused many swarming species to expand their range

2. Some are **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 nematyocytes in their skin and use them for defense

3. numerous **symbioses** within this phylum:
   eg. The “upside-down jellyfish” is not a predator
   it harbors symbiotic algae in its tissues and spends its time in shallow water laying upside-down ‘sunning’ its algae

   in deeper waters it moves up to the surface during the day for photosynthesis
   **eg.** many anthozoa live as commensals on shelled animals
   **eg.** attach to shells of hermit crabs
   **eg.** decorator crabs
   **eg.** almost every sea anemone is a host to a variety of fish and other reef animals (shrimp, crab, fish)
   over 50 species of fish associated with anemones
   (also some shrimp)
   **eg.** clown fish
   fish symbionts are stung on first contact (on tail or nonvital body part)
   \(\rightarrow\) then body mucus or slime is chemically altered so the fish is not affected by further stings
   must continually refresh mucus layer
   **eg. most corals** are mutualistic with dinoflagellate algae (**zooxanthellae**)
   base of food chain in coral reef communities
   **eg. most coral species** produce large amounts of slime which harbors a diverse community of bacteria and other microbes.

   this community acts in lieu of an immune system to protect the animals which is lacking in most invertebrates, including corals
   **eg. some corals** call for help when being smothered by seaweeds
   corals compete for light with seaweeds
   a new (2012) study found that when a staghorn coral species in Fiji is being smothered by mats of seaweed it signals gobies to come eat the seaweed
   gobies don't touch the seaweed unless signalled by the coral
   in return gobies get shelter from the coral

5. Coral Reefs
   "cold water corals"
   some live below 0ºC
   no light
   no **zooxanthellae** for extra nutrients
   almost 700 species
   "tropical coral reefs"
Tropical Coral Reefs

corals are familiar to most people as main components of coral reefs

Coral Reef Diversity

coral reef communities are the most luxuriant, complex and diverse of all aquatic communities while they are dominated by coral species practically all animal phyla are represented

an abundance of sponges, clams, snails, octopi, squid, worms, fish, eels, sea stars, sea urchins, shrimp, crab, etc
also seaweeds, algae, bacteria, protists, etc

each species of life has developed ways to cooperate and compete within a myriad of nooks and crannies

reef ecosystems are characterized by high diversity

→ lots of competition especially for space & food
eg. algae, sponges and corals are constantly growing over and killing each other
eg. most reef fish are very localized with specific feeding preferences

→ also coralline algae, mollusks, and a few other groups

3. coral reef communities have survived for 1000’s or 10,000’s of years
relatives of corals appeared over 500 MY ago
→ mainly solitary individuals
modern colonial reef building forms appeared and diversified in the last 25 M years
eg. one reef (Eniwetok) is ~ 4000' thick (1283 m) and estimated to be over 60 M years old
oldest reefs are in the pacific; youngest in the atlantic (10-15,000 years old)

the extensive vertical growth of reefs is the result of changes in sea level &/or subsistence of the seabed
→ virtually all modern reefs have grown upward due to recent sea-level rise beginning ~18,000 BP (rate of 3-15 M (10-40’)/1000yrs)
→ some of the thickness may also be due to subsistence (especially at atolls and some barrier reefs)

Where are Coral Reefs

individual corals are found in all oceans from the poles to the equator
but coral reefs are only found in warm, clear equatorial waters

eg. reef fish even differ between day and night
coral reefs cover 0.1% of earth’s surface area
all kinds of reefs cover 1.5 M sq miles (=568,600 km²)
(the most productive shallow water reefs, ie. reefs in <30m of water, cover ~0.75 M sq. miles (=284,300 km²) = area ~ size of Italy)
coral reefs contain about 200,000 known species (~15% of all species)

Reefs are unique ecosystems:

1. reefs are the largest biological structures on the earth
2. their structure is created by biological activity
→ they create their own ecosystem
massive deposits of calcium carbonate
→ esp by corals

Reef Requirements & Structure

to become established a reef has some essential requirements:

1. hard substrate
initial growth requires a hard surface (firm base) on which to start construction
reef forming organisms are mainly sessile, benthic animals
= animals that live in or on a substrate (don’t swim in open ocean)

