Simple Animals

all animals are multicellular

while most animals have complex tissues and organs
some of the simplest, most primitive groups lack them

For us, Simple Animals:

are generally very small

all are aquatic: freshwater or marine

some are poorly known forms that are often found in unusual environments

usually with few or no true tissues

most with only few or no organs or organ systems

the organ systems present are usually primitive and simple

no circulatory system
not respiratory system
most with no nervous system
  when present is nerve net
most with no excretory system
  when present is protonephridia (flame cells)
diffusion plays a major role in distributing oxygen, nutrients, carbon dioxide, and wastes
eg. **Placozoa**

one of the simplest kinds of animals

microscopic form barely visible to unaided eye

was 1\textsuperscript{st} discovered in 1883 in a marine aquarium

Originally thought it was some kind of larval jellyfish or something

eventually it was determined to be a new life form

Placozoa $\to$ *Trichoplax*

for almost 100 years it was only known from aquariums in 1971 was found in plankton in the Pacific Ocean

in 1980’s it was found to be common in oceans

consists of only $\sim1000$ cells,

- no true tissues,
- no true organs

has the least amount of DNA of any animal species

yet all other characteristics place it clearly in the animal kingdom

small disc shaped animal

- there is a dorsal and ventral surface
- ventral surface has cilia for movement
no front or rear → moves in any direction
probably feeds on algae
reproduces both sexually and asexually
eg. **Mesozoa**

small, parasitic, worm-shaped animals

made up of only 20-30 cells

one group is found only in the kidneys of octopii

consist of 2 layers of cells – not true tissues

the only structures resembling organs are the gonads
eg. **Sponges**

a much better known and more common animal group

an ancient group with abundant fossil record

still very simple in structure

no true tissues or organs
  no nervous system
  no digestive system

only a few cells have been specialized for certain functions

→ can force a sponge through sieve and cells will regroup and reform the sponge

all are aquatic, most marine; a few are freshwater

are **sessile** (non motile); but they have motile larvae

often brightly colored: yellows, reds, greens, lavenders

body is a network of canals and passageways

water is pumped through these passageways and the animals filter nutrients from the water currents
**Sponge Anatomy**

small openings are pores or **ostia** where water is drawn into the sponge

some sponges have one or more relatively large inner chamber = **spongocoel** or **flagellated chambers**
where food is extracted from the water passing by

These canals and/or spongocoel are lined with “**collar cells**” (=choanocytes)

each collar cell has a **flagellum**
surrounded by a sieve-like **collar** that acts as a strainer

the flagellum beats to draw the water currents into the sponge and then to strain particles through the collar

food is absorbed (phagocytosis) by the collar cell and then sent to other cells in the sponge

water exits the sponge through larger openings = oscula (sing. = **osculum**)
**Support**

sponges maintain their shape and keep pores and canals open by supporting structures called **spicules**

these spicules can be made of:

- **calcium carbonate**
- **silica** \(\rightarrow\) spicules often united to form a rigid network that looks like fiberglass (eg. Venus Flower Basket)
- **spongin fibers** (protein) \(\rightarrow\) flexible common commercial sponge and most sponges normally encountered on reefs

**Reproduction**

sponges can reproduce asexually and sexually:

Asexually
- budding
  - internal buds = gemmules in freshwater sponges = dormant masses of encapsulated cells produced during harsh conditions
Ecological Interactions

many commensal organisms live in or on sponges:

→ protection from predators

eg. 1 specimen, 2M tall had 16,000 shrimp inside

eg. another had >100 species of organisms in and on it

eg. venus flower basket:  
used as a wedding gift in SE Asia  
typically has a male and female shrimp locked inside  
=“bonded bliss” or “prisoners of love”

also sponges are used by some animals as camoflage

eg. decorator crabs: mobile substrate

eg. some snails and clams have specific species of sponges encrusting their shells

many sponges have mutualistic associations with bacteria

eg. bacteria live inside the tissue of some sponges  
eg. demospongiae 38% of its volume was bacteria for bacteria food and space  
for sponge – it eats the bacteria as needed

eg. some sponges have blue green bacteria or algae that live inside their tissues  
microorganisms get protection
sponge gets food

until 90’s all sponges were thought to be filter feeding omnivores

now, one is known to be a **predator**
  found in Mediterranean caves
  lives in stagnant water → not much to filter
  has developed a tentacle like appendage covered with velcro like hooks
  the hooks snag shrimplike crustacea
  other “tentacles” grow around victim and engulf and digest it

Another group of sponges = boring sponges (*demospongiae*)
  live in shells and corals
  excavate holes in shells and coral = “bioerosion”
  have significant impacts on coral reefs
  important in recycling shells and corals

sponges have few predators
  → a few bony fish and hawksbill turtle eat only sponges

sponges are important components of coral reefs
  their distribution is mainly limited by proper substrate
  corals are their chief competitor for space
  sponges produce quite a few chemicals that repel potential predators or other competitors for space
(often brightly colored to warn others)

