

Echinoderms

means "prickly skin"

6225 living species; >20,000 fossil species

"If there are animals from another planet already here, they're probably starfish."

"Echinoderms are the Bohemians of the animal kingdom"
-Burnet & Matsen

echinoderms counter the direction of the story of evolution so far

→in fast paced world they live in the slow lane

include: starfish, sea cucumbers, basket stars, brittle stars, sea lilies, etc

has an extremely abundant and diverse fossil record

15 classes of extinct species

→ more extinct classes than any other animal group

much more diverse fossil record than species existing today

all marine; found in all oceans at all depths

some of the most abundant of all marine invertebrates

Animals: 1409 Echinoderms; Ziser Lecture Notes 2009

1

almost all are **bottom dwellers**

mostly drab colors

but a few are red, orange, purple, blue, etc

only major invertebrate phylum with affinities for vertebrates

→ deuterostome, bilateral, coelomate

Unique Characteristics:

most with **pentamerous** (=pentaradial) **radial symmetry**

unique **water vascular system** for feeding and movement

pedicellariae for protection

Body Form

most evident feature: **radial symmetry**

no distinct head

→**oral** vs **aboral** surface

radial symmetry is a secondary trait

→ larvae are bilateral then after

Animals: 1409 Echinoderms; Ziser Lecture Notes 2009

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metamorphosis they become radial

in most its **pentamerous radial symmetry**

Body Wall

epidermis

outer surface covered by **epidermis**

below epidermis are skeletal pieces = **ossicles**

= **endoskeleton**

ossicles are bony plates made of **calcium crystals**

unlike any other phylum, echinoderms can vary rigidity of dermis

pliability of collagen fibers is under nervous control

= "catch collagen"

soft and pliable → rigid

→allows animal to hold various postures for long periods without muscular effort

Movement

movement & food gathering done predominantly by

Animals: 1409 Echinoderms; Ziser Lecture Notes 2009

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water vascular system

the whole system operates hydraulically

filled with fluid (mainly sea water and some proteins and cells

internal canals connect to the outside through the **madreporite**

joins **ring canal** just inside and around the mouth

long **radial canals** extend into each arm

in arm, **lateral canals** branch off radial canals

have valves to prevent backflow

connected to muscular **tube feet**

the tip of the tube feet are flattened, forming **suckers**

suctionlike cups can produce strong force

tube feet used to cling to substrates, move and to feed

most echinoderms don't have large muscles

Animals: 1409 Echinoderms; Ziser Lecture Notes 2009

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muscles mainly used to move **tube feet**

but some also attached to ossicles to allow them to bend and flex

water vascular system also compensates for the absence of a blood circulatory system

Feeding & Digestion

echinoderms are particle feeders, scavengers or predators

no parasitic species

simple, usually complete digestive tract

Respiration

tiny saclike projections extend through epidermis

= **dermal branchae** (or papulae)

→ exchange respiratory gasses

→ get rid of ammonia (N-wastes)

the same functions are also shared by **tube feet** in most groups

Nervous System

no brain or centralized processing area

circumoral ring and **radial nerves** branching from it

helps coordinate movement of arms and movement of the starfish in general

tube feet are innervated by nervous system

→ enables all feet to move in single direction

few specialized sense organs

have some simple **tactile**, **chemical** and **photoreceptors** and **statocysts**

Protection

in many starfish the body surface bears small jaw-like **pedicellariae**

→ protect against animals and debris that settle on the animals surface

Reproduction & Development

sexes typically separate → dioecious

external fertilization

produce characteristic ciliated, free-swimming, planktonic larva

= **bipinnaria**

some can also reproduce **asexually** by **fragmentation**

many also have excellent powers of **regeneration**

→ can regenerate from 1/5th of oral disc & a single arm

but may require up to a year

some deliberately cast off an arm as a means of asexual reproduction

don't seem to age → can live forever?

Main Kinds of Echinoderms:

Class: Asteroidea

(starfish, sea stars, sea daisies)
1500 living species

Class: Ophiuroidea

(brittle stars, basket stars, serpent stars)
>2,000 living species

Class: Echinoidea

(sea urchins, heart urchins, sand dollars & sea biscuits)
950 living species

Class: Holothuroidea

(Sea Cucumbers)
1150 living species

Class: Crinoidea

(sea lilies, feather stars)
625 living species

there are at least 17 extinct classes of Echinoderms

Class Asteroidea (sea stars, starfish)