2. warm tropical temperature
→ waters >68º F (20º C)
tropical reefs are most common in the western Pacific and Indian Oceans
many are brightly colored
numerous symbioses occur between reef organisms
yet most reefs grow in areas of ocean with fewest nutrients
→clear clean water = nutrient poor water
reef communities are also restricted by water temperature
   - most occur only in tropical and subtropical seas (+30° latitude)
   - where average water temperature ~23° - 25° C
   - none are found below 18° C
   - few on W coast of N America or Africa due to upwelling of cold water

3. shallow
   - most reefs grow depths of 75 ft (25 M) or less
   - limit is 50-70 M
   - they are therefore restricted to coastal areas or seamounts
   - most reef building corals contain symbiotic photosynthetic algae that require sunlight
     - form basis of reef food chain
     - not too deep (to 60M)
     - light is quickly filtered out
     - depth of active reef is restricted by light penetration
     - the growth and health of the coral community is directly dependent on the amount of light reaching the reef

4. salinity near 33 ppt
   - normal salinity of sea water
   - can’t withstand lower salt concentrations
   - eg. don’t see any near E coast of S America because of outflow of Amazon River

5. clear
   - reef organisms require clear waters to allow their photosynthesis
     - low amounts of dissolved materials and few nutrients
     - not at mouth’s of large rivers
   - if the water is shallow, but murky (turbid) sunlight will not get through for photosynthesis
   - also, too much sediment will smother the polyps
   - another reason why they are not usually found near outlets to large rivers

6. Prefer areas with Strong Wave Action
   - wave action oxygenates waters, brings in nutrients, and reduces sedimentation

Established Reefs

once established, reefs create their own environment:
- coral colonies form the main framework of a reef
  - may be over 100 species of corals alone
- the coral colonies are able to extract calcium carbonate from sea water to form the reef structure
  - they use sugar produced by the algae that live inside their tissues to do this
  - without the algae the corals cannot grow
- most reef building corals contain symbiotic photosynthetic algae (=zooxanthellae)
  - present in enormous populations
  - provides a vital energy source for the reef organisms base of reef food chain
  - this symbiosis is beneficial to both organisms:
    - corals provide CO₂, N₂, P
    - algae provide O₂, remove wastes, make organic nutrients
    - some corals also have symbiotic nitrogen fixing cyanobacteria
      - numerous crevasses and holes provide excellent hiding places
      - create numerous habitats
- any exposed surface created when organisms die, is quickly attacked by boring organisms especially sponges, worms and clams
- as organisms live and die get build up of coral skeletons, encrusting algae, shells, etc
- waves also break up and destroy old reef material
- fine materials settles into crevasses and holes
  - fills spaces
  - cements reef together
  - waves also break up and destroy old reef material
- fine materials settles into crevasses and holes
  - fills spaces
  - cements reef together
- coral reefs show very rapid recycling of nutrients (similar to rainforests)
  - virtually all the nutrients the algae create are cycled to corals and the rest of the food web
  - prevents nutrients from sinking out of productive sun lit zone and lost
  - produce several times more organic material/area than phytoplankton communities
- reef communities show numerous symbioses and interactions
  - eg. zooxanthellae, sponge symbionts, crabs, molluscs, cleaner fish, etc
  - a common characteristic of many reef organisms is mass spawning events
  - most corals are hermaphrodites
  - take 7-10 years to reach sexual maturity
Animals: Phylum Cnidaria; Ziser Lecture Notes, 2015.9

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corals don’t have complex nervous systems or sense organs yet many coordinate their release of sperm and eggs within the same few evenings each year, sometimes timed to within minutes of each other each year, at late-spring full moon, 100’s of coral species simultaneously spawn → synchronized by a light sensitive pigment in the coral animals

Kinds of Reefs

Two general types of reefs:

1. Fringing Reefs or Barrier Reefs
   most common type
   surround islands and border continents
   grow in shallow waters and border the coast closely or may be separated by a shallow stretch of water
   project seaward directly from shore
   subdivided into several zones:
   reef crest – part of reef the waves break over
   forereef – medium energy
   buttress (spur & groove) – rows of coral with sandy canyons or passages between rows
   eg. Great Barrier Reef is longest in world ~1000 miles

