**Simple Animals**

**Introduction**

_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_

→ diffusion plays a major role in distributing oxygen, nutrients, carbon dioxide, and wastes

_all are aquatic: freshwater or marine_

_some are sessile others are motile_

_usually with few or no true tissues; and if they have tissues they have few or no organs & organ systems_

_the organ systems present are usually primitive and simple_

_no circulatory respiratory or excretory systems_

_if present at all, only a primitive nervous system_

→ few 1000 cells total

_has top (dorsal) and bottom (ventral); but no front, back or sides_

_glides on ventral cilia - can move in any direction_

_can also make amoeba like movements_

_no tissues or organs_

_between dorsal and ventral layer is fluid filled cavity_

_with some simple contractile cells for movement_

_probably feeds on algae by covering it and secreting enzymes then absorbing_

_reproduces both asexually & sexually_

_asexually by binary fission & fragmentation_

_sexually using egg and sperm_

**eg. The Placozoa**

_1 known species, _Trichoplax_ sp._

_one of the simplest animals_

→ simplest organization; no tissues or organs

→ least DNA/cell than any other animal

_yet all other characteristics place it clearly in the animal kingdom_

_first discovered in 1883 from marine aquarium_

→ until 1971 thought it was a larval cnidarian

_only known from walls of marine aquaria until 1980’s, when they were found throughout the Pacific Ocean_

_now known to occur in shallow waters of all warm oceans of tropical and subtropical areas_

_small disc shaped animal_

_barely visible to naked eye_

**eg. Sponges (Porifera)**

~10,000 living species; >2200 fossil forms

_a much better known and more common animal group_

_genetic analysis indicates that sponges are the most primitive animal group alive today_

_and probably some of the first animals to appear on earth_

_they are closely related to the group of protozoan protists called the choanoflagellates whose cells very closely resemble the collar cells of sponges_

~ 1/4th of their genes are shared by all other animals

_about 1000 of those are absent from protozoa and other protists_

→ may hold key to origin of multicellularity_

_abundant fossil record_

_eg. 400 MY ago sponges dominated the oceans as reef builders_

_eg. some fossil sponge reefs are much larger than the great_

_all are aquatic_

_most marine_
a few ~150 species in freshwater
most range from <1/2 inch to over 3 feet tall
often brightly colored: yellows, reds, greens, lavenders
all are sessile (non motile)
most are colonial
very simple in structure
Aristotle thought they were an intermediate between plants and animals
→ no true tissues organs or organ systems
→ no true tissues
only a few loosely organized cells specialized for a particular functions
(6 kinds of cells in sponges; humans have >250 kinds of cells)
eg. can force a sponge through a thin mesh to separate the cells and the cells will reform a sponge
but only of its own species (if 2 mixed together)
→ no organ systems
cells generally fend for themselves taking in food and oxygen and ridding themselves of wastes

water exits the sponge through a larger opening
= osculum
a sponge must pump >240 gallons (=1 ton) of water to get 1 oz of food
eg. large sponges can filter up to 400 gallons (1500 liters)/day
sponges can also control the flow by constricting osculum at night and opening in day when food is more plentiful
sponges can also reverse the flow to clean out canals after a storm
like cleaning pool filters
one sponge is a predator
until 90’s all sponges were thought to be filter feeding omnivores
one sponge from Mediterranean is now known to be a predator = Cladorhiza corona
found in Mediterranean caves
lives in stagnant water → not much to filter
has developed a tentacle like appendage covered with velcro-like hooks

→ no nervous system or sense organs
sponges do produce a few hormones for chemical control
almost all sponges are filter feeders
they use a very distinctive kind of cell called a collar cell (=choanocyte)
each collar cell has a flagellum
surrounded by a sieve-like collar that acts as a strainer to filter the water
the flagellum beats to create water currents that draw in food that is trapped by the collar
food is absorbed by the collar cell and then sent to other cells in the sponge
feed on detritus, plankton, bacteria
the sponge body is a network of pores, canals and passageways
all the collar cells working in unison create a continuous flow of water through the sponge
small openings are pores (ostia) where water is drawn into the sponge

the hooks snag shrimplike crustacea
within days other "tentacles" grow around victim and engulf and digest it
a small number of sponges are "parasites" = boring sponges
excavates hollow tubes and passageways into shells and corals (living or dead host shells) or limetone rock
the animal grows into the canals and holes it creates
when boring into live animal shells the host will either die outright or be much more susceptible to predation
may have significant impacts on coral reefs and oyster reefs
important in recycling shells and corals = "bioerosion"
in some areas bridge supports are no longer constructed of limestone because it is attacked by these sponges
sponges maintain their shape and keep pores and canals open by supporting structures called spicules
spicules can be composed of:

  a. calcium carbonate
  b. silica
    → spicules often united to form a rigid network that looks like fiberglass
Animals: Simple Animals, Ziser, lecture notes, 2017