→ they make a wide range of “biotoxins”

reduce crowding: create “dead zone” around some sponges

**Economic Importance**

eg. bath sponges have been used over 4000 years
→ holds up to 35x’s its weight in water
takes 5 years to reach marketable size

eg. medicines:
  anticancer drugs
  drugs that promote wound healing,
  antiinflammatories

eg. aquarium trade
eg. Cnidaria (Jellyfish & Corals)

very abundant group

again, a very ancient group with lots of fossil representatives
    (plenty of hard parts – corals)

widespread in marine habitats
    → especially shallow waters, warmer oceans

typically marine but some are freshwater
    all but 1 species of fw cnidarians are polyps
    but there is one small fw jellyfish *Craspedacusta*

more complex than sponges but still very simple
    do have true tissues
        → but only two, not the 4 typical of animals

    between the two tissues is a jelly layer
        → very thick in “jellyfish”

    only a few very simple organs

often beautiful and graceful forms
    sometimes superficially resemble plants and flowers

many are **colonial**
    → groups of individuals usually living together and interconnected eg corals
**Anatomy**

**two main body forms:**

**polyp:**
- tubular body with tentacles around mouth
- usually sessile (attached)

**medusa:**
- umbrella shaped with mouth pointing down
- often with thick jelly layer between cell layers
- free floating, pelagic, motile

predatory
- use **stinging cells** with **nematocysts** for feeding and defense

- each nematocyst is a coiled tubular thread
- thread inside capsule covered by lid
- most have a trigger (=cnidocil) –responds to touch
- when triggered can fire in a fraction of a second

- different kinds of nematocysts:
  - some wrap around prey or are sticky
  - some with tiny barbs that inject poison
  - most are harmless to humans
  - a few can be very painful (Man-O-War)
  - some are fatal (cubomedusae)

**digestive system** is a mouth that opens into a saclike cavity
  → incomplete digestive tract
most have various **sensory cells** (light, balance, chemicals) on surface of body

have simple **nerve net** (no CNS) to coordinate movements; no central processing area

**Reproduction**

asexual reproduction usually by budding
   if buds remain connected = colonial

in many members of the group there is an **alternation of generations** between
   **polyp** which reproduces **asexually** and the
   **medusae** which reproduces **sexually**

**Ecological Interactions**

anemones form interesting mutualistic relationships with other organism

   eg. decorator crabs

   eg. clown fish (immune to nematocysts)

most corals are mutualistic with zooxanthellae (algae)
Coral Reefs

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

coral reef communities are the most luxuriant, complex and diverse of all benthic communities

>3000 species of animals alone

corals form the main framework of a reef

also an abundance of clams, snails, worms, fish, eels, sea stars, sea urchins, shrimp, crab, sponges, etc

reef organisms are mainly benthic animals
  = animals that live in or on a substrate
    (don’t swim in open ocean)

the most diverse aquatic or marine ecosystems consists of a diverse array of photosynthetic algae and bacteria and numerous animals

reef organisms require clear waters to allow photosynthesis
  → not many nutrients, not too deep
  → depth of active reef is restricted by light penetration

found in warm tropical, shallow waters (to 60M)
most reefbuilding corals contain **symbiotic algae** (=zooxanthellae)

<table>
<thead>
<tr>
<th>corals</th>
<th>algae</th>
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<tbody>
<tr>
<td>provide CO2</td>
<td>provide O2</td>
</tr>
<tr>
<td>N, P</td>
<td>remove wastes</td>
</tr>
<tr>
<td></td>
<td>make organic nutrients</td>
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present in enormous populations
provides a vital energy source for the reef organisms
base of reef food chain
→ require **light** for photosynthesis
→ **depth** of reef community is restricted

because of dependence on **light** reef communities also require clean water
→ low amounts of dissolved materials and few nutrients
  → not at mouth’s of large rivers

reef communities are also restricted by water
**temperature**
→ occur only in tropical and subtropical seas
  (±30° latitude) where average water temperature
  ~20° - 28° C

especially in S Pacific and Indian Oceans

**Reef Structure:**
reefs create their own environment:
  high diversity
  \[\rightarrow\text{lots of competition especially for space \& food}\]

  algae, sponges and corals are constantly growing over and killing each other

  rapid recycling of nutrients (similar to rainforests)
  (produce several times more organic material/area than phytoplankton communities)

require a **hard surface** (firm base) on which to start construction

the coral colonies are able to extract calcium carbonate from sea water to form the reef structure

as organisms live and die get build up of coral skeletons, encrusting algae, shells, etc

involve construction and destruction phases:
  any exposed surface is quickly attacked by boring organisms especially sponges, worms and clams

  waves also break up and destroy old reef material

fine materials settles into crevasses and holes
  \[\rightarrow\text{fills spaces}\]
  \[\rightarrow\text{cements reef together}\]
the extensive vertical growth of reefs is the result of changes in sea level

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

Three general types of reefs:

1. **Fringing Reefs**
   most common type
   surround islands and border continents
   project seaward directly from shore

2. **Barrier Reefs**
   platforms separated from adjacent land mass by a lagoon
   eg. Great Barrier Reef is longest in world ~1000 miles

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

**Zonation**

All three reef types show similarities in profile (vertical zonation)

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
**Threats to Reefs:**

Coral Reefs are among the most endangered ecosystems in the world.

