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

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

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

water vascular system

the whole system operates hydraulically

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

internal canals connect ot 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
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
\[= \text{dermal branchae (or papulae)}\]
\[\rightarrow \text{exchange respiratory gasses}\]
\[\rightarrow \text{get rid of ammonia (N-wastes)}\]
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
\[\rightarrow \text{enables all feet to move in single direction}\]
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**
\[\rightarrow \text{protect against animals and debris that settle on the animals surface}\]

**Reproduction & Development**
sexes typically separate \(\rightarrow\) **dioecious**
external fertilization
produce characteristic ciliated, free-swimming, planktonic larva

**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 \rightarrow 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
\rightarrow 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)]
\sim 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 cece (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

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 ricks 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

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 ambulacrual groove

basket star extends it 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 grand 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 of 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

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:

- Some fish with strong teeth
- 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

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”