2. Atolls
   at summits of submerged volcanoes (seamounts)
   usually circular or oval with a central lagoon

Reef Zonation

Animals: Phylum Cnidaria; Ziser Lecture Notes, 2015.9

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Both reef types show similarities in profile (vertical zonation)
these differences due mainly to differences in wave energy and water depth

a. Reef Face
   seaward side
   inclined from gentle to steep slopes
   often with terraces creating more zonation
   10-20M: high energy – help to dissipate wave energy (30-60°) grooves drain off sand masses of large dome shaped and columnar corals, large fish
   20-30M: little wave energy (65-100°) only 25% of surface light reaches here more delicately branched corals
   30-40M: gentler slope (100-130°) very reduced light sediments accumulate here corals become patchy
   >50M: slope drops off sharply (>165°)

b. Reef Crest
   highest point of reef front
   exposed at low tide, covered by waves at high tide
   elkhorn coral and shelf coral

c. Reef Flat (back reef)
   sheltered, lagoon side
   highly variable short to several 100 meters lowest energy, coral sand

delicate corals, eg. staghorn becomes shallower and supports sea grasses

Reef communities are characterized by a coordinated reproductive frenzy at specific times of the year often late spring: “spawning”
→ one species after another will discharge reddish clouds of eggs and milky white sperm into the water
→ described as an underwater ‘snowstorm’

Economic Impacts of Coral Reefs:

Animals: Phylum Cnidaria; Ziser Lecture Notes, 2015.9

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reef communities have significant impacts on human economies and activities:
   fisheries
   tourism
   coastal protection
   pharmaceuticals

1. Fisheries
   eg. worldwide, coral reefs provide 1/4th of the annual commercial fish catch and feed over 1 Bil people in asia alone.
   eg. US reefs support millions of jobs and a $200 M annual fishery
   on global basis 1/2 sq mile of reef:
   → can sustainably yield 15 tonnes of fish and other seafood/yr
   → $8.6 M in revenue/yr

2. Tourism
   eg. reefs of the florida keys generate $1.2 Bil/yr in tourist dollars

3. Biochemicals
   scientists have extracted over 20,000 new biochemicals from marine life, mainly from coral reef organisms over past 20 yrs(04)
since the greatest marine diversity is in coral reefs, they offer the greatest possibilities for potential uses

scientists first began looking at softbodied sessile organisms of coral reefs because they thrived under highly competitive conditions with no apparent claws, teeth, etc for defense

→ must use chemical weapons

by some estimates, coral reefs provide over $30 Billion in benefits (direct and indirect), worldwide per year

destroying 1/2 sq mi of reef costs $137,000-$1.2 M in loss of fisheries, tourism and shoreline protection over a 25 year period.

Threats to Reefs:

Coral Reefs are among the most endangered ecosystems in the world

recent (93) assessments of world’s reefs show they are globally threatened

→ there are no “pristine” reefs left:
  all reefs are impacted by human activities
  only reefs in remote areas are generally healthy

→ 30% of reefs are damaged
  up to 30% have been lost in last 50 years (95)
  another 16% are severely damaged

→ 60% may be completely dead by 2030

generally, coral reefs are very resilient

→ have existed for 1000’s to 100,000’s of years

but today are being degraded in a matter of decades

the greatest threats to reefs are from human activities

eg. ~1/2 of world’s population live in coastal regions

eg. in SE Asia, 70% of population is in coastal areas

Coral Bleaching

one of earliest signs of stress is coral bleaching

→ when water gets too warm algae “flee” their coral hosts

therefore lose their color

triggered by disease, pollution, elevated temperatures, salinity changes, increased UV radiation, etc

bleaching is a normal response to short term stresses

while bleached, corals stop growing

→ leaves reef vulnerable to erosion

after one bout the reef can recover,

→ but frequent episodes may kill the coral polyps

what is significant about bleaching today is its frequency, severity and extent

Coral Reefs are associated with 109 countries, those in 93 countries show significant damage

reefs at highest risk:

<table>
<thead>
<tr>
<th>Country</th>
<th>Region</th>
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<tbody>
<tr>
<td>Japan</td>
<td>Asia</td>
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<tr>
<td>Sri Lanka</td>
<td>Asia</td>
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<td>India</td>
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<td>Indonesia</td>
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<tr>
<td>Phillipines</td>
<td>Asia</td>
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</tbody>
</table>

eg. Phillipines only 5% of reefs are pristine

30% are dead

39% are still healthy

all are areas with dense coastal populations and heavy coastal development

Human Causes of Coral Reef Decline:

while natural events, eg diseases and hurricanes can cause extensive damage to specific reefs

humans are having a global impact on reefs

human causes of reef decline:

1. sedimentation
2. eutrophication
3. shipping and oil spills
4. exploiting for food (overfishing)
5. collecting
6. mining
7. tourism
8. Climate Change
9. Ozone Depletion

1. Sedimentation

by far the greatest impact

increase in suspended silt, clay, dirt

mainly due to deforestation esp. mangroves

due to logging, farming, mining, dredging
doesn’t have to occur near coast to have and impact

sediment blankets coral reef

initial plume blocks sunlight→ reduces photosynthesis

smothers polyps

as they produce mucus to remove it, depletes their energy reserves; makes them more susceptible to disease

impedes larval settling
2. **Eutrophication**

Food and nutrients usually limit the growth of most organisms. 

eg. N & P \( \rightarrow \) plants, algae; organics \( \rightarrow \) bacteria, heterotrophs

Reef ecosystems are especially susceptible since they are found in nutrient-poor waters.

too much food can upset the balance between organisms in the community:

- Some grow much faster than others and can become toxic.
- Sometimes a new predator gains upper hand.
- eg. crown of thorns starfish \( \rightarrow \) can clean out entire reefs when its predators are eliminated.

Some algal infestations caused by eutrophication cause algae to release sugars that fertilize the symbiotic bacteria making them pathogenic and killing their coral hosts.

3. **Shipping and Oil Spills**

eg. Oil tankers pollute and kill reefs.

eg. 1st Gulf oil release (10M BBL’s) caused extensive damage to reefs in Arabian Sea.

eg. In the Middle East a phosphate tanker ran aground on a reef, releasing phosphates into the water.

killing 500 mi\(^2\) of reef.

4. **Exploiting for Food (overfishing)**

Reef fish are prone to overfishing because many are slow-growing, long-lived fish (K-selected; low natural fertility).

When depleted they are slow to repopulate.

Historical record shows that over the last several 1000 years, large fish and animals have been hardest hit of reef community.

**blast fishing**

use explosives to kill or stun fish.

5. **Collecting**

eg. 1.5 Million kg’s (15 tonnes; 3M lbs) of coral & shells/year are harvested.

mainly for “shell shops” around the world.

- 1/3 of the Philippines.

Most is exported. Most goes to US gift shops and aquarium shops.

Live corals were collected and sold in Florida until 1989 when it was outlawed. Some is still traded on the black market.

6. **Use as Building Material**

In Sri Lanka and parts of India entire sections of reef have been removed to make cement.

- There is no other source of rock nearby.

7. **Tourism (Ecotourism)**

Walking on reef and touching it kills polyps and kicks up sediment.

Many break off souvenirs of live reef.

Beauty of reef stimulates beach front developments.

eg. On the Pacific Island of Palau they mined an area of reef to build a new airport runway.

- To accommodate an increasing number of tourists coming to see the reef.

eg. In Grand Caymans a 525’ cruise ship dropped a 5 ton anchor and dragged its chain across 150M of reef.

- Creating a 3M wide path 150M long. Uprooted 8M diameter blocks of coral.

- Destroyed an area 1/2 the size of a football field.

**Indirect Human Effects:**

8. **Climate Change**

Global temperatures are increasing 1/2 – 1 degree every decade. This rate is 100x’s faster than natural rate at end of last glaciation.

Most of this accelerated warming is due to human activities.

Global warming will alter weather patterns.

- Alter ocean circulation.

- Warm ocean surface waters.

- Cause significant sea level rise up to 6 cm/decade.

- But reefs can grow up to 10 cm/decade. 

- Cause acidification (lowering of pH) of ocean waters.

- Diversity decreases.

- Individuals are less healthy.

- Dissolves coral skeletons; reefs don’t grow.

- Reduces reproductive success of coral eggs and larvae.

9. **Ozone Depletion**

Will continue into next century.

- Ozone levels decrease 5-5% over the tropics.
Economic Importance of Cnidaria (excluding coral reef ecosystems):

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
   eg. anti-inflammatories, painkillers for arthritis, antimicrobials
   eg. cardiac stimulant from sea anemone
   eg. toxins from soft corals, Palython used as antitumor medication

4. 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

5. space travelers: in 1991 2500 moon jellies flew aboard the Columbia space shuttle
to study how their balance organs develop under weightlessness