Phylum Porifera (Sponges)

~9,000 living species; >2200 fossil forms

abundant fossil record
- first signs of multicellular life are in 750 MY old rock, in this same rock are unique chemical signatures of sponges
- newly discovered (2010) fossils that may be sponges have been found in 635-659 MY old rocks
- 400 MY ago sponges dominated the oceans as reef builders
- some fossil sponge reefs are much larger than the great barrier reef → covered an arc across most of N Europe 200 MY ago
- fossilized into hard rock used to build castles and other buildings in the Middle ages

some signs of multicellular life may be as old as 750 MY, and likely as old as 650 MY
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genetic analysis indicates that sponges are the most primitive animal group alive today

ancient spongelike ancestors were the first animals
- all other animal groups descended from this ancestor
- the earliest sponges in symbiosis with bacteria may have significantly helped to aerate the ancient oceans making them more suitable for animal diversification

sponges are some of the simplest animals

all sponges are sessile

- some are round, flat, grow as crusts or vaselike
- most are assymetrical
- some are radially symmetrical
- often brightly colored: yellows, reds, greens, oranges, lavenders → pigments in surface cells
- most are colonial – colonies formed by budding
  - all are sessile (non motile), most are filter feeders
  - but larvae are free swimming (motile)
- very simple in structure
  - though multicellular, they function largely like a colony of unicellular organisms
  - Aristotle thought they were an intermediate between plants and animals
- cellular level or organization
  - no true tissues or organs; loose aggregate of cells
  - masses of cells in gelatinous matrix = mesophyll
  - only a few cells have specialized for a particular function
  - (6 kinds of cells in sponges; humans have >250 kinds of cells)
  - can force sponge through fine sieve to separate cells and individual cells will reform a sponge

sponges are some of the simplest animals

Body Plan

body consists of just 4 kinds of cells arranged around a system of pores and canals

though multicellular, no true organs or even tissues

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

~ 1/4 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

while multicellular their structure is unlike any other animal group
- early biologists thought they were some kind of plant
- all are aquatic, mostly marine
- found at all depths from intertidal to the abyssal zone
- a few (~150 sp./27 US) occur in freshwater
- most range from <1/2 inch to over 6 feet tall (=loggerhead sponges)

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Body Plan

body is a network of pores, canals and passageways

no “mouth”

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

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

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

natural selection favored an increase in surface area leading to more complex “folding” of the sponge:

simple to more elaborate canal systems

a. asconoid
  - simplest type
  - very small tube shaped sponges
  - large central cavity = spongocoel
  - in via small openings called ostia
  - out through single osculum
Animals – Animal Phyla: Porifera; Ziser Lecture Notes, 2015.9

b. syconoid
derived from asconoid pattern by folding
more branching
has incurrent canals and side passages
still have main spongocoel
single osculum

c. leuconoid
most complex
consists of many small flagellated chambers
no longer a central spongocoel but almost unlimited
ability for sponge to grow in size
generally larger colonial forms
each mass has its own osculum
incurrent and excurrent canals

a typical sponge can pump water equivalent to its own
volume in ~ 8 seconds

a sponge must pump >1 ton of water to get 1 oz of
food

they can also control the flow by constricting osculum
at night and opening in day when food is more
plentiful

also can reverse the flow to clean out canals after a
storm
like cleaning pool filters

Cell Types
only a few cells have been specialized for certain
functions
most cells are “totipotent” (ie. can change form
and function – probably an important key to
their success)

1. Choanocytes (= collar cells)
probably the most distinctive and most important
of sponge cells
each collar cell has a flagellum
surrounded by a sieve-like collar that acts as a
strainer
“collar” is made of microvilli and microfibrils
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

choanocytes line major cavities depending on canal system:
a. spongocoel on asconoid types
b. radial canals on syconoid types
c. flagellated chambers on leuconoid types

collar cells are almost identical to the cells of
choanoflagellates

genetic analysis indicates a very close
relationship between these protists and
sponges
> choanoflagellates are ancestors of
animals

2. Pinacocytes
form outer “epithelium” and sometimes lines
inner passages

nearest thing to tissues

thin flat cells

some are contractile = myocytes in circular bands
around oscula to regulate water flow

3. Porocytes
tubular cells form the pores of asconoid sponges

4. Archaeocytes
amoeboid type cells
move about in mesophyll matrix
receive particles from choanocytes for digestion
phagocytize old cells

can differentiate into any other type of cell
different kinds
sclerocytes → secrete spicules
spongocytes → secrete spongin
collencyotes → secrete collagen

Support
the cells in gelatinous matrix of a sponge are arranged
around a skeleton of spicules

spicules maintain its shape and keep pores and
canals open

spicules may be composed of:

a. calcium carbonate

b. silica
> spicules often united to form a rigid network that looks
like fiberglass

(eg. Venus Flower Basket)
c. spongin (a form of collagen – a protein only
found in animals)
> flexible protein fibers related to keratin

(eg. common commercial sponge and most sponges
Feeding and Digestion

1. all but a few sponges are filter feeders
   feed on detritus, plankton, bacteria
   pinacocytes, archaeocytes and choanocytes can all phagocytize food
   archaeocytes can eat larger particles
   choanocytes can eat smaller particles
   sponges can also absorb dissolved nutrients directly from the water
   digestion is all intracellular
   each cell is responsible for getting its own food

2. 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
   the hooks snag shrimplike crustacea
   within days other “tentacles” grow around victim and engulf and digest it

3. a small number of sponges are “parasites”
   = boring sponges (demospongiae)
   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

No respiratory or Excretory Systems

take in O₂ and get rid of wastes and CO₂ by simple diffusion

a few have contractile vacuoles in choanocytes and archaeocytes

No Nervous System or Sense Organs

sponges can react to local stimuli

some produce electrical signals

sponges do produce some hormones for chemical control

Reproduction & Development

reproduce both sexually and asexually

Asexual
   a. regeneration
   b. asexual buds:
      may break off or remain attached to form colonies
   c. fw & a few marine forms produce internal buds = gemmules
      → dormant masses of encapsulated cells
      usually produced during harsh conditions
      may be retained inside “parent” sponge or as original sponge dies, they fall to bottom

Sexual
   some sponges are monoecious, some are dioecious

specialized sex cells in mesenchyme form egg or sperm
   sperm released into water
   eggs are retained in mesenchyme
   sperm are drawn into female sponge through ostia or pores and fertilize egg
   most sponges are viviparous
   = retain and nourish embryo

free swimming ciliated larvae hatch and are released
   unique larval form = amphiblastula
   swims in plankton for a while then turns inside-out and settles to become a sessile adult
**Sponge Classification** [not current taxonomy]

**A. Class Calcarea (calcareous sponges)**
- small, vase shaped, primitive group
- mostly drab colored; a few are yellow, red, green, lavender
- all marine, especially shallow waters
- show all 3 types of canal systems; mostly asconoid canals
- spicules of CaCO$_3$, needle shaped or 3-4 rayed

**B. Class Hexactinellida (glass sponges)**
- all marine; mostly deep colder waters
- body often cylindrical or funnel shaped
- most vaselike or tubular; 7-10 cm to 1 m tall
- all with siliceous spicules, 6 rayed or long hairs like fiberglass
- usually with large spongocoel and large osculum
- synconoid and leucon canal systems

**C. Class Demospongiae (spongin sponges)**
- largest class: ~90% of all living species;
- most diverse group
- includes common bath sponges
- 1 small family of freshwater sponges
- spicules of silica (but not 6-rayed), spongin fibers, or both
- some tall and fingerlike, some encrusting
- includes 1 group of "boring sponges"; burrow into shells and corals

**Phylogeny of Sponges**
- origin dates to cambrian
- related to flagellate protozoans
  - choanoflagellates
- sponges diverged early
- new genetic analysis (2010) indicate that sponges are the most primitive animal group
- and should be divided into at least 2 separate phyla; Calcarea and Silicaria

**Ecological Interactions**

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: sponges, snails, mites, fishes
- protection from predators
- larger sponges often harbor a larger variety of commensals
- 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: still used as a traditional wedding gift in SE Asia typically has a male and female shrimp locked inside
  - *=bonded bliss* or *prisoners of love*
- Sponges also grow on many other animals; molluscs, barnacles, corals, crabs
- 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. heterotrophic bacteria (*Pseudomonas, Aeromonas*) live inside the tissue of some sponges
  - bacteria live in *mesohyl* jelly; a rich growth medium up to half the weight of a sponge is bacteria
  - sponge eats bacteria
  - esp Demospongiae
  - eg. demospongiae 38% of its volume was 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
→ in freshwaters, spongilla fly larvae feed on
  sponges

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

Human Impacts of Sponges

1. bath sponges
   have been used since bronze age; 4000 yrs
   holds up to 35 x’s its weight in water
   takes 5 yrs to reach marketable size

eg. before 1940’s the Florida sponge fleet in Key West had >350
  ships and employed 1400 people

the sponge harvest ceased in 1940’s due to overcollecting,
  red tides and a fungal disease that wiped out the
  sponge beds

  this was also the same time that synthetic sponges
  were introduced to the market

2. sponges produce a wide variety of bioactive
   compounds:

pharmaceuticals: antibiotics, asthma, arthritis,
  anticancer drugs, chemicals that promote
  wound healing, anti-inflammatorries

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. Vidarbarine

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

also, its silica spicules transmit light better than
  commercial optic fibers

  efforts are being made to artificially duplicate
    them

3. Aquarium Trade

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

  → they lose their resistance to all antibiotics and die

esp from corals and other sponges
  produce "dead zone" around sponge

these biotoxins can be antimicrobial

→ may cause painful skin rashes in humans