- **c. spongin fibers**
  - flexible protein fibers similar to collagen in us
  - (eg. common commercial sponge and most sponges normally encountered on reefs)

- **No respiratory or Excretory Systems**

- **No Nervous System or Sense Organs**

- **Reproduction & Development**
  - sponges reproduce both sexually and asexually
  - **Asexual**
    - a. regeneration
    - b. budding
    - may break off or remain attached to form colony
  - **Sexual**
    - some are monoecious, some are dioecious
    - sperm are released into water
    - sometimes all sponges on a reef synchronize the release of sperm into the water

**Ecological Interactions of Sponges**

1. **Mutualism & Commensalism**
   - the greatest ecological role of sponges is to provide homes for a wide variety of organisms
   - 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 *camouflage*
     - 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 (*Pseudomonas, Aeromonas*) live inside the tissue of some sponges
     - sometimes making up over one third the mass of the sponge
     - sponge eats bacteria
     - eg. some sponges have blue green bacteria or algae that live inside their tissues
     - microorganisms get protection
     - sponge gets food
     - no other animal has cyanobacterial symbionts

4. **Sponges as Prey**
   - sponges seem to have few predators
     - some sponges produce chemicals to repel potential predators
     - eg. several sponges are known to be toxic to fish
     - still have some major predators
     - a few bony fish
     - Hawksbill turtle
     - an endangered species associated with tropical reefs
     - feeds almost exclusively on sponges
only vertebrate known with such a diet
most predators avoid the glass spines and poisonous
secretions of the hawksbill prey

5. Sponges and Competition
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"
→ prevent competition for space on
crowded reefs
esp from corals and other sponges
produce "dead zone" around sponge
these biotoxins can be antimicrobial
→ may cause painful skin rashes in humans

Human Impacts of Sponges
1. bath sponges
have been used since bronze age; 4000 yrs
holds up to 35 x’rs its weight in water
takes 5 yrs to reach marketable size
2. sponges produce a wide variety of bioactive
compounds:
pharmaceuticals: antibiotics, asthma, arthritis,
anticancer drugs, chemicals that promote
wound healing, anti-inflammatories
eg. antibiotics against bacteria such as E. coli and Staph
aureus
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
a new (2009) Chemical derived from a sponge has
the ability to resensitize bacterial pathogens to
antibiotics

3. Material Science
the intricate glass skeleton of the venus flower basket
is the strongest "glass" structure known
it is so sturdy that it is being investigated by material
scientists for the source of its strength
4. Aquarium Trade
eg. Hydras & Corals
="flower animals"
→ often beautiful, graceful & colorful "plant-like" or
"flower-like" forms
includes: hydras, corals, sea anemones, sea fans, sea
whips
most members are sessile
body in the form of a polyp
tubular body
upward facing mouth surrounded by tentacles
most form large colonies with up to 1,000,000
individuals
little is know of lifespans but one sea anemone kept
in an aquarium lived for 80 years until the tank was
accidentally drained
some individuals may live 1000’s of years but no direct
way to measure it
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 dated at 2742 years old
eg. a black coral in the same area was dated at 4265 years old
again, a very ancient group with lots of fossil representatives
(plenty of hard parts – corals)
appeared in fossil record 600 my ago
all are aquatic
widespread in marine habitats
→ especially shallow waters, warmer oceans
a few freshwater forms; eg hydra
may be solitary or colonial
the solitary species (=sea anemones) are usually larger, the colonial species are usually much smaller
most of the larger solitary species do not secrete any hard exoskeleton
most colonial species secrete an exoskeleton in the form of “cups” of calcium or protein

these cups become ‘welded’ together to form the basic structure of coral reefs

have true tissues
more complex than sponges but still very simple
but only two kinds of tissues; not the 4 typical of most animals:
an outer skin-like epidermis
an an inner layer surrounding the digestive cavity
all hydrams and corals are carnivores
most species have tentacles surrounding mouth
capture prey with unique Stinging Cells (cnidocytes) located mainly on the tentacles
inside each cell is harpoon-like nematocyst
→ highly coiled tubular thread
→ contained within a capsule like organelle
→ trigger (cnidocil)
when triggered can fire in a fraction of a second
can differentiate between animate and inanimate objects
→ doesn’t just fire at anything

some simple sense organs such as eye spots and chemical receptors

Life Spans
little is know of lifespans of these animals
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

