Phylum Porifera (Sponges)

~9,000 living species; >2200 fossil forms

abundant fossil record

eg. first signs of multicellular life are in 750 MY old rock, in this same rock are *unique chemical signatures* of sponges

eg. newly discovered(2010) fossils that may be sponges have been found in 635-659 MY old rocks

eg. 400 MY ago sponges dominated the oceans as reef builders

eg. 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

genetic analysis indicates that sponges are **<u>the</u> 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**

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

~ 1/4th 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

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)

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)

eg. can force sponge through fine sieve to separate cells and individual cells will reform a sponge

but only of its own species (if 2 blended together)

sponges need only very small amts of oxygen and, as some of the earliest animals, may have played a role in helping to raise earths oxygen levels by feeding on dead or dying bacteria that would deoxygenate the water

<u>Body Plan</u>

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**

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

<u>Cell Types</u>

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

<u>Support</u>

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

normally encountered on reefs)

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 appendge 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 O_2 and get rid of wastes and CO_2 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 coloried; 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
including most large sponges
includes common bath sponges
mostly marine
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 **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. 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

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'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-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

→ they lose their resistance to all antibiotics and die

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