~1500 species

free moving

inhabit all seas

bottom dwellers

mostly found on hard rocky surfaces

many live in deep ocean

also common along littoral zone in coastal waters

where they may congregate in very large numbers

1 cm to 1 M diameter

eg. giant *Pycnopodia* has over 20 arms and is the size of a manhole cover

often brightly colored: red, orange, blue, purple, green etc

best representatives of the basic features of the phylum

body composed of rays (arms) projecting from a central disc

arms not sharply set off from central disc

in some arms are very short

eg. *Culcita* → a pentagon with no arms

mouth and 100's of tube feet underneath

most with 5 arms

sunstar up to 40 arms

some have up to 50 arms

Oral Surface

mouth in center of oral surface

wide furrows project from mouth into each arm
= **ambulacral grooves**

each groove contains 2-4 rows of **podia**
(= **tube feet**)

margins of each groove are guarded by moveable **spines**

tip of each arm has 1 or more tentacle-like sensory tube feet and a red pigment spot (=eye spot)

Aboral Surface

large sievelike **madreporite** toward one side

aboral surface bears numerous **pedicellariae**

keeps integument free of sponges, corals

also used in feeding and defense

Feeding and Digestion

many sea stars are **scavengers**

a few are **suspension feeders**

feed on small plankton and organic debris

mucous strands carry food to the mouth

most are **carnivores**

feed on molluscs, crustaceans, polychaetes and other echinoderms

use **chemoreceptors** to detect and locate prey

some can locate buried prey and dig down to get them

eg. some swallow prey whole and regurgitate undigested ossicles & spines, etc

eg. some attack larger seastars and begin eating the end of an arm and work their way up

eg. many are able to evert their stomachs through the mouth to engulf and eat prey

eg. some feed exclusively on bivalves

→ some, such as *asterias*, are notorious predators of oysters

wraps itself around its prey

exert steady pull on valves

[force of 12.75 newtons (equivalent to human lifting 1000lbs wit 1 hand)]

~ a half hour the adductor muscles of bivalve fatigue and relax slightly

only need 0.1mm gap to insert stomach and digest oyster

takes 2.5 - 8 hrs to digest a bivalve

mouth at the center of the disc

opens to large **stomach** that fills most of the inside of the oral disc

pyloric caeca (digestive glands) , 2 per arm, drain into pyloric region

products of digestion in stomach are carried to pyloric caecae to complete digestion and absorption

short tubular **intestine** opens through the **anus** on aboral side

Reproduction & Development

Asexual reproduction

many starfish regularly reproduce asexually

→ central disc divides in half and animal breaks into two parts;

each regrows missing part

starfish can also **regenerate** from an arm

or others an arm and a small piece of the central disc

Sexual Reproduction

most are dioecious

gonads in small area at base of each arm

when filled with eggs or sperm they almost completely fill arm

gametes released through pores near base of each arm

1 breeding season per year

1 female may shed 2.5 M eggs

larvae are planktonic

Class: Ophiuroidea (brittle stars, basket stars, serpent stars)

~2000 sp

the most **active** of the phylum

found in all types of **marine benthic habitats**

mainly **benthic**

tend to be secretive

in cracks and crevices on hard substrates

some can burrow

a few can swim

up to 12 cm diameter

most are fairly drab, a few are highly colored

leathery skin and few cilia

have **arms** with **central disc** but:

long thin arms sharply set off from disc

no ambulacral groove

→ tube feet (podia) play little role in locomotion

visceral organs are confined to central disc

typically 5 arms

but in basket stars they repeatedly branch to produce tentacle like mass

muscles are much more important in this group

locomotion by snake-like arm movements of arms

ossicles of arms are arranged into flexible columns (called "vertebrae") connected by muscle strands

can rapidly clamor over rocks and seaweed

no arm preferences

→ can move easily in any direction

Feeding & Digestion

brittle stars are **carnivores, scavengers, deposit feeders** or **filter feeders**

deposit and suspension feeders collect small organic particles from the water or sediment and use mucous strands to send food toward mouth

basket star extends its arms into the water to catch plankton

some carnivores use their arms to capture prey and "hand" it to mouth

others "ambush" their prey

use arms to hold central disc off ground to form a kind of shelter

when fish takes an interest in the area under the starfish it quickly wraps its arms around it

Reproduction & Regeneration

sexual reproduction

mostly dioecious, a few species are monoecious

asexual reproduction & autotomy

brittle stars can spontaneously cast off arms

the cast off pieces can regenerate into whole brittle stars

Class Echinoidea
(sea urchins, heart urchins,
sand dollars & sea biscuits)

~950 sp.

widely distributed in all seas

all are **benthic**

remain close to the substrate

typical urchins seem to prefer hard substrates

some, eg sand dollars and heart urchins like to burrow in softer sandy substrates

compact body enclosed within a **test** (or shell) of closely fitting ossicles or plates

plates are sutured firmly together

most are more or less hemispherical in shape

no arms, but 5 **ambulacral areas** on test through which **very long tube feet** extend

with numerous long moveable spines

most 6-12 cm dia; a few to 36 cm

many colors: brown, black, purple, green, white, red

Movement

use very long tube feet and prehensile spines

in most urchins, **moveable spines** cover most of the body

have **ball & socket joints** with tubercles on test

collagen fibers can make spines stiff and erect for protection

in some urchins spines are hollow and can inject a painful poison

Feeding & Digestion

most sea urchins are **grazers**

scrape algae from substrates with teeth

a few boring sea urchins feed on encrusting algae on walls of their burrows

mouth contains a complex chewing mechanism of 5 converging teeth attached to muscle bands