Life Cycle & Reproduction
both sexual and asexual reproduction

asexual:
asexual reproduction usually by budding
if buds remain connected = colonial
sea anemones can also split by fission into two animals

sexual:
most are dioecious
many shed gametes into water
the fertilized egg develops into a motile larva (=planula) that drifts with the current until it settles and attaches to the bottom to become a sessile adult.

**Ecological Interactions**

1. numerous **symbioses** within this group
   - eg. anemones form interesting mutualistic relationships with other organisms
     - eg. decorator crabs
     - eg. attach to shells of hermit 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)
       - then body mucus or slime is chemically altered so the fish is not affected by further stings
       - must continually refresh mucus layer
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2. **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 aquatic communities
   - coral reefs cover 0.1% of earth’s surface area

   Most coral reefs found in warm, shallow, clear, unpolluted water generally ±30° N & S latitude
   - (the most productive shallow water reefs cover an area ~ size of Italy)
   - they are therefore restricted to coastal areas or seamounts
   - most reef building corals contain **symbiotic photosynthetic algae**
     - this symbiosis is beneficial to both organisms:
       - **Corals**
         - provide CO₂, N, P
       - **algae**
         - provide O₂, remove wastes, make organic nutrients
   - these symbiotic organisms require clear shallow warm water for photosynthesis
   - the growth and health of the coral community is directly dependent on the amount of light reaching the reef
   - coral reefs contain about 200,000 known species (~15% of all species)

   - Diversity per unit area: coral reefs are 400-500 times more diverse than rain forests
   - eg. >1/4th of all marine fish species are associated with coral reefs
   - while they are dominated by coral species practically all animal phyla are represented
     - an abundance of sponges, clams, snails, worms, fish, eels, sea stars, sea urchins, shrimp, crab, etc
     - eg. 32 of the 34 animal phyla are found on coral reefs compared to only 9 of the 34 found in the rainforests
     - also seaweeds, algae, bacteria, protists, etc
   - reefs are the largest biological structures on the earth
     - their structure is created by biological activity
       - they create their own ecosystem
       - the reef structure is primarily created by colonial corals that secrete CaCO₃ cups
         - exoskeleton for support and protection
     - reef structure consists of compressed & welded together:
       - calcium carbonate coral skeletons
       - encrusting coralline algae
       - foraminiferan shells

   Tropical rainforests
   - 6% of earth’s surface; 14 M sq mi, support ~50% of all species
   - Coral reefs
     - 0.1% of earth’s surface; 1.5 M sq mi, support ~15% of all species
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
coral reef communities have survived for 1000’s or 10,000’s of 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 sea-level rise beginning ~18,000 BP (rate of 3-15 M (10-40’)/1000yrs)
economic impacts of coral reefs:
reef communities have significant impacts on human economies and activities:
1. Fisheries
eg. worldwide, coral reefs provide 1/4th of the annual commercial fish catch and feed over 1 Bil people in asia alone.
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 & Pharmaceuticals
scientists have extracted over 20,000 new biochemicals from marine life, mainly from coral reef organisms over past 20 yrs
eg. antinflammatories, painkillers for arthritis, antimicrobials
eg. cardiac stimulant from sea anemone
eg. toxins from soft corals, Palythoa used as antitumor medication
eg. coral used for bone replacement
eg. 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
many other reef animals also provide benefits
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:
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
Coral Reefs are now among the most endangered ecosystems in the world
recent (04) assessments of world’s reefs show they are globally threatened
Economic Impacts of Coral Reefs:
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
another 16% are severely damaged
→ 60% may be completely dead by 2030
the greatest threats to reefs are from human activities
Coral Bleaching
one of earliest signs of stress is coral bleeding
bleaching is a normal response to short term stresses
→ 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
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

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:

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 → plants, algae; organics → 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 → 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 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 killing 500 mi² 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
eg. ~1/6th of reefs in Phillipines have been damaged this way since 1945
cyanide fishing
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 km² 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. Collecting
1.5 Million kg’s (15 tonnes; 3M lbs) of coral & shells/year are harvested

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mainly for “shell shops” around the world
~1/3rd from the Phillipines
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
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

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 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. 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
tentacles can be quite long making jellyfish some of the longest living animals
e.g. lion's mane jellyfish → over 120'

9. Ocean Acidification
due to increases in CO₂ the ocean is becoming more acidic.
just a few 10⁶s of a degree makes it harder for ocean creatures to form 'hard parts' like corals and shells
→ dissolves coral skeletons; reefs don't grow
→ reduces reproductive success of coral eggs and larvae

10. Ozone Depletion
will continue into next century
→ ozone levels decrease 1.5-5% over the tropics
→ this causes a 1-10% increase in UV radiation
shallow marine communities are particularly susceptible to damage from this additional radiation

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eg. Jellyfish
large graceful, usually translucent animals with bell shaped body and long trailing tentacles
most jellyfish are less than 1 foot in diameter
but some are up to 20’ in diameter

Life Cycle and Reproduction
asexual:
   asexual reproduction usually by budding

sexual:
   most jellyfish are dioecious
   many shed gametes into water
   eg. moon jellies swarm
   male releases sperm threads into water
   female collects and eats them to fertilize eggs

Animals: Simple Animals, Ziser, lecture notes, 2017.5

nerve net controls contractions of bell for swimming
watching jellyfish swim it looks like they’re not going anywhere
   contractions of bell creates water currents that draw food through tentacles and toward mouth
   → its not ‘trying to go anywhere’
a few jellyfish are active predators with strong stinging cells
   they can actually chase their prey
the life cycle of jellyfish is more complex than that of coral

they show a true **alternation of sexual and asexual generations**:

jellyfish have 2 main body forms:

- **polyp** (=hydroid)
- **medusa** (=jellyfish)

the medusa is the most visible form and reproduces **sexually**

jellyfish also have an **asexual polyp** stage in their life cycle

the polyp is usually very small, in a few cases the polyp stage is colonial and looks like strange moss growing on rocks or other objects

embryo in marine species is usually a motile larva (=planula) as in corals

**Ecological Interactions**

1. jellyfish are eaten by some marine animals
   - eg. some fish: sunfish, moonfish, swordfish, salmon, tuna
   - eg. some cephalopods (squid)
   - eg. sea turtles (leatherback & loggerhead) like jellyfish
     unfortunately many are suffocated by eating plastic bags floating in the ocean

2. 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

**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
   - eg. anti-inflammatory, painkillers for arthritis, antimicrobials
   - eg. cardiac stimulant from sea anemone
   - eg. treatment for multiple sclerosis from coral venom is in clinical trials

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

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 nanodevices 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
eg. Planarians

body is elongated, slender or leaf-like or long and ribbon-like
  → still rely on diffusion for much exchange of
gasses, nutrients and wastes
range from less than an inch to 6 or 8" long
free living in oceans, freshwaters and moist soil
has a distinct head with two large eyes
  can’t form images; simple ocelli
chemical sensors in auricles on the side of head
have a simple nervous system with pair of ganglia in head and ladderlike nerve cord running down length of animal
glide on mucus trails
all are carnivores with incomplete digestive tract
  → mouth, no anus
mouth is near middle of body on the end of a prehensile throat-like tube (=pharynx)
some have more than one mouth & more than one pharynx
  sucks up bits of prey
  in intestine secrete enzymes which further digest prey
  in some the intestine is highly branched to deliver digested food throughout the body
undigested food is discarded through mouth
a few marine species feed on coral polyps and are able to absorb the stinging cells into their skin, then use them to catch prey

Reproduction
Asexual
  fission
  pinch in half
  some times produces a chain of zooids
  → superficial resemblance to segmentation
  regeneration

Sexual
  almost all flatworms are monoecious
  (hermaphrodites)
  cross fertilization not self fertilization
  some with internal fertilization

flatworms have considerable powers of regeneration
  replacement of lost parts
  also to recover from long food shortage
  some can survive for months by self digesting up to 90% of their body
early researchers also reported learning by cannibalism
  → has never been repeated???
  taught planarian to run a maze
cut in half and allowed to regenerate
  both new worms learned the maze quicker

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