The greatest threats to reefs are from human:

- ~1/2 of world’s population live in coastal regions in SE Asia, 70% of population is in coastal areas.
- To date, humans have directly or indirectly caused the death of 5-10% of the world’s reefs.
- At current rates, ~60% of world’s reefs could be gone in next few decades due to human impacts (but excludes effects of global warming and ozone depletion).
- All reefs are impacted by human activities; only reefs in remote areas are generally healthy.

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

Reefs at highest risk:
- Japan
- Singapore
- Taiwan
- Sri Lanka
- India
- Indonesia
- Asia

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

One indication of reef decline is “coral bleaching”
→ symbiotic algae die
→ corals lose color (=bleaching)
→ then coral polyps die

**Causes of Coral Reef Decline:**

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
   from rivers and coastal activity – 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 → plants, algae; organics→ bacteria, heterotrophs
   too much food can upset the balance between organisms in the community:
   some grow much faster than others and can become toxic
   eg algae
   sometimes a new predator gains upper hand
   eg. crown of thorns starfish → can clean out entire
reefs when its predators are eliminated

3. **Shipping and Oil Spills**
   eg. oil tankers pollute and kill reefs
   eg. 1\textsuperscript{st} gulf war oil release (10M BBL’s) caused extensive damage to reefs in arabian sea
   eg. in Mid East a phosphate tanker ran aground on a reef, releasing phosphates into the water and killing 500 mi\textsuperscript{2} of reef

4. **Exploiting for Food**
   reef fishing are prone to overfishing because many are slow growing, long lived fish (K-selected; low natural fertility); when depleated they are slow to repopulate
   blast fishing → use explosives to kill or stun fish
   eg. \(1/6\textsuperscript{th}\) of reefs in Phillipines have been damaged this way since 1945
   some use cyanide and poisons to fish → kills other organisms as well
   child labor → in Phillipines 40 ships carry 300 children to reef each day
   children pound reef with rocks to scare fish into nets can destroy up to 1 km\textsuperscript{2} of reef/day
   children killed by needlefish, sharks, barracuda, poisonous snakes, etc
   as fish become more scarce, fishermen earn extra income collecting turtles, clams, etc

5. **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

6. **Collecting**
   1.5 Million kg’s of coral/year is harvested mainly for “shell shops” around the world – most is exported
   \(\sim 1/3\textsuperscript{rd}\) from the Phillipines
   most goes to US gift shops and aquarium shops
live corals were collected and sold in Florida until 1989 when it was outlawed but some is still traded on black market shells etc collected by malacologists: prefer killing live specimens rather than dead shells from beach exotic fish collected from reefs feed a $4 Billion/yr aquarium industry

7. **Tourism (Ecotourism)**
walking on reef and touching it kills polyps and kicks up sediment many break off souvenirs of live reef stimulates beach front developments

eg. On S 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. **Global Warming**
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 cause significant sea level rise up to 6 cm/decade reefs can grow up to 10 cm/decade alter ocean circulation all of these factors can adversely affect coral reef communities

9. **Ozone Depletion**
will continue into next century
ozone levels decrease .5-5% over the tropics this causes a 1-10% increase in UV radiation shallow marine communities are particularly susceptible to damage from this additional radiation
Economic Value of Coral Reefs:

many marine animals produce biologically active compounds
the earliest known use of marine resources was for medical uses:
2700 BC – China – medical text

perhaps 10% of all marine organism could yield medically important compounds

since the greatest marine diversity is in coral reefs, they offer the greatest possibilities for potential uses

Some examples:

1. Sponges
   antibiotics, antitumor drugs, antifungal drugs
   eg. Acyclovir
   from Caribbean sponge
   1st antiviral compound approved for human use
   fights herpes infections
   used since 1982
   eg. Vidabarine
   may attack AIDS virus
   eg. a species of S Pacific sponge produces chemicals
   that can kill Candida → a human pathogen that causes thrush and vaginal infections

2. Corals
   antiinflammatories, painkillers for arthritis,
antimicrobials

cardiac stimulant from sea anemone

3. Segmented Worms
   eg. Padan – a powerful insecticide produced from a polychaete worm

4. Snails & Other Molluscs
   muscle relaxants, painkillers
   adhesives

5. Bryozoa
   potent anticancer chemicals

6. Tunicates
   antiviral, antitumor
   including possible treatment for malignant melanoma
   → the most dangerous form of skin cancer