= **Aristotle's lantern**

used to scrape and chew algae from rocks

around mouth are circle of heavy modified **tube feet**

Class: Holothuroidea
(Sea Cucumbers)

~ 1150 sp

rule the deep ocean benthos

→ make up 90% of biomass on deep ocean floor

often on sandy or muddy bottoms

some crawl on sea floor

others hide beneath rocks

some are burrowers

range from 3 cm to 1 M long

most are black, brown, or olive green

sea cucumbers are among the strangest of the echinoderms:

like sea urchins have no arms

have ambulacral areas instead

tend toward **bilateral symmetry**:

polar axis is elongated so some become

long and wormlike or

“cucumber shaped”

“U-shaped”

with mouth and anus are on opposite ends

bottom side = “sole” on which they crawl

body has a leathery appearance

in most the ossicles are greatly reduced to microscopic plates embedded in body wall

a few are covered in armor of calcareous plates

mouth is always surrounded by 10-30 **tentacles** (modified tube feet) which are part of the water vascular system

tentacles are highly retractile

→ can be completely retracted into mouth

tube feet can also be modified into sensory papillae, fins, sails, etc

Body Wall

nonciliated **epidermis** with thick **dermis** below

microscopic **ossicles** embedded in dermis

beneath dermis is layer of **circular** then **longitudinal muscle**

Movement

large fluid filled coelomic cavity serves as a **hydrostatic skeleton**

relatively sluggish

lie on bottom or burrow into mud

many hard bodied forms live beneath stones or in coral crevices

there are a few deep water pelagic (swimming) forms

move by wavelike contractions of body wall

have tube feet modified into fins, sails, or medusa-like bells

Feeding & Digestion

mainly **deposit feeders** and **suspension feeders**

use **tentacles** to collect food and deliver it to **mouth**

mouth opens into a muscular **pharynx**

then to **esophagus** and **stomach**

some holothurians lack stomach

most have a long, looping **intestine**

leads to **anus** which opens into **cloaca**

cloaca = chamber in which digestive system, excretory system (if present) and reproductive system all open into

Respiration

most have a **respiratory tree** consisting of two highly branched tubes

its attached to the cloaca

also used for excretion

pumping action of cloaca circulates water through it

a tropical pearlfish makes its home in the respiratory tree of some sea cucumbers

leaves at night to search for food

Protection

many sea cucumber are capable of **evisceration**

the front or back end ruptures and the internal organs are expelled

seems to be a seasonal phenomenon

possibly when food is scarce or in order to eliminate wastes stored inside the internal tissue

the organs are later regenerated

may also be a protective mechanism

a few sea cucumbers possess a large mass of white, pink, or red tubules (= **tubules of Cuvier**) attached to the base of their respiratory tree

when irritated or attacked, the anus is directed toward the intruder and the tubules are shot out of the anus

in some the tubules are sticky; in others they release a toxin

small crabs and lobsters may be rendered completely harmless and helpless

the sea cucumber later regenerates the tubules for the next attack

Reproduction

most are dioecious; a few are hermaphrodites

some brood their young inside coelom

most have external fertilization

Ecology

sea stars are often the top predators in some benthic communities

though unpalatable to most organisms to some they are the preferred meal:

eg. some fish with strong teeth

eg. sea otters

Economic/Human Impacts

1. echinoderms never attack humans

don't transmit any diseases

although handling poisonous forms can kill

2. "crown of thorns" starfish destroys Pacific coral reefs

feed on coral polyps

sometimes attack in "herds"

the number of reef attacks is increasing

sometimes results in extensive damage

very expensive to control outbreaks

3. sea urchins destroy kelp forest

but are preyed on by sea otters

4. predatory starfish can devastate commercial clam or oyster beds

eg. a single starfish can eat a dozen clams or oysters in a day

sometimes an infestation is treated with quicklime

→ destroys dermal branchiae and kills animal

→ but also kills many other soft bodied invertebrates;

but not the oysters who temporarily close their shells

5. as food:

eg. in China and Pacific Islands sea cucumbers are boiled and dried and eaten as a delicacy or used as a food flavoring

in some areas collecting has severely depleted their populations

eg. roe (gonads & eggs) are sold, raw or roasted, as a delicacy in Japan and in sushi restaurants

>30M pounds of urchins were harvested in 1986

6. echinoderms have been widely used in developmental research

"we know more about the embryology of echinoderms than probably any